Handbook of Research on

Lifestyle Sustainability and Management Solutions Using AI, Big Data Analytics, and Visualization

Sailesh Suryanarayan Iyer, Arti Jain, and John Wang

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Handbook of Research on Lifestyle Sustainability and Management Solutions Using AI, Big Data Analytics, and Visualization

Sailesh Suryanarayan Iyer
Rai University, India

Arti Jain
Jaypee Institute of Information Technology, India

John Wang
Montclair State University, USA

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701 East Chocolate Avenue, Hershey, PA 17033, USA
Tel: 717-533-8845 x100 • Fax: 717-533-8661
E-Mail: cust@igi-global.com • www.igi-global.com

List of Contributors

Ahir, Sanketkumar Jagdishbhai / *Rai University, India* 1
Aravinth, S. S. / *Koneru Lakshmaiah Education Foundation, Vaddeswaram, India* 338
Arepalli, Gopi / *Koneru Lakshmaiah Education Foundation, Vaddeswaram, India*..................... 338
Avasthi, Sandhya / *ABES Engineering College, India* 75
Bhagavathy, Sunandha / *Karunya Institute of Technology and Science, India* 206
Chatterjee, Ayan / *Guru Nanak Institutions, Telangana, India* 160
Devaraj, Uthirakumar / *Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India*..................... 137
Doctor, Gayatri / *CEPT University, India* 305
Edeh, Michael Onyema / *Coal City University, Nigeria*..................... 197
Elumalai, Balamurugan / *epartment of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India*..................... 137
Eucharia, Ani Ukamaka / *Coal City University, Nigeria*..................... 197
G., Boopathi Raja / *Velalar College of Engineering and Technology, India*..................... 57
Garikipati, Jyotsna / *V.R. Siddhartha Engineering College, India* 274
Gejji, Sujay / *S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India*..................... 18
Gupta, Chabi / *Christ University, India* 294
Gupta, Shaurya / *University of Petroleum and Energy Studies, Dehradun, India*..................... 325
Iyer, Sridhar / *S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India*..................... 18
Jain, Pooja / *Indian Institute of Information Technology, Nagpur, India* 91
Jani, Raxit / *Gandhinagar Institute of Technology, India* 231
Jani, Raxit Girishkumar / *Gandhinagar Institute of Technology, India* 254
Jayaram, Pratima Bichandarkoil / *Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India* 109
Jodhwani, Nidhi Ashokbhai / *Rai University, India* 1
Joshi, Vedant / *L.J. Institute of Engineering and Technology, India*..................... 37
Kasinathan, Aruna / *Karunya Institute of Technology and Science, India* 206
Kasthurirangan, Deepa / *Kumaraguru College of Liberal Arts and Science, India* 206
Kaur, Ashneet / *Jagannath International Management School, Vasant Kunj New Delhi, India* 185
Kumar, Senthil J. / *Sona College of Technology, India* 338
Kumar, Viknesh D. / *SNS College of Technology, India*..................... 338
Maru, Jalay Saurin / *Gandhinagar Institute of Technology, India*..................... 231
Mukherjee, Shankarashis / *West Bengal State University, India*..................... 160

Namasivayam, Nalini / *Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India* 109
P., Sakthivel / *Knowledge Institute of Technology, India* 338
Pal, Anikesh / *Indian Institute of Information Technology, Nagpur, India* 91
Pandya, Rahul J. / *Indian Institute of Technology, Dharwad, India* 18
Parikh, Satyen M. / *Ganpat University, India* 168
Parmar, Nishith / *Gandhinagar Institute of Technology, India* 231
Patel, Hiral R. / *Ganpat University, India* 168
Patel, Kuldeep Kumar / *Indian Institute of Information Technology, Nagpur, India* 91
Prajapati, Ramesh / *L.J. Institute of Engineering and Technology, India* 37
Prajapati, Ramesh T. / *Shree Swaminarayan Institute of Technology, Bhat, India* 254
Prajapati, Ramesh Tribhovan Bhai / *L.J. Institute of Engineering and Technology, India* 185
Pramila, S. / *Christ University, India* 294
Raval, Helly Yogeshkumar / *Ganpat University, India* 168
Roselyn, Akindutire Opeyemi / *Ekiti State University, Nigeria* 197
Sanwal, Tanushree / *Amity University, Noida, India* 75
Sareen, Puja / *Amity University, Noida, India* 75
Saurav, Kumar / *Indian Institute of Information Technology, Nagpur, India* 91
Sharma, Aabha / *G.D. Goenka University, Gurgaon, India* 197
Suthar, Anilkumar / *L.J. Institute of Engineering and Technology, India* 254
Suthar, Anilkumar C. / *L.J. Institute of Engineering and Technology, India* 37
Thomas, Anu / *L.J. Institute of Engineering and Technology, India* 185
Tripathi, Suman Lata / *Lovely Professional University, India* 75
Varkey, Mayuri / *CEPT University, India* 305
Vasylevska, Halyna / *West Ukrainian National University, Ukraine* 221
Vyas, Sonali / *University of Petroleum and Energy Studies, Dehradun, India* 325
Yogi, Manas Kumar / *Pragati Engineering College, India* 274

Table of Contents

Foreword xx

Preface xxi

Acknowledgment xxvi

Chapter 1
AI in Health and Diagnostics 1
Nidhi Ashokbhai Jodhwani, Rai University, India
Sanketkumar Jagdishbhai Ahir, Rai University, India

Chapter 2
Survey on Applications of Wearable Technology for Healthcare 18
Sridhar Iyer, S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India
Sujay Gejji, S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India
Rahul J. Pandya, Indian Institute of Technology, Dharwad, India

Chapter 3
A Review of Generative Adversarial-Based Networks of Machine Learning/Artificial Intelligence in Healthcare 37
Anilkumar C. Suthar, L.J. Institute of Engineering and Technology, India
Vedant Joshi, L.J. Institute of Engineering and Technology, India
Ramesh Prajapati, L.J. Institute of Engineering and Technology, India

Chapter 4
An Intelligent Approach for Detecting and Preventing Heart Attacks Using Wearable Technology ... 57
Boopathi Raja G., Velalar College of Engineering and Technology, India

Chapter 5
Augmenting Mental Healthcare With Artificial Intelligence, Machine Learning, and Challenges in Telemedicine 75
Sandhya Avasthi, ABES Engineering College, India
Tanushree Sanwal, Amity University, Noida, India
Puja Sareen, Amity University, Noida, India
Suman Lata Tripathi, Lovely Professional University, India

Chapter 6
Mental Health Detection Using Transformer BERT 91
Kuldeep Kumar Patel, Indian Institute of Information Technology, Nagpur, India
Anikesh Pal, Indian Institute of Information Technology, Nagpur, India
Kumar Saurav, Indian Institute of Information Technology, Nagpur, India
Pooja Jain, Indian Institute of Information Technology, Nagpur, India

Chapter 7
Cancer Precision Drug Discovery Using Big Data and Artificial Intelligence Technologies 109
Pratima Bichandarkoil Jayaram, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India
Nalini Namasivayam, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

Chapter 8
Robot Therapy: A New Horizon in Mental Healthcare 137
Uthirakumar Devaraj, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India
Balamurugan Elumalai, epartment of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

Chapter 9
Cardiac Fitness Status Among Male Paddy Cultivators: A Study in the Context of Emerging Increase in Ambient Temperature... 160
Ayan Chatterjee, Guru Nanak Institutions, Telangana, India
Shankarashis Mukherjee, West Bengal State University, India

Chapter 10
Self-Maintained Health Surveillance Artificial Intelligence Assistant.. 168
Helly Yogeshkumar Raval, Ganpat University, India
Satyen M. Parikh, Ganpat University, India
Hiral R. Patel, Ganpat University, India

Chapter 11
Technology-Powered Education Post Pandemic: Importance of Knowledge Management in Education 185
Anu Thomas, L.J. Institute of Engineering and Technology, India
Ramesh Tribhovan Bhai Prajapati, L.J. Institute of Engineering and Technology, India
Ashneet Kaur, Jagannath International Management School, Vasant Kunj New Delhi, India

Chapter 12
Prospects and Challenges of Using the Flipped Classroom in Computer Science Instruction During the Coronavirus Lockdown.. 197
Michael Onyema Edeh, Coal City University, Nigeria
Aabha Sharma, G.D. Goenka University, Gurgaon, India
Akindutire Opeyemi Roselyn, Ekiti State University, Nigeria
Ani Ukamaka Eucharia, Coal City University, Nigeria

Chapter 13
The Prevalence and Predominance of Artificial Intelligence in YouTube Advertisements in Shaping the Lifestyle of the Budding Generation 206
Aruna Kasinathan, Karunya Institute of Technology and Science, India
Deepa Kasthurirangan, Kumaraguru College of Liberal Arts and Science, India
Sunandha Bhagavathy, Karunya Institute of Technology and Science, India

Chapter 14
Peculiarities of Mutual Influence of the Components of the Fiscal Space of Ukraine 221
Halyna Vasylevska, West Ukrainian National University, Ukraine

Chapter 15
Load Balancing Improvement Through Flexible Assignment of Jobs in the Grids 231
Jalay Saurin Maru, Gandhinagar Institute of Technology, India
Raxit Jani, Gandhinagar Institute of Technology, India
Nishith Parmar, Gandhinagar Institute of Technology, India

Chapter 16
Air Miner: An Air Pollution Detection and Alert System 254
Raxit Girishkumar Jani, Gandhinagar Institute of Technology, India
Ramesh T. Prajapati, Shree Swaminarayan Institute of Technology, Bhat, India
Anilkumar Suthar, L.J. Institute of Engineering and Technology, India

Chapter 17
Beyond the Pandemic: Survival of the Human Race and Challenges 274
Manas Kumar Yogi, Pragati Engineering College, India
Jyotsna Garikipati, V.R. Siddhartha Engineering College, India

Chapter 18
Beyond the Pandemic: Recovery, Resilience, and Adaptation 294
Chabi Gupta, Christ University, India
S. Pramila, Christ University, India

Chapter 19
Artificial Intelligence in Healthcare: Case Studies 305
Gayatri Doctor, CEPT University, India
Mayuri Varkey, CEPT University, India

Chapter 20
Case Study on State-of-the-Art Wellness and Health Tracker Devices 325
Sonali Vyas, University of Petroleum and Energy Studies, Dehradun, India
Shaurya Gupta, University of Petroleum and Energy Studies, Dehradun, India

Chapter 21
AI Technology in Lifestyle Monitoring: Futuristic View – AI Technology and IoT.......................... 338
S. S. Aravinth, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
Gopi Arepalli, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
Sakthivel P., Knowledge Institute of Technology, India
Viknesh D. Kumar, SNS College of Technology, India
Senthil J. Kumar, Sona College of Technology, India

Compilation of References 352

About the Contributors 402

Index.. 409

Detailed Table of Contents

Foreword xx

Preface xxi

Acknowledgment xxvi

Chapter 1
AI in Health and Diagnostics 1
Nidhi Ashokbhai Jodhwani, Rai University, India
Sanketkumar Jagdishbhai Ahir, Rai University, India

The chapter explores how artificial intelligence can be used in the healthcare sector, as monitoring of various parameters related to health is tremendously needed (i.e., early signs of any disease). Monitoring of these parameters can prove an important step to avert the development of ailment or illness in the human body as late diagnosis may lead to various grave effects on a patient's health. AI has reduced the burden on overworked medical and paramedical staff. AI-based devices are easy to use, mostly related to the gadgets we are using in daily life, and most importantly, they are another pair of eyes that never sleeps. The chapter describes various devices and the apps that are used for the purpose stated above and how they actually work. It describes the principle of working, sensors and technology used by them, and parameters measured by them.

Chapter 2
Survey on Applications of Wearable Technology for Healthcare 18
Sridhar Iyer, S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India
Sujay Gejji, S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India
Rahul J. Pandya, Indian Institute of Technology, Dharwad, India

In this chapter, the authors present a detailed survey of wearable technology applications regarding healthcare. They focus on existing studies that use various AI technologies for formulating models which, upon being applied with structured or unstructured data, can predict the various aspects that help the health firms to identify future risk. They also detail important use cases of wearable device usage in healthcare, such as health data acquisition, incentivization, health monitoring, health predictions, improved competitive position, etc. Lastly, they expect that within the next two to three years, with drastic improvement in connectivity and miniaturization, wearable devices will assume more seamlessness and integrate more readily with the consumers' lives, thereby realizing the health-related value.

Chapter 3
A Review of Generative Adversarial-Based Networks of Machine Learning/Artificial Intelligence in Healthcare 37
Anilkumar C. Suthar, L.J. Institute of Engineering and Technology, India
Vedant Joshi, L.J. Institute of Engineering and Technology, India
Ramesh Prajapati, L.J. Institute of Engineering and Technology, India

Machine learning has been proven to be a game-changing technology in every domain since the late 20th century. There have been many advancements in healthcare not only for the diagnosis of disease but advanced in the prognosis of the diseases. Artificial intelligence/machine learning (AI/ML) has progressed a lot in the medical domain in just a couple of decades and played a very important role in exploring human data to understand human body behavior better than ever before, for predicting and classifying all kinds of medical images or videos. A recent and best-used application is detecting COVID-19 by just checking the chest x-ray in a very accurate manner that can be used without human presence and stop the spread of the virus resulting in fewer doctors getting affected. It is known as generative adversarial networks. Some of the types of GANs used for differentiate domains without human supervision and many such mutations of GANs are useful in the health sector. This is simply a quick review of various technologies that will become more in-depth as time goes on.

Chapter 4
An Intelligent Approach for Detecting and Preventing Heart Attacks Using Wearable Technology ... 57
Boopathi Raja G., Velalar College of Engineering and Technology, India

Health-related parameters and issues are extremely important to man's existence and influence. Diabetes mellitus, high cholesterol, and high blood pressure can all cause a blockage of the coronary arteries, resulting in heart palpitation. Various systems use an alarm to display the current state of a patient and are capable of tracking the human body's medical parameters. A defibrillator device with an alert system has been implemented for low-cost, efficient, and flexible heart rate detection and control. The sensors monitor and calculate heart rate, body temperature, and sweat and send the signals to the control device for processing. The local system will issue an alert if there is a significant difference between the normal and measured heart rates, body temperature, or sweat rate. This system monitors heart rate in a constant, real-time, stable, and precise manner. If an abnormality in the patient's heartbeat is observed, the defibrillator can deliver a shock to the patient's external body as a buzzer emits a beep to warn nearby people.

Chapter 5
Augmenting Mental Healthcare With Artificial Intelligence, Machine Learning, and Challenges in Telemedicine 75
Sandhya Avasthi, ABES Engineering College, India
Tanushree Sanwal, Amity University, Noida, India
Puja Sareen, Amity University, Noida, India
Suman Lata Tripathi, Lovely Professional University, India

Artificial intelligence is a huge part of the healthcare industry, having applications and uses in oncology, cardiology, dermatology, and many other fields. Another area where AI is constantly attempting to improve is mental healthcare by integrating machine learning to evaluate data generated by mobile and IoT devices. AI aids in the diagnosis and tailoring of therapy for mentally ill individuals at various stages. The artificial intelligence and machine learning methods utilize electronic health records, mood rating scales, brain images, mobile devices monitoring data in prediction, classification, and grouping of mental health issues, mainly psychiatric illness, suicide attempts, schizophrenia, and depression. The goal of this chapter is to review the literature on artificial intelligence and machine learning algorithms for detecting a person's mental health by utilizing patient health records. In addition, the chapter explains the use of artificial intelligence in curing and monitoring a patient with mental illness through telemedicine.

Chapter 6
Mental Health Detection Using Transformer BERT 91
Kuldeep Kumar Patel, Indian Institute of Information Technology, Nagpur, India
Anikesh Pal, Indian Institute of Information Technology, Nagpur, India
Kumar Saurav, Indian Institute of Information Technology, Nagpur, India
Pooja Jain, Indian Institute of Information Technology, Nagpur, India

The COVID-19 pandemic has affected the daily life of each individual drastically at global level. The adverse effects of the pandemic on an individual and people around them have created an anxious and depressive environment. The virus has changed the way of living for most people and increased the distance between individuals. As the COVID-19 spread, people have been constantly in bad mental health which includes fear, boredom, sadness, and stress. Based on this situation, in this chapter the authors have analysed the mental health of people affected due to COVID-19 by analyzing two parameters of mental health, boredom and stress, from social media posts by detecting different emotions and feelings expressed in the form of text. The authors have utilized the BERT pre-trained model on preprocessed data to create classification models of boredom, stress, and consequently, determining the emotion of the person. These models are used to determine the emotions (i.e., stress and boredom) during different stages of the COVID-19 pandemic.

Chapter 7
Cancer Precision Drug Discovery Using Big Data and Artificial Intelligence Technologies 109
Pratima Bichandarkoil Jayaram, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India
Nalini Namasivayam, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

Improved cancer treatments are widely cited as a significant unmet medical need. Recent technological developments and the increasing availability of biological "big data" provide an unprecedented opportunity to systematically classify the primary genes and pathways involved in tumorigenesis. Artificial intelligence (AI) has shown great promise in many healthcare fields, including science and chemical discovery. The AI will explore and learn more using vast volumes of aggregated data, converting this data into "usable" information. The aim is to use current computational biology and machine learning systems to predict molecular behaviour and the probability of receiving a helpful medication, thus saving time and money on unnecessary tests. Clinical trials, electronic medical records, high-resolution medical images, and genomic profiles can all be used to help with drug growth. The discoveries made with these emerging technologies have the potential to lead to innovative therapeutic approaches.

Chapter 8
Robot Therapy: A New Horizon in Mental Healthcare 137
Uthirakumar Devaraj, Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India
Balamurugan Elumalai, epartment of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

This chapter discusses the current and potential use of robot technology in mental healthcare. Robots use the transition using effectors, which may shift the robot itself (locomotion) or move objects in the background (manipulation), making judgments based on sensor input. Robotics has long been defined as the science that examines the intelligent links between perception and action, but in recent years, this definition has shifted outward, with a greater emphasis on challenges connected to connecting with real people in the virtual environment. This transformation has been referred to in the literature as human-centered robotics, and a developing area in the last decade focusing on problems in this arena is known as human-robot interaction (HRI). Robotics technology is still in its early phases in mental healthcare, but it represents a potentially powerful tool in the professional's toolkit. Socially assistive robotics (SAR) is an up-and-coming field that has spawned a slew of fascinating mental health applications.

Chapter 9
Cardiac Fitness Status Among Male Paddy Cultivators: A Study in the Context of Emerging Increase in Ambient Temperature 160
Ayan Chatterjee, Guru Nanak Institutions, Telangana, India
Shankarashis Mukherjee, West Bengal State University, India

Physical work capacity of the human resources is affected due to adverse thermal working conditions. Keeping this in view, the present study has been undertaken to assess cardiac fitness status in terms of indices of physiological strain among male food crop cultivators. Physical and physiological parameters of the study participants was measured. Indices of thermal working environmental conditions were calculated. Indices of physiological strain of the study participants were also calculated. Result of the present study indicated that environmental condition adjudged by select popular heat indices is above the suggested threshold value making the task strenuous. Additionally, human resources are suffering from varying degrees of physiological strain.

Chapter 10
Self-Maintained Health Surveillance Artificial Intelligence Assistant 168
Helly Yogeshkumar Raval, Ganpat University, India
Satyen M. Parikh, Ganpat University, India
Hiral R. Patel, Ganpat University, India

Artificial intelligence assistant is a program and software that can interact with the user in natural language or with voice or in picture format. After the pandemic situation, people are highly worried about their health. People are not usually aware of all medications or symptoms of diseases. Undernutrition can lower immunity, increase the risk of illness, affect physical and mental growth, and decrease productivity. Issues of this kind may be resolved by providing suitable advice on healthy living with medical chatbots. Chatbots may be used to calorie count, check the quantity of water a person has taken, monitor the schedule of sleep, and maintain training records. They might offer various healthy meal recipes, remind individuals of taking medication, or advise a doctor. Finally, chatbots are able to provide inspiring and motivating phrases to increase self-esteem and attitude.

Chapter 11
Technology-Powered Education Post Pandemic: Importance of Knowledge Management in Education 185
Anu Thomas, L.J. Institute of Engineering and Technology, India
Ramesh Tribhovan Bhai Prajapati, L.J. Institute of Engineering and Technology, India
Ashneet Kaur, Jagannath International Management School, Vasant Kunj New Delhi, India

In order to provide personalized learning and to track student performance, many learning platforms accelerated pre-pandemic. But the focus was for the fortunate students. The recent COVID-19 pandemic taught the education sector the importance of including technology in day-to-day learning activity. Knowledge management is beneficial to all institutes in order to retain experienced teachers and in order to strengthen new teachers with the various steps involved in the process. Managing intellectual assets in order to provide excellent education and to meet all related challenges would be the right step. This study focuses on growth and demand of knowledge management in the education sector. In this chapter, the authors include the matter, like to study the impact of each of the steps involved in knowledge management on the performance of student. In light of the objectives of this chapter, more exploration on studying the effectiveness of knowledge management on education and empirical evidence of the efficacy of KM on the performance of the student is carried out.

Chapter 12
Prospects and Challenges of Using the Flipped Classroom in Computer Science Instruction During the Coronavirus Lockdown.. 197
Michael Onyema Edeh, Coal City University, Nigeria
Aabha Sharma, G.D. Goenka University, Gurgaon, India
Akindutire Opeyemi Roselyn, Ekiti State University, Nigeria
Ani Ukamaka Eucharia, Coal City University, Nigeria

The coronavirus pandemic brought about devastating challenges to every segment of human endeavours, particularly the education sector. This study examines the prospects and challenges of using flipped classroom in computer science instruction during the coronavirus lockdown. The conclusions here were based on available literature and practical experience of the researchers. Though the face-to-face class discussions were not possible due to COVID-19 restrictions, flipped model provided opportunities for computer science educators to upload lesson notes in digital platforms and then engage the students in remote class discussions. However, factors such as COVID-19 lockdown restrictions, time constraints, and lack of face-to-face class interactions hampered the successful implementation of flipped classroom in computer science instructions during the COVID-19 lockdown. The authors conclude that the use of flipped classroom strategy could potentially enhance technology application and learning outcomes in computer science instruction.

Chapter 13
The Prevalence and Predominance of Artificial Intelligence in YouTube Advertisements in Shaping the Lifestyle of the Budding Generation 206
Aruna Kasinathan, Karunya Institute of Technology and Science, India
Deepa Kasthurirangan, Kumaraguru College of Liberal Arts and Science, India
Sunandha Bhagavathy, Karunya Institute of Technology and Science, India

The prevalence of AI in marketing and promotion has taken the role of the personal relations personnel of an ad promotion organization. This chapter attempts to study the cognitive manipulation done by YouTube advertisements with the presence of artificial intelligence. This is where artificial intelligence, which keeps track of the preferences of the user, intervenes, reads the mind of the viewer, and tries to convert the viewer into a potential customer. With the emergence of the pandemic and the enhanced usage of gadgets and the internet, YouTube advertisements are rulers of the minds of the budding generation. This has explained that with the increase in educational qualification, the likelihood to gain information from YouTube advertisements increases. Further, the study reveals that attention towards advertisement and the resulting desire to purchase the product leads to conversion of viewer into consumer. The study has led to the development of a model that highlights the presence of AI in YT ads.

Chapter 14
Peculiarities of Mutual Influence of the Components of the Fiscal Space of Ukraine 221
Halyna Vasylevska, West Ukrainian National University, Ukraine

The chapter deals with the formation and functioning of the fiscal space of the state and peculiarities of the mutual influence of its main components—political, economic, social, and financial ones—in order to ensure their effective interaction in the projected development of the state. The author's interpretation of the definitions of "the fiscal space" and "the fiscal environment" has been presented, which made it possible to clarify their theoretical basis and outline prospects for practical research. The key factors of influence upon the formation and functioning of the fiscal environment as a basic element of building the eponymous state space within the legal field have been established. There have been reasoned the mechanisms of mutual influence of complementary components of the fiscal space on the basis of dynamics of investigated statistical indicators of revenues and expenditures of the State Budget of Ukraine and with the help of correlation coefficient which made it possible to draw certain conclusions about the efficiency of taxpayer fund use in Ukraine.

Chapter 15
Load Balancing Improvement Through Flexible Assignment of Jobs in the Grids 231
Jalay Saurin Maru, Gandhinagar Institute of Technology, India
Raxit Jani, Gandhinagar Institute of Technology, India
Nishith Parmar, Gandhinagar Institute of Technology, India

Grid computing has emerged as a striking computing concept due to the availability of high-speed wide area networks and low-cost computational capital. This represents a novel load balancing algorithm for grid systems by allowing for node allure. The set of partners and neighbours are created for each node using the prestige of the job. For each job, in the gird, the given algorithm uses the popularity of other nodes in the grid to form k number of partners and p number of neighbours. The methods for constructing neighbours and partners are existing. A new job arriving to a node is immediately dispersed to the originating node or to its partner nodes. The load adjustment is approved incessantly, and reciprocal information administration is used to minimize the communication overhead in the elaborated load balancing algorithm. The given algorithm is self-motivated, sender-initiated, and decentralized.

Chapter 16
Air Miner: An Air Pollution Detection and Alert System 254
Raxit Girishkumar Jani, Gandhinagar Institute of Technology, India
Ramesh T. Prajapati, Shree Swaminarayan Institute of Technology, Bhat, India
Anilkumar Suthar, L.J. Institute of Engineering and Technology, India

Air miner gathers live data about the carbon monoxide indoors. It significantly reduces the chances of residents contracting respiratory disorder owing to its proactive alert systems. It utilizes the NodeMCU (ESP-8266) for the smaller-scale micro-controller board to interface with the gas sensors, Django for the front end web interface, and Python in the backend for systematic AI. A comprehensive indoor air monitoring and analysis system shall serve like a fitness tracker for your house. This system will proactively alert users if it can predict a rise in the concentration of gas levels. The primary purpose of 'air miner' is to alert users proactively about a probable surge in the concentration of carbon monoxide. Along with this, it will give a complete analysis of the similar metrics. Air quality monitoring system for city uses multiple sensors with location co-ordinate. AQI LED indicator is actuated as per pollution level, and the real-time pollution level is visualized using the line graph.

Chapter 17
Beyond the Pandemic: Survival of the Human Race and Challenges 274
Manas Kumar Yogi, Pragati Engineering College, India
Jyotsna Garikipati, V.R. Siddhartha Engineering College, India

The COVID-19 pandemic is changing our lives in an unanticipated manner. Various sectors like healthcare, education, business, entertainment, tourism, etc. are affected. Many disruptive technologies like AI, blockchain, 3D printing, robotics, genomics, distributed power systems, etc. made a huge impact during the pandemic. Wearing masks, frequent handwashing, maintaining social distance, etc. are the new normal. The Sustainable Development Goals (SDG) that were targeted for 2030 are moving against the goals. Due to COVID, online shopping increased, reported crime rates reduced, cybercrimes increased, school dropouts increased, financial instability increased, etc. Many researchers are affirming that only after attaining herd immunity, the corona virus will vanish. But another question to be answered is whether it is possible to achieve herd immunity with so many variants of the virus spreading all over the world. This chapter discusses various disruptive technologies, how humans are struggling to live along with the virus, and a future look on how the world will be after the pandemic.

Chapter 18
Beyond the Pandemic: Recovery, Resilience, and Adaptation 294
Chabi Gupta, Christ University, India
S. Pramila, Christ University, India

Scientists predicted many years ago that a contemporary society would develop that would be more organised around and influenced by new characteristics of heinous danger. The global economy is recovering; multinational, big, and small companies are rebounding; workspaces are revitalising; and governments and society all over the globe are waking up. With reduced oil prices and low financing rates across the globe, India has a lot of possibilities to connect to global markets and achieve rising development. There are many opportunities to attain self-sufficiency via the careful application of a culture of make in India, as well as dependable innovation, continuous economic, infrastructural, and technological upgrades. A post-pandemic world offers a once-in-a-lifetime chance to review policies, refocus objectives, and reimagine institutions.

Chapter 19
Artificial Intelligence in Healthcare: Case Studies 305
Gayatri Doctor, CEPT University, India
Mayuri Varkey, CEPT University, India

Artificial intelligence simply means machine learning that can sense, reason, act, and adapt based on experience with the goal of contributing to the economic growth of the country and contributing to the betterment of people's standards of living. The main aim of artificial intelligence in healthcare is to make machines more useful in solving ambiguous healthcare challenges, and by using the latest technology, it is possible to interpret data accurately and rapidly. It helps in the early detection of many chronic diseases like Alzheimer's, diabetes, cardiovascular diseases, and several types of cancers like breast cancer, colon cancer, etc., which simultaneously reduces the financial burden and severity of the disease. The key areas where AI can be applied medically include disease detection and treatment, patient connection and engagement, and managerial and security activities. The research has been aimed at a study of AI systems in the healthcare sector in India. The methodology used here consisted of a systematic literature review followed by live, on field interviews.

Chapter 20
Case Study on State-of-the-Art Wellness and Health Tracker Devices 325
Sonali Vyas, University of Petroleum and Energy Studies, Dehradun, India
Shaurya Gupta, University of Petroleum and Energy Studies, Dehradun, India

In today's world, the concept of smart health is attaining acceptance in the field of medical sciences which is based completely on the concept of IoT. IoT devices are responsible for collecting and analyzing voluminous data, which involves monitoring the health status of various patients, which would enhance the clinical support system and provisions of monitoring and controlling patients with the help of sensors and medical devices equipped with IoT unit. With the aid of various architectural constituents, interactive communication between the medical spaces and remote users, health or wellness systems are being developed in such a manner that they collect data from varied monitoring devices. Then the data being collected is processed, and then a personalized scheme for an individual or patient is suggested for his wellness goal, like walking ten thousand steps would help him lower his blood pressure. This chapter provides an understanding and discusses various environmental considerations like humidity, air temperature, and the forecast provided by the organisation's system.

Chapter 21
AI Technology in Lifestyle Monitoring: Futuristic View – AI Technology and IoT.......................... 338
S. S. Aravinth, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
Gopi Arepalli, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
Sakthivel P., Knowledge Institute of Technology, India
Viknesh D. Kumar, SNS College of Technology, India
Senthil J. Kumar, Sona College of Technology, India

Artificial intelligence-assisted technologies are playing a crucial role in the lifestyle monitoring cycle. AI-enabled advancements, devices, products, and clothes are giving a clear picture of the enormous usage of smart applications. These predominantly used solicitations are classifying emails, monitoring health-related issues with smart wearable devices, self-driving cars and unmanned vehicles, faster communications, and web searches. These AI-enabled services are being rendered into industries and home automation initiatives. Also, AI-powered healthcare services and devices are getting few attractions in recent days. In this chapter, a few of the usages of AI technologies in healthcare are discussed, and some proposed ideas are presented. In this chapter, the detailed study and implementation are discussed. This chapter also focuses on revealing some useful information about applying AI-enabled services in the home automation category.

Compilation of References 352

About the Contributors 402

Index 409

Foreword

In the past few decades, there has been a drastic change in lifestyle, leading to many lifestyle-related diseases manifesting themselves irrespective of age or income bracket. Lack of physical activity and addiction to gadgets has increased obesity, emotional insecurity, and many other personality-related disorders in the younger generation. COVID-19 Pandemic has exposed the various lifestyle-related issues and diverted the attention for lifestyle sustainability and management Solutions. A balanced lifestyle with emphasis on automation in wellness and healthcare solutions is the need of the future.

The book *Handbook of Research on Lifestyle Sustainability and Management Solutions Using AI, Big Data Analytics, and Visualization* gives a comprehensive use of technology like artificial intelligence, analytics, and visualization in the field of healthcare. This Handbook is an organized collection of 21 chapters with contributions from reputed authors around the globe, providing exhaustive and crisp coverage of lifestyle sustainability solutions using cutting edge technological advancements with emphasis on wellness solutions.

Chapters delve into the use of technology like wearable devices in the healthcare sector and the progressive research conducted in this area. The authors of the chapters have focussed on an important component of health called emotional intelligence. It highlights computational biology and machine learning, and innovative therapeutic approaches. Handbook adequately explores the research avenues in healthcare robotics, cardiac fitness status in crop cultivators, and the role of chatbots, augmented reality and virtual reality in the domain of healthcare. The wellness of students in the covid-19 scenario and how technology can be used for student wellness have been aptly deliberated both in terms of the current mechanism and research prospects.

This Handbook provides theoretical, practical, emotional, and societal approaches towards life sustainability solutions using advanced technologies like artificial intelligence, IoT, big data analytics, and visualization. It can be effectively used to enhance the research and technological perspective in the area of healthcare in particular and wellness solutions in general.

The editors have done a commendable job at all stages and ensured that the chapters are reviewed through reputed reviewers, as I am aware of it. There is no book currently available probably that addresses this set of crucial public health and health care issues.

The Handbook can be used as a reference book by researchers, academics, practitioners, policy makers, and postgraduate students in the areas of IT, health care, technology management and public policies.

Sardar M. N. Islam
Victoria University, Australia

Preface

The sudden outbreak of the COVID-19 pandemic has curbed human lifestyle by imposing restrictions on regular daily movements that had been taken for granted. Due to the pandemic, the welfare segment has received more attention, and every possible effort is being made to prioritize the services at the top. This can be made possible while using the latest tools, technologies, and resources that impact the human culture and welfare of well-being. Novel methods and devices that make the welfare services more efficient, adaptive, transparent, and cost-effective need to be explored.

The *Handbook of Research on Lifestyle Sustainability and Management Solutions Using AI, Big Data Analytics, and Visualization* offers extensive research on lifestyle management and services that contribute towards indication, detection, conduction, protection, and technological enhancement including machine learning, deep learning, artificial intelligence, big data analytics, and visualization. It also provides mechanisms that can improve lifestyle monitoring and help in increasing the immunity of the human body. Covering topics such as big data, robot therapy, and wearable technology, it is ideal for students, researchers, technologists, IT specialists, computer engineers, systems engineers, data scientists, doctors, hospital administrators, engineers, academicians, and technology providers.

This Handbook is an organized collection of 21 chapters with contributions from reputed Authors around the globe providing an exhaustive and crisp coverage of Lifestyle Sustainability solutions using cutting edge technological advancements with emphasis on wellness solutions.

Chapter 1 provides an insight into how artificial intelligence can be used in the health care sector, as we know nowadays monitoring of various parameters related to health is tremendously needed i.e. early signs of any disease. Monitoring of these parameters can prove an important step avert the development of ailment or illness in the human body as late diagnosis may lead to various grave effects on a patient's health. AI has reduced the burden on overworked medical and paramedical staff. AI based devices are easy to use, mostly related to the gadgets we are using in daily life and most importantly they are another pair of eyes that never sleeps. The chapter describes various gadgets devices and the apps which are used for the purpose stated above and how they actually work. It describes the principle of working, sensors and technology used by them, and parameters measured by them.

Chapter 2 present a detailed survey of wearable technology applications regarding healthcare. We focus on existing studies that use various AI technologies for formulating models which, upon being applied with structured or unstructured data, can predict the various aspects that help the health firms to identify future risk. We also detail important use cases of wearable device usage in healthcare, such as health data acquisition, incentivization, health monitoring, health predictions, improved competitive position, etc. Lastly, we expect that within the next two to three years, with drastic improvement in connectivity and miniaturization, the wearable devices will assume more seamlessness and integrate more readily with the consumers' lives, thereby realizing the health-related values.

Chapter 3 discusses Machine Learning as a game-changing technology in every domain since the late 20th century. There have been many advancements in healthcare not only for the diagnosis of disease but advanced in the prognosis of the diseases. Artificial Intelligence/Machine Learning (AI/ML) has progressed a lot in the medical domain in just a couple of decades also played a very important role in exploring human data to understand human body behavior better than ever before, for predicting and classifying all kinds of medical images or videos. A recent and best-used application is detecting COVID-19 by just checking the Chest x-ray in a very accurate manner that can be used without human presence and stop the spread of the virus resulting in fewer doctors getting affected. It is known as Generative Adversarial Networks used nowadays, some of the types of GANs used for differentiate domains without human supervision and many such mutations of GANs are useful in the health sector.

Chapter 4 emphasizes on Wearable Technology. Health-related parameters and issues are extremely important to man's existence and influence. Diabetes mellitus, high cholesterol, and high blood pressure can all cause a blockage of the coronary arteries, resulting in heart palpitation. Various systems use an alarm to display the current state of a patient and is capable of tracking the human body's medical parameters. A defibrillator device with an alert system has been implemented for low-cost, efficient, and flexible heart rate detection and control. The sensors monitor and calculate heart rate, body temperature, and sweat, and send the signals to the control device for processing. The local system will issue an alert if there is a significant difference between the normal and measured heart rates, body temperature, or sweat rate. This system monitors heart rate in a constant, real-time, stable, and precise manner. If an abnormality in the patient's heartbeat is observed, the defibrillator can deliver a shock to the patient's external body as a buzzer emits a beep sound to warn nearby people.

Chapter 5 highlights artificial intelligence and machine learning algorithms for detecting a person's mental health by utilizing patient health records. In addition, the chapter explains the use of artificial intelligence in curing and monitoring a patient with mental illness through telemedicine. The artificial intelligence and machine learning methods utilize electronic health records, mood rating scales, brain images, mobile devices monitoring data in prediction, classification, and grouping of mental health issues mainly psychiatric illness, suicide attempts, schizophrenia, and depression.

Chapter 6 deals with Emotion Detection especially for Mental Health. It is one of the most important fields of research in Emotional Intelligence. This Chapter targets people from social media, especially from twitter and studies the emotional state of people which is affected by COVID-19, the emotional states is collected in the form of stress and boredom data categories. From this data, text classification performed using transformer BERT, the results obtained were promising to classify emotional states of people.

Chapter 7 aims to use current computational biology and machine learning systems to predict molecular behaviour and the probability of receiving a helpful medication, thus saving time and money on unnecessary tests. Clinical trials, electronic medical records, high-resolution medical images, and genomic profiles can all be used to help with drug growth. The discoveries made with these emerging technologies have the potential to lead to innovative therapeutic approaches.

Chapter 8 discusses the current and potential use of robot technology in mental health care. Robots use the transition using effectors, which may shift the robot itself (locomotion) or move objects in the background (manipulation), making judgments based on sensor input. Robotics has long been defined as "the science that examines the intelligent links between perception and action," but in recent years, this definition has shifted outward, with a greater emphasis on challenges connected to connecting with real people in the virtual environment. This transformation has been referred to in the literature as human-centered robotics, and a developing area in the last decade focusing on problems in this arena is known as human-robot interaction (HRI). Robotics technology is still in its early phases in mental health care, but it represents a potentially powerful tool in the professional's toolkit. Socially assistive robotics (SAR) is an up-and-coming field that has spawned a slew of fascinating mental health applications.

Chapter 9 assesses cardiac fitness status in terms of indices of physiological strain among male food crop cultivators. Physical and physiological parameter of the study participants was measured. Indices of thermal working environmental condition were calculated. Indices of physiological strain of the study participants also calculated. Result of the present study indicated that environmental condition adjudged by select popular heat indices is above the suggested threshold value making the task strenuous. Additionally, human resources suffering from varying degree of physiological strain.

Chapter 10 explores the Artificial Intelligent Assistant as a program and software that can interact with the user in natural language or with voice or in picture format. Chatbots may be used to calorie count, check the quantity of water a person has taken, monitor the schedule of sleep, and maintain training records. They might offer various healthy meal recipes, remind individuals of taking medication, or advise a doctor. Finally, chatbots are able to provide inspiring and motivating phrases to increase your self-esteem and attitude.

Chapter 11 studies the growth and demand of knowledge Management in Education sector. In this chapter, the impact of each steps involved in knowledge management on the performance of student. Knowledge Management and its impact on the Student performance in particularly the COVID situation is analyzed.

Chapter 12 confirms the view that use of flipped classroom strategy could potentially enhance technology application and learning outcomes in Computer Science instruction. This study examines the prospects and challenges of using flipped classroom in Computer Science instruction during the Coronavirus lockdown. The conclusions here were based on available literatures and practical experiences of the researchers.

Chapter 13 highlights the cognitive manipulation done by YouTube advertisements with the presence of Artificial Intelligence. This study reveals that attention towards advertisement and the resulting desire to purchase the product leads to conversion of viewer into consumer. The study has lead to the development of a model which highlights that the presence of AI in You Tube Advertisements.

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Chapter 15 represents a novel load balancing algorithm for grid systems by allowing for node allure. The set of partners and neighbours are created for each node using the prestige of the job. For each job, in the gird, the given algorithm uses the popularity of other nodes in the grid to form k number of partners and p number of neighbours. The methods for constructing neighbours and partners are existing. A new job arriving to a node is immediately dispersed to the originating node or to its partner nodes. The load adjustment is approved incessantly and reciprocal information administration is used to minimize the communication overhead in the elaborated load balancing algorithm. The given algorithm is self-motivated, sender-initiated and decentralized.

Chapter 16 'Air Miner' is to alert users proactively about a probable surge in the concentration of Carbon Monoxide, along with this it will also give a complete analysis of the and similar metrics for the indoors. Air Quality Monitoring System for City: In plug and sense device method, it Uses multiple sensors with location co-ordinate, AQI LED indicator is actuated as per pollution level and the Real time pollution level visualized using the line graph. Air Miner gathers live data about the indoor focus dimensions of Carbon Monoxide indoor. It significantly reduces the chances of residents contracting respiratory disorder owing to its proactive alert systems. It utilizes the NodeMCU (ESP-8266) for as the smaller scale micro controller board to interface with the gas sensors, Django for the front end web interface and Python in the backend for systematic AI. A comprehensive Indoor Air Monitoring and Analysis system that shall serve like a fitness tracker for your house.

Chapter 17 discusses various disruptive technologies, how humans are struggling to live along with the virus and future look on how the world will be after the pandemic. Many disruptive technologies like AI, Blockchain, 3D printing, Robotics, Genomics, Distributed Power Systems, etc made a huge impact during the pandemic. Wearing masks, frequent handwashing, maintaining social distance etc are the new normal The Sustainable Development Goals (SDG) that were targeted for 2030 are moving against the goals.

Chapter 18 explores the post-pandemic world that offers us a once-in-a-lifetime chance to review our policies, refocus our objectives, and reimaging our institutions. The global economy is recovering, multinational, big and small companies are rebounding, workspaces are revitalizing, and governments and society all over the globe are waking up. With reduced oil prices and low financing rates across the globe, India has a lot of possibilities to connect into global markets and achieve rising development. There are many opportunities to attain self-sufficiency via the careful application of a culture of make in India, as well as dependable innovation, continuous economic, infrastructural, and technological upgrades

Chapter 19 provides a study of AI systems in the healthcare sector in India. The methodology used here consisted of a systematic literature review followed by live, on field interviews. Artificial Intelligence simply means machine learning which can sense, reason, act and adapt based on experience with the goal of contributing to the economic growth of the country and contributing to the betterment of people's standards of living. The main aim of Artificial Intelligence in healthcare is to make machines more useful in solving ambiguous healthcare challenges and by using the latest technology it is possible to interpret data accurately and rapidly. It helps in the early detection of many chronic diseases like Alzheimer, Diabetes, Cardiovascular diseases and several types of cancers like breast cancer, colon cancer etc. which simultaneously reduces the financial burden and severity of the disease. The key areas where AI can be applied medically include disease detection and treatment, patient connection and engagement, and managerial and security activities.

Chapter 20 provides an understanding and discusses various environmental considerations like humidity, air temperature, the forecast is provided by the organisation's system. Smart Health is attaining acceptance in the field of medical sciences which is based completely on the concept of IoT. IoT devices are responsible for collecting and analyzing voluminous data, which involves monitoring the health status of various patients, which would enhance the clinical support system and provisions of monitoring and controlling patients with the help of sensors and medical devices equipped with IoT unit. With the aid of various architectural constituents, interactive communication between the medical spaces and remote users. Health or wellness systems are being developed in such a manner that they collect data from varied monitoring devices then the data being collected is processed and then a personalized scheme for an individual or patient is suggested for wellness goal, like walking ten thousand steps would help him lower his blood pressure.

Chapter 21 explores the basic idea of Artificial intelligence and IoT based technologies in digital world. These technologies are being incorporated in various industries and domains to provide the better experience with digitally assisted devices. Future scope of AI and IoT is also explored which can provide sustainable solutions for Lifestyle related problems.

This Handbook provides a theoretical, practical, emotional, and societal approach towards Life sustainability solutions using advanced technologies like Artificial Intelligence, IoT, Big Data Analytics and Visualization. This book can be effectively used to enhance the Research and Technological perspective in the area of healthcare in particular and wellness solutions in general. The contributing authors for this Handbook are from across the globe with suitable experience in the healthcare, technology and psychological domain which makes this a quality-oriented effort to build healthy and sustainable solutions for a more productive and satisfying lifestyle.

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Dr. Sailesh Iyer would dedicate this book to his late parents Shri K.S. Suryanarayan and Smt. K R Ananthalakshmy and really miss them during this proud moment. A special thanks to the backbone of his family especially his daughter Miss. Nethra and wife Mrs. Rohini, father-in-law Shri Krishnamoorthy for allowing and foregoing quality time to be dedicated to this book. A special acknowledgement of all the near and dear ones with a special mention of my Uncle Shri Ramakrishnan, my elder brother Mr. Mohan Iyer and my sister Ms. Radhika Iyer for nurturing and motivating dream of holding and reading his Book in their hands. Last but not the least a Special thanks to Co-Editors Dr. Arti Jain and Dr. John Wang who have been constantly the driving force behind this project.

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Chapter 1
AI in Health and Diagnostics

Nidhi Ashokbhai Jodhwani
https://orcid.org/0000-0001-8496-1703
Rai University, India

Sanketkumar Jagdishbhai Ahir
Rai University, India

ABSTRACT

The chapter explores how artificial intelligence can be used in the healthcare sector, as monitoring of various parameters related to health is tremendously needed (i.e., early signs of any disease). Monitoring of these parameters can prove an important step to avert the development of ailment or illness in the human body as late diagnosis may lead to various grave effects on a patient's health. AI has reduced the burden on overworked medical and paramedical staff. AI-based devices are easy to use, mostly related to the gadgets we are using in daily life, and most importantly, they are another pair of eyes that never sleeps. The chapter describes various devices and the apps that are used for the purpose stated above and how they actually work. It describes the principle of working, sensors and technology used by them, and parameters measured by them.

INTRODUCTION

According to WHO the leading cause for death are non-communicable diseases which accounts for 44% of total deaths in 2019 globally. These leading causes include ischemic heart diseases, stroke, chronic pulmonary diseases, diabetes etc. (The Top 10 Causes of Death, n.d.).

Nowadays it is very important to monitor various vital health parameters to diagnose the diseases at early stage. Early diagnosis can help to plan the patient's treatment and medicines accordingly to increase the prognosis of the disease. Vital health checks may also help the patients who are at risk of developing familial diseases like heart diseases or diabetes in prevention of the diseases or the timely treatment (Why Is Health Screening Important?, n.d.). Wearables play important role in this early detection. E.g., According to the preliminary study submitted to US FDA shows that apple watches showed 99 percent correct identification for atrial fibrillation. (Smartwatches Will Lower Healthcare Costs. One Might

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Have Saved My Father's Life - MedTech Boston | MedTech Boston, n.d.). Use of artificial intelligence has greatly helped in reducing the burden of overworked medical and paramedical staff. Conventional methods has some limitations of monitoring in the clinical observation area and for specific time only, whereas AI based devices are easy to use and can be used daily. Most importantly they are another pair of eyes which never sleeps. This also improves the efficiency of medical practitioners. There are many vital parameters which need to be monitored everyday over a period of time and can help in diagnosis of certain medical conditions. There are too many advanced apps available to use on mobile phones as well as on PC and laptops in which you have to enter the data every day or at a specified time. These will record the data as well as analyze it and give the useful information accordingly .Nowadays there are various wearable devices and sensors available which will record the data and transmit it to various e-health tools and services, such as tele-monitoring platforms and mobile health applications. This helps in monitoring activity changes and signs outside the clinical observation period. Importantly they are made as comfortable as possible so as with regular use person can set their health baseline and alert the user in case of any deviation (Khan et al., 2016). This chapter mainly focuses on principle of various gadgets, wearables and apps to monitor various vital health parameters.

BACKGROUND

Below mentioned parameters play a very important role in disease diagnosis. An early diagnosis can help the patient to escape from graving effects of disease as well as it will help to plan the treatment in a better way.

Vital signs which needs to be monitored continuously are:

ECG
Blood glucose
Blood pressure
BMI
Body fat
Cardiovascular parameters
Activity parameters
SpO2
Body temperature
Respiration rate
Mobility measurements
Sleep pattern tracking
Hearing
Nutrition
Mental health parameters
Menstrual cycle tracking
Atrial fibrillation
Skin perspiration etc.

Since the 1970s AI has been used for diagnosis and treatment of disease, MYCIN is an early backward chaining system which utilize AI for identification of bacteria in infection. Also it is recommends treatment drugs along with the dosage (Davenport & Kalakota, 2019). CASNET and Internist -1 are also examples of Artificial Intelligence Medicine (AIM) systems. .Fuzzy experts systems, Bayesian networks, artificial neural networks, hybrid intelligent systems etc are the different AI based healthcare systems introduced during late 90s (Amisha et al., 2019). Since then many inventions have occurred. Today AI has much more role in healthcare services.

The human physician cannot be replaced by AI based machines and devices but at least AI can assist physicians in making better decisions (Jiang et al., 2017). AI based software, systems, wearables and devices are trending from the 1980s. Invention of digital hearing aid can be marked as the beginning of wearable technology. Heart guide can be considered as the first wearable technology for health care which was made by Omron healthcare. During last few years wearable technology has been connected to mobile health technology e.g. ExMedicus launched world's first health smart watch in 2018 which comes with inbuilt PPG , ECG and other sensor to detect heart related diseases. Nowadays most of mobile phones come with inbuilt health related application which records and keeps the data which helps to track parameters and also predicts risk factors.

HOW ARTIFICIAL INTELLIGENCE PLAYS IMPORTANT ROLE IN DIAGNOSIS?

Details of Parameters to be Monitored

ECG: It is the waveform of cardiac rhythm, analysis of which plays important role in various cardiovascular diseases like angina, atherosclerosis, CHF, CAD, cardiac dysrhythmia, atrial fibrillation etc.

Blood Glucose: Glucose monitoring is now emerging as a vital parameter to be monitored because diabetes has been a global problem now and also the root cause of many pathological conditions like cerebral vascular disturbance, retinopathy and nephropathy. So prevent all the damaging effects one must have to measure glucose level, inject insulin shots accordingly and keep record of that. By doing this one can manage their blood glucose level within prescribed range.

Blood Pressure: Gives the idea regarding cardiac output, blood volume and vessel elasticity thus helps in better prediction of cardiovascular disease and hypertension.

Body Mass Index: BMI is the measurement of obesity and overweight. It can be measured by your height and weight taking age into consideration. Higher the BMI, Higher the risk for obesity associated diseases e.g. hypertension, gallstones, type 2 diabetes, respiratory disorders, cardiovascular diseases etc.

Body Fat: Gives ideas regarding how much fat you are carrying with you in comparison to muscles, bones, organs and others. No matter how you weigh, if you carry more percentage of fat you are more prone to have obesity associated disease as mentioned above.

Cardiovascular Parameters: It gives ideas regarding the physiological state of the person. It includes the measurement of heart rate during resting phase, sports activity, and exercise. Simply the heart rate variability provides idea regarding the status of the cardiovascular system.

Activity Parameters: there are so many different activity parameters recorded using wearable health devices like walking, cycling, running, swimming, exercise, workout, stand time, sports etc.. This tracking helps to achieve daily workout targets and gives insight into the daily activity routine of a person.

Activity and motion tracking in sports will help to assess physiological signs, body kinetics and fatigue during exercise.

SpO2: Measured by PPG (photoplethysmography) or pulse oximetry principles. Decrease in oxygen saturation below 95% indicates decreased oxygenation (hypoxia) because of any pathologic condition or infection in which a person's ventilation capacity is lowered or in most cases it is because of anemia.

Body Temperature: Body temperature varies throughout the day and is affected by many parameters such as exercise, external temperature and eat, humidity, menstrual cycle and ovulation but it may be because of some underlying illness to which we call fever.

Respiratory Rate: Indicator of distress, potential hypoxia, asthma, sleep apnea and other pulmonary diseases.

Mobility Parameters: These include walking speed, walking symmetry, step length, double support time. All these parameters indicate walking patterns and certain pathological conditions like lamping, lack of coordination, age or any other underlying issue.

Sleep Pattern Tracking: Keeping track of sleep is important because if you don't rest properly it will directly affect mood, weight loss, recovery, energy, exercise performance, productivity, immune system strength, cardiovascular function and brain health.

Hearing: Hearing is the result of signals produced by ears which are processed by the brain. Intensity of sound waves is measured in Decibels. Hearing can be affected by loudness (decibels) and span of exposure. Long term, repeated exposure to loud sound causes damage to the inner ear and leads to permanent hearing loss.

Nutrition: Plays an important role in metabolism, and maintenance of the body. There are many nutritional factors which need to be taken in proper amounts otherwise their deficiency can lead to various diseases as well as aggravating health conditions.

Mental Health Parameters: Mental health parameters are measured passively from sleep time, activity log, GPS, communication logs etc. Different apps may access data from the sensors and may assess different behavioral indicators. These indicators are then subjected to statistical analysis and related to mental health.

Menstrual Cycle Tracking: It is a very important vital sign because the menstrual cycle involves many parts of the female body. Cycle varies from person to person and month to month. But if it is going normal for your body that can be only known by the tracking. With the help of tracking you can get to know what is your cycle length, period length, ovulation, fertile window and also about changes worth bringing up with your doctor.

Atrial Fibrillation: Atrium is the upper chamber of the heart which beat in sync with the lower ventricle. When they sync out the condition is known as atrial fibrillation which results in abnormal heart rhythm. If it is left untreated it can cause blood clots in the heart leading to heart strokes, failure and other related complications.

Skin Perspiration: It is not a clinical parameter but amount and composition of sweat can give idea regarding mental and physiological state of person as it is under control of ANS.

All these parameters can be monitored using wearable devices, wearable sensors, different gadgets, health applications (inbuilt and third party), smart phones and smart watches etc.

Table 1. List of Gadgets, Wearable Devices and Sensors

Gadgets:	Wearable devices and sensors:	Apps:
Blood glucose monitors/ Glucometer Pulse oximeters Blood pressure monitors Pedometers Smart Weighing scales Digital thermometers Accelerometer Katabi's device E-nose devices Suzuken Lifecorder EX Tanita AM-160 Omron Active Style Pro Omron CaloriScan PIP stress management device Alivecor heart monitor Scanadu scout tricorder	Smartphones with many inbuilt sensors Smart watch and fitness bands (Apple watch series 6, Garmin vivosmart 4, Samsung galaxy watch active 2, Fitbit versa 3, Withings Pulse Hr fitness tracker, Jawbone fitness bands, Epson Pulsense , Fitbit Flex, Misfit Shine, Fitbit Change 2, Oppo bands, pebble time etc..) Skin to skin wearable devices and smart patches Google smart contact lenses Vital jackets / t-shirt Smart shoes Khushi baby necklace Current health's AI powered all in one wireless wearable NeuroOn smart sleep mask	Apple health Samsung health monitor Mi health Google fit Companian MX Face2Gene

1. GADGETS USED IN DIAGNOSTICS

a. Glucometer

Used for blood glucose measurement by electrochemical principle. First generation glucometers rely on colorimetric measurement which is still being used for glucose measurement in urine. But the latest glucometer relies upon amperometric principle. A small amount of blood is placed on the test strip which is coated with the enzyme glucose oxidase. This enzyme when comes in contact with blood it reacts with glucose and converts it into gluconic acid. It interacts with another chemical present within the strip ferricyanide and converts it into ferrocyanide. When this reaction occurs, an electric current is generated and measured.

In the colorimetric method, the color intensity is measured in the reaction layer of the strip with the help of LED or photosensors which is followed by a Transimpedance Amplifier (TIA). The numerical value is displayed on the glucometer attached.

In an amperometric method, electrodes are attached to a test strip coated with enzymes which are used to measure the current (electrons) by the reaction. This current will change according to the concentration of glucose present in the sample. The current is measured using the current to voltage converter such as transimpedance amplifier and analogue to digital converter (*Working Principle of Glucometer (or Glucose Meter) to Measure Blood Sugar Level - Biolearners*, n.d.).

Most glucometers now come with clock and memory which allow patients to keep the record of past readings of a few days or week. Latest glucometers are enabled with data transfer capacity. The data can be transferred to computers with diabetes management software or to smartphones using Bluetooth technology where third party apps can be used to monitor the glucose level over period of time and data along with some additional information such as exercise and calorie intake can be used to decide the dose of insulin to be taken (*Glucose Meter - Wikipedia*, n.d.).

b. Pulse Oximeter

Pulse oximetry is rapid noninvasive method for measuring one of the important vital sign i.e. oxygen saturation in arterial blood. Pulse oximetry works on the principle of spectrophotometry and the fact that oxygenated and deoxygenated hemoglobin have difference in absorption at red and far red light. Oxyhemoglobin absorbs a higher amount of IR light whereas deoxygenated hemoglobin absorbs a higher amount of red light (Chan et al., 2013; Jubran, 2015) .

Pulse oximeter consist of SpO2 sensors, MPM (multi parameter monitoring) module, ADC (analogue to digital converter), MATLAB processing.

c. SpO2 Sensors

It consists of red and infrared LEDs and photo detectors.Two wavelengths of red at 660 nm and IR at 940 nm are emitted by a small LED located in one arm of the finger probe. Light is then transmitted through the finger and absorbance is measured by a photo sensor located in another arm of the finger probe (Chan et al., 2013).

MPM module: MPM receives the SpO2 signals and filters it for noise and amplifies it.

ADC: Converts the signals from MPM module to digital value and plots the Photoplethysmography waveform graph which shows the change in light absorbance of both lights which changes with each cardiac cycle / pulse.

MALAB: Matrix laboratory is the multiparadigm programming language. It acquires the data from ADC and processes it to measure SpO2. To calculate SpO2, red: infrared modulation ratio (R) is calculated. From this ratio, SpO2 is calculated. At higher oxygen saturation IR light is absorbed more than red light resulting in lower R, conversely at lower oxygen saturation Red light is absorbed more than IR light resulting in higher R.

Generally oximeters are SpO2 is calculated from the calibration curve which was generated by calculating R value from the healthy volunteers whose saturation varied from 100% to 70% so the readings below 70% are not that much reliable (Chan et al., 2013).

d. Blood Pressure Monitors

It is used to monitor blood pressure at home and comes in two variants: upper arm and wrist model. Traditionally used manual device for measuring blood pressure is known as a sphygmomanometer.

The basic principle for both electric and manual pressure monitors are the same. It starts with an inflation of the pressure cuff on the arm until it blocks the flow of blood in the local artery. This inflation is personalized for every person by intellisense technology. After that pressure is gradually released, when the pressure reaches systolic pressure, vibration starts which is measured by the sensor present in the cuff and is noted, still the pressure is released and when vibration stops, it is noted as diastolic blood pressure. At the same time pulse is also measured (*How Do Blood Pressure Monitors Work? – Livongo Tech Blog*, n.d.).This is also known as the oscillometric method of detection.

The signals obtained by pressure sensors are amplified and then sent to ADC which makes calculations for pulse, systolic and diastolic pressure with the help of different algorithms depending upon the type of sensor utilized and monitor on which results are going to be displayed. These data can be stored depending on the model.

e. Pedometers

Pedometers actually count how many steps you have taken. Mechanical pedometers have a pendulum-like arrangement. When you move it moves back and forth it counts as one step.

In electronic type pedometers, metal pendulum (hammer with weight on one side) is present, every time you take a step it swings and completes the circuit which allows current to flow and is counted as step. When you complete the step hammer again comes in the original position and opens the circuit. The count is recorded and displayed on the monitor. Pedometers have inbuilt GPS which measures the total distance travelled by the person.

Latest pedometers are completely electronic, they have no moving parts, so they are more durable. They are having accelerometer which detects the minor change in the force as you move the legs and counts the steps. It also comes with calorie counting and memory function for past records up to 7 days (*How Do Pedometers Work? - Explain That Stuff*, n.d.).

f. Smart Weighing Scales

Smart weighing scales not only measures the body weight but also provides the data about a number of other parameters such as BMI, body fat, body water, muscle mass, bone mass, basal metabolic rate, body fat ratio etc. that's why it is also known as body composition scales.

The basic principle is BIA (Bio impedance analysis).when you step on the weighting scale a small electric current is passed through one leg and passed through body and sensed from another leg. From the speed of current, amount/ percentage of fat bone water and muscle is calculated as fat and bone are poor conductors of electricity. The data is sent to mobile applications or software for calculation of different parameters. Information like age, gender, height and different parameters will be calculated and synchronized accordingly. There is facility for tracking and monitoring one's progress as all previous records are saved (*Body Fat, Water Balance: How Smart Scales Work - QATestLab Blog*, n.d.).

g. Digital Thermometer

Body temperature is one of the most important vital signs. It consists basically of a sensor, amplifier, ADC, linearizer and display.

Sensor: There are 4 different sensors used today. Thermocouple, RTD , thermistors, solid state sensor.

1. Thermocouple generates voltage depending upon difference of temperature on both ends.
2. Resistance temperature detectors(RTD) measures change in resistance linearly with temperature change
3. Thermistor measures change in resistance non-linearly with temperature.
4. Solid state sensor emits a small amount of linear voltage directly proportional to temperature.

Amplifier and ADC: Converts electrical analogue signals to digital signals.

Linearization and display: Thermocouple uses thermocouple tables or polynomials states by ASTM RTD uses callendar-van dusen equation.

Thermistor uses tables or polynomials provided by sensor supplier (*Digital Thermometers, How Does A Digital Thermometer Work - TEGAM*, n.d.).

h. Accelerometer

Generally used to measure steps by measuring the force generated during walking movement. There are different types of accelerometers working on different principles but MEMS -micro electro mechanical systems - are widely used on mobiles and wearable devices.

They work on the principle of change in the capacitance when the space between two charged plates is changed due to force. The construction includes two sets of charged plates. One is movable which is placed between fixed plates. When the device moves, force will allow the movable plates to move nearer to fixed ones thus changing the distance and capacitance between two plates. This change will be measured and converted to electrical signals& then to digital (*MEMS Accelerometers | Silicon Sensing*, n.d.) .

i. Katabi's Device

This device uses low power Wi-Fi signals to monitor the heart rate, respiration rate and movement of a person from a distance of approximately 8m without even touching the person. The device has two transmitter antennas and one receiver antenna.

These two antennas send identical but inverse waves so that they cancel out each other. Receiver only detects the signal when waves are reflected by moving objects. Static objects reflect waves in a similar manner as it is imparted so no net signals (*New System Uses Low-Power Wi-Fi Signal to Track Moving Humans — Even behind Walls | MIT News | Massachusetts Institute of Technology*, n.d.).These signals are then processed by using Fourier transformations. Various parameters can be calculated and displayed. These has wide application in this current pandemic as it allows doctors to monitor the patient from outside thus preventing unnecessary contact with covid patient.

j. E-Nose Device

E nose devices nowadays hold an important place in diagnosis as it is a cheap and easy way to determine volatile organic compounds. The instrument is made up of electronic chemical sensors which converts the physical change of concentration into electrical signal which is analyzed and compared with existing disease specific library (Farraia et al., 2019). These uses artificial neural networks for analyzing the signals and concludes within minutes after introducing the sample (Wilson, 2018).

k. Lifecorder EX

This is a pedometer sensor based device used to monitor various parameters like step counts and activity calories.(*SUZUKEN KENZ*, n.d.)

l. TanitaAM-160

It is a Bluetooth activity monitor that can pair with an iPhone. It tracks running, walking and daily life activities using 3 –axis accelerometer technology. It also monitors calories expanded and fat burned (*AM-160 Tanita Handheld Bluetooth Activity Monitor*, n.d.).

m. Omron Active Style Pro

It is one kind of pedometer, consisting of a highly accurate 3D sensor i.e. triaxial accelerometer and can track particular activity or time separately (Yano et al., 2019).

n. Omron Calorie Scan

It accurately measures calories burn and helps in weight management. It also uses 3-axis accelerometer (*Rating of the Best Pedometers of 2018-2019 with a Heart Rate Monitor, Tonometer*, n.d.).

o. PIP Stress Management Device

A tiny device which measures your stress level by monitoring skin conductance for some time when you hold the device between your index finger and thumb. It sends feedback to the connected application and also helps in stress reduction (*The Pip Stress Management Biosensor - Review 2016 - PCMag India*, n.d.).

P. Alivecor Heart Monitor

It is a medical grade personal ECG device which lets you monitor your heart rate at home accurately. Its 6 lead ECG technology provides detailed heart information and lets you detect 3 most common arrhythmias: bradycardia, tachycardia, and atrial fibrillation. It also measures pulse (*AliveCor Kardia Mobile 6L | 6 Lead ECG Device in India*, n.d.).

q. Scanadu Scout Tricorder

It measures temperature, heart rate, SpO2, blood pressure and respiratory rate when placed against the forehead for 10 sec (*Scanadu Scout Wants to Be Your Personal Health Tricorder | WIRED*, n.d.).

2. WEARABLE DEVICES AND SENSORS

a. Smartphone

Nowadays the smartphone is has become essential, at least we can say that it can be found with most of the patients as well as the clinician (*How Smartphones and Apps May Change the Face of Healthcare | DAIC*, n.d.) .So connecting smartphones with healthcare or diagnostic AI based systems can be a very convenient way for records of healthcare data and diagnosis purposes. Nowadays pre-installed healthcare applications are provided by most of smartphone manufacturing company. These applications have most of the basic features like step count, calorie calculator, BMI calculator, sleep monitoring and menstrual cycle tracking. Various kinds of third party applications known as mobile health or mHealth apps are available and can be installed in smartphones. These applications can be divided in two types: I) Apps for health care providers - which can be used for patient monitoring, medical databases, clinical assistance, professional networking etc. II) Apps for patients or users which can be used for diagnosis, health monitoring, reminder, telemedicine, mental health, nutrition, women's health, healthy living etc.

(*Healthcare Application Development Guide: Types, Features, Challenges - Techexactly*, n.d.). Smartphone applications used for telemedicine are simple to use. Chatting options with consultants are also provided. Patients can talk with a medical person, can discuss their queries and prescriptions. Diagnostic apps can use entered data by the patient for the prediction of illness or disease. Several health monitoring applications work on Internet, Wi- fi, GPS, Bluetooth, and WAP which can sometime measures diabetes, cardiac problems, neurological disease and in some cases psychiatric conditions are possible to monitor. GPS based applications are proved helpful in diagnosis of mental illness and Alzheimer cases where patient's location could to be traced by application installed in their phone. These applications can collect information with the help of sensors available in the phone. Certain sensors that can detect even minor movements are used to collect data for study of sleep patterns in individuals. BMI and calories can monitored easily by various applications. For BMI calculation, person have to add different data values like body weight, height, age, sex etc. on that basis the app will count BMI. In the same way calorie calculators are also available and can easily be accessed in smartphones.

b. Smart Watches and Fitness Bands

Fitness bands are also known as fitness trackers. They can track steps, sleep and heart rate. Fitness trackers or bands measure motion, as most wearable devices contain a three axis accelerometer to track movement in every direction. Some also contain gyroscope for tracking rotation or twisting movements. The data collected are them converted into step count and then into estimated calories amount are displayed on the screen (*How It Works: We Explain How Your Fitness Tracker Measures Your Daily Steps*, n.d.). Sleep pattern is tracked by wrist actigraphy, in which wrist movement and motor activities are recorded using sensors. Specialized algorithms are used to determine sleep parameters. (Martin & Hakim, 2011). Optical sensors and green LEDs are fixed in smart watches and fitness trackers to measure pulse. This method is known as photoplethysmography (PPG)(*Optical Heart Rate Monitoring Technology: What You Need to Know*, n.d.). Digital signal processor (DSP) uses different algorithms to process digital data and calculates important heart related parameters. Latest smart watches and fitness trackers or bands pair with smartphones and transfer the data to phones where it can be stored and processed. Smart watches and fitness bands are designed in such a way that they are more comfortable for daily use and fashionable.

c. Skin to Skin Wearable Devices and Smart Patches

Skin to skin wearable devices and smart patches can be referred as wearable electronic devices, as they contain electronic components like sensors for detectors and processors for energy storage & communication(*Skin Patches: The Advantages of the Ultimate Wearable | IDTechEx Research Article*, n.d.) They are attached to the skin by using adhesives. Site of application depending upon the parameters to be monitored like cardiovascular monitors are attached to chest area, concussion monitors are placed around head. Patches are widely used in case of cardiovascular monitoring and diabetes, obesity and cancer where continuous monitoring of physiological changes are required. Some smart patches can be used to analyze sweat to measure sodium, glucose and proteins.

d. Smart Contact Lenses

Contact lenses having various sensors which can measure different parameters have wide range of application in diagnosis and therapeutics. These lenses are soft and made up of poly (2 hydroxyethyl methacrylate) (pHEMA), polyvinyl alcohol (PVA), polyacrylamide (PA), polyethylene terephthalate (PET) or polydimethylsiloxane (PDMS) .They are having good oxygen permeability hence provide user's comfort(Kim et al., 2017). These lenses are used for continuous real time monitoring like in case of diabetes and are also used for drug delivery (Therapeutic). They can measure various parameters in secretions like sodium, calcium, uric acid, lysozymes etc. Smart lenses glucose sensors, wireless power transfer circuits and LEDs. Sensors send electrical signals to LEDs. Wireless antenna embedded into the lenses transmit real time information from the lenses (*Smart Contact Lenses – Scitech Patent Art*, n.d.).

e. Vital Jackets/ T shirts

Vital jackets are blend of health technology and textile technology. Vital jacket has microelectronics interwoven in fabric which monitors the heart parameters of wearer like ECG and heart rate which is useful for physicians to diagnose possible heart problems (*VitalJacket Holter – Biodevices*, n.d.). Vital jacket is enabled with Bluetooth technology which is connected to the smartphone or computer systems in which data is stored. The real time data can also be transmitted to the clinical persons via internet.

f. Smart Shoes

Smart shoes comes with varieties of sensors like accelerometer, gyroscope, GPS, pressure sensors and environmental sensors. These measures various parameters like distance, steps, calories and posture to analyze health. These shoes can connect be to various health related mobile apps via Bluetooth to transfers data (*Smart Shoes: Innovations Revolutionizing the Future of Footwear - PreScouter - Custom Intelligence from a Global Network of Experts*, n.d.).

g. Khushi Baby Necklace

A mobile app and a wearable used for monitoring health care for mothers and infants in rural areas. All the data is stored in a NFC chip embedded in a pendant worn by the patient, and synced to cloud storage which can be accessed by healthcare workers (*Khushi Baby Necklace Helps Kids Get Vaccinated on Time*, n.d.). This provides a benefit over the traditional paper based records which could be lost and may be cumbersome (*Necklace Aids Child Vaccination - BBC News*, n.d.). This chip also stores mother's health records. The proper vaccination records help in proper immunization of the rural community children. The NFC chip can store 888 bytes of data. Chip can be scanned by NFC enabled mobiles owned by health workers and data can be updated or seen via anroid app(*Khushi Baby - Engaging the Community with Wearable Health - NFC Forum*, n.d.).

h. Current health's AI Powered all In One Wireless Wearable

It is the first FDA approved RPM (remote monitoring platform) based wearable. It is a wearable for upper arm which provides end to end monitoring of vital signs on real time basis (*FDA OKs Current*

Health's AI-Powered Remote Patient Monitoring For In-Home Care - Medical Product Outsourcing, n.d.). Manufactures claims that device gives ICU level accuracy and analytics which helps clinicians to monitor(*Current Health's AI Wearable for Keeping Chronically Ill Patients out of the Hospital Gets FDA Clearance | FierceHealthcare*, n.d.). This device helps physicians and nurses to monitor chronically ill patients. This reduces the burden from medical staff and because of continuous monitoring it also helps to avoid hospitalization. It continuously monitors patient's respiration, oxygen saturation, pulse, temperature and movement(*Current Health's AI Wearable for Keeping Chronically Ill Patients out of the Hospital Gets FDA Clearance | FierceHealthcare*, n.d.). This also provides telehealth platform for patients and doctors(*Current Health's AI Wearable for Keeping Chronically Ill Patients out of the Hospital Gets FDA Clearance | FierceHealthcare*, n.d.) .This uses combination of clinical indicators, vital sign monitoring , signs & symptoms and machine learning allowing patients at risk to manage the disease at early stage and thus improving the prognosis (*Current Health Raises $11.5 Million for AI-Powered Remote Health Monitoring*, n.d.).

i. NeuroOn Sleep Mask

This mask not only blocks light but can also measure brain waves, head movements, pulse, REM (Random Eye Movement). It helps in analysing your sleep patterns, induces lucid dreaming, and relaxes your brain by light therapy. It reduces sleep time from 6.5 hours to just 2 hour/day. It utilizes gold plated electrodes which measures ECG, EOG (electrooculography)-eye movement and EMG (electromyography) - muscle movement. Some versions also features 3- axis accelerometers which measures body movements during sleep. LED lights are also there for light therapy (*Review: Neuroon Intelligent Sleep Mask | Sleep Tech | Sleep Junkies*, n.d.).

3. APPS

a. Apple health

Apple health is an inbuilt application of iPhone and iPod which run on iOS 8 or higher where your health and fitness related data are stored. It measures various parameters like steps counts, running, heart rate, nutrition, sleep analysis, heart rates, weight etc. This application can collect data from apple iPhone and Apple watch. It can also collect data from other third party apps and compatible medical devices. It has some of interesting features like: Data is secured and encrypted, data sharing with trusted person, summary of parameters, trends of changes in parameters, access to health history (allergies and immunization), medical ID card setup (this card shows important medical information even when phone is locked)(*IOS - Health - Apple (IN)*, n.d.).

b. Samsung Health Monitor

Samsung Health Monitor application is generally a pre-installed application in smartphones running on Android 8 or higher version, which gathers data from one sensors and phone accessories which can be connected via bluetooth. Galaxy watches measure Blood pressure, sleep, steps and ECG and deliver data to smartphones. Samsung health application stores data for sleep tracking, heart rate, weight tracking, dietary monitoring, SpO2, water consumption monitoring, Blood sugar monitoring and many more (*Samsung Health | Apps & Services | Samsung India*, n.d.).

c. Mi Health

It is pre-installed application available in MIUI smartphones developed by Xiaomi. Its features include fitness tracking, sleep monitoring and menstrual cycle tracking. Newly updated version also includes heart rate monitoring feature.

d. Google Fit

Google fit was developed by Google for health tracking and suitable for android as well as iOS operating systems. It can collect data from different apps and devices and all data is tied to your Google account which can be accessed anywhere at any time. It stores data about nutrition and hydration, heart rate, sleep time and physical activities like step count, calories burned, and speed for activities like running, walking etc. Google fit has also collaboration with WHO for heart and activity related recommendations and goal setting (*Google Fit*, n.d.).

e. Companian MX

Companian MX is a mental health monitoring system which keeps track of symptoms, stores & analyses data and provides feedback (*CompanionMx Launches with Mobile Mental Health Solution | Business Wire*, n.d.). There are mainthree components of this system: Companian App(records biomarkers related with mental health) , Companian AI (converts data received from application into clinically relevant data), Companian dashboard (shows data and help clinician to take better decision)(*Product - CompanionMx*, n.d.).

f. Face 2 Gene App

Face2Gene app uses a deep learning algorithm which analyses the picture of a person's face and helps doctors and researchers to diagnose the wide range of genetic disorders. The patients face expression is compared to syndrome gestalts to quantify similarity (gestalt scores) resulting in a prioritized list of syndromes with similar morphology.(*Face2Gene Technology - How It Works*, n.d.)

CONCLUSION

AI based tools and devices has really made impact on person's overall health management and diagnosis. No doubt AI based technologies cannot replace physicians but at least it can help them with administrative work, image analysis for precise diagnosis, clinical decision support, robot assisted surgeries, automation of medical devices, patient monitoring, virtual assistance, clinical documentation etc. Looking on patient's side wearables have played important role in picking up early symptoms in case of chronic disease. By constant monitoring by wearables or manual entry in applications, patient can give proper case history which can be proven beneficial in diagnosis and planning treatment. Continuous monitoring by AI tools enables patients to track and commute to their health care professionals without disrupting the daily routine. AI based devices uses different algorithms to get most out of the data and help patient to achieve their target health goals (Bohr & Memarzadeh, 2020).

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Chapter 2
Survey on Applications of Wearable Technology for Healthcare

Sridhar Iyer
https://orcid.org/0000-0002-8466-3316
S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India

Sujay Gejji
S.G. Balekundri Institute of Technology, Visvesvaraya Technological University, India

Rahul J. Pandya
Indian Institute of Technology, Dharwad, India

ABSTRACT

In this chapter, the authors present a detailed survey of wearable technology applications regarding healthcare. They focus on existing studies that use various AI technologies for formulating models which, upon being applied with structured or unstructured data, can predict the various aspects that help the health firms to identify future risk. They also detail important use cases of wearable device usage in healthcare, such as health data acquisition, incentivization, health monitoring, health predictions, improved competitive position, etc. Lastly, they expect that within the next two to three years, with drastic improvement in connectivity and miniaturization, wearable devices will assume more seamlessness and integrate more readily with the consumers' lives, thereby realizing the health-related value.

INTRODUCTION

As a consequence of the increase in the stress levels due to various reasons, human beings have been severely affected by various health issues. As a response, research on the wearable technology has picked up pace within the research community since, the wearable devices aid in obtaining critical updates regarding the physical health behaviour, including heart rate, blood pressure, calories, etc. As

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per various existing sources, the wearable technology market has grown from approximately 22 billion dollars in 2018 to approximately 35 billion dollars in 2021. This trend is most likely to continue with a surge in the wearable technology market, reaching approximately 55 billion dollars in 2023. Thus, the global data forecast suggests a Compound Annual Growth Rate (CAGR) of approximately 20% by 2023. The aforementioned is possible since, the wearable devices are being adopted over a wide range of fields with a larger healthcare sector potential. The wearable devices also address changing costs of healthcare, varying populations, and the chronic diseases burden. Also, in the current scenario, the wearable technology is almost exclusively being used for fitness purposes. It is being steered by an increase in the consumers' demands to monitor the personal health. The applications of wearable technologies in healthcare, known to be non-invasive, use autonomous devices capable of capturing, analysing, and aggregating the physiological data to improve health. The research community has put forth that the various wearable technologies with advanced smart Artificial Intelligence (AI) methods could aid in the understanding of health updates and the related outcomes. Further, using AI and wearable technology may also aid in health insurance by covering various risks which are associated with multiple uncertainties related to health, enhanced span of life, and the treatments' high cost. The use of wearable technology with augmented reality (AR), Big Data, AI, cloud and edge computing methods, simultaneously with the constant lowering of the sensors' prices, open-source application programming interfaces (APIs), frameworks, and libraries, enables faster and cost-efficient solutions within the Internet of Things (IoT) and the Internet of Everything (IoE) ecosystem. However, advancements in the wearable device(s) technology is both, a challenge and an opportunity for researchers.

With recent advancements in the wearable technology, value addition is being provided in healthcare with a major focus on the diagnosis, treatment, monitoring, and prevention while providing the entire healthcare value chain with benefits including personalization, early diagnosis, remote patient monitoring, adherence to medication, information libraries, and better decision making, simultaneously minimizing the healthcare costs. Besides, the growing demands and functionality have also directed insurers and companies' attention to supply the wearable health technology to the consumers and employees for wide-ranging benefits. Few applications of the wearable technology are designed to prevent diseases and maintain health. These applications include, the monitoring of physical activities and control of weight. Further, wearable devices are also being used to manage both, diseases and patients. On the other hand, such wearable applications can seriously have an impact on the clinical decision-making. They could also improve the quality of patient care, simultaneously minimizing the overall cost incurred in the care, such as rehabilitation of any patient outside the hospitals' premises. However, majority of the wearable technologies and hence, their applications currently stand at the prototype stage. Also, the major issues in the wearable technology, such as consumer acceptance, security, and ethics, are yet to be addressed for enhancing their usability and functioning of these devices for practical usage. Overall, wearable technologies and their applications are foreseen as innovative solutions for various healthcare problems.

Wearable technology has enabled continuous monitoring of an individual's everyday physical activities and behaviours in addition to the multiple physiological and biochemical parameters. The commonly gathered data includes key attributes such as heart rate, blood pressure, oxygen level, etc. Further, the daily physical activities can also be tracked through the use of electrocardiogram (ECG), ballistocardiogram (BCG), and various other devices. Healthcare professionals are using few wearables to monitor patterns of walk, including the accelerometer, multi-angle video recorders, and gyroscopes whereas, few others are being used by the consumers, including on-wrist activity trackers, mobile phone applications, and add-ons. The wearables can be attached to (i) external outfits such as shoes, eyeglasses, earrings, etc., and/or (ii) skin or to skin attachable devices. Further, sensors can be used within wearable environment to collect and transmit the key data to a remote server for further analysis and/or storage.

In the current scenario, wearable technology can serve as an innovative solution for various healthcare problems. Further, these wearable devices have had a major influence in the industries related to medical health and health insurance due to the advancements in digital platforms used to monitor multiple health attributes continuously. With the spread of the recent pandemic, the global population is concerned regarding health maintenance more than ever. Hence, there is now an instant willingness by the healthcare practitioners and the health insurers to adopt the wearables concerning the better health of the population (Dunn, Runge, & Snyder, 2018). Many variants of the wearables are available in the market, tracking multiple health related values. Further, such wearables are also gaining immense popularity within the market as they can be used to monitor fitness. In addition to helping people maintain a healthy lifestyle, wearable devices are also being used by people to obtain various benefits including, discounts, vouchers, reduction in claim payment, etc., from their health insurance company. Overall, the data collected through wearable device aids the medical company and the insurance company in predicting the outcome of any disease (Burnham, Lu, Yaeger, Bailey, & Kollef, 2018).

In general, wearable devices and data analysis algorithms are used to perform various evaluating tasks in various cases. The advancement of wearable technology and possibilities of Artificial Intelligence (AI)usage in healthcare has been investigated by many researchers. The presence of smartphones and wearable sensors continuously results in the fast collection of data, and AI and machine learning (ML) are emerging as the major techniques to map the data to the clinical predictions. Specifically, AI technology has shown efficiency for healthcare and health insurance applications in recent years. The AI technology has been used for multiple applications and uses cases such as pricing, prevention, prediction, personalization, etc. (Infosys AI insurance). Further, health prediction and risk of various diseases can be predicted using AI-based models which work on the existing data available through the hospitals. However, the prediction of such a large set of data consumes time; hence, recent research focuses on developing such AI-enabled predicting models that consume less time (Amin, Anikireddypally, Khurana, Vadakkemadathil & Wu, 2019). For the aforementioned, multiple AI methods e.g., ML, Deep Learning (DL), Natural Language Processing (NLP), and many more, can be used for developing efficient predictive models (How & Chan, 2020). Further, once the available data, which can be structured or unstructured, is applied to the developed model, multiple desired parameters can be predicted, which can aid the health firms in the identification of future health-related risks (Kumar, Srivastava & Bisht, 2019).

Few various use cases regarding the applications of wearables in the healthcare and insurance industry are as follows:

- **Acquisition of Health Data**: Helps improve the prediction of cost claiming by collecting an individual's vital statistics through the wearables.
- **Incentivization**: Through the wellness sessions will provide a healthier lifestyle to the people.
- **Health monitoring**: The status of an individual's health is continuously shared through the wearables through notifications and alert messages.
- **Health predictions**: Through the wearables, multiple health problems, customer retention, fraud detection, etc., can be predicted.
- **Enhanced competitive position**: Aids the insurance companies to strengthen their competitive position within the market.

Therefore, to ensure a sustainable and secure development in the healthcare, the current and future health professionals must have a thorough understanding of the emerging wearable technology, and the digital data which originates in regard to the individuals through the wearable devices.

In this chapter, we present a survey on the research conducted in the domains of the sector of health and insurance that use wearables (see **Section 2**). In **Section 3**, we have discussed and analyzed the major findings obtained after completing literature survey. Lastly, in **Section 4**, we conclude the chapter which presents the usefulness of the wearables for prediction.

RELATED WORK

In this section, we discuss the various applications of wearable technology for various use cases.

Wearables Application in Life Style Monitoring

(Dunn, Runge, & Snyder, 2018) have shown that wearable technology is having a wide variety of applications in domains of medicine health system. With a continuous revolution in these systems, wearables are being used for the general systems which manage health in view of improving healthcare irrespective of the individual is inside or outside of the hospital. In the case of an individual being outside the hospital, the wearables, in conjunction with the sensors, help monitor and track the condition of an individual in regard to heart, metabolism, disorders, sleep, mental health, and environmental exposures, etc. The authors also show that using the wearables within the medical system will aid an individual in monitoring the activity(s) and minimizing frequent visits of hospital, reducing the rates of readmission in the hospitals, and enhancing the person's health. Lastly, the authors demonstrate that the wearables can also be used to inform an individual regarding any symptoms related to health; in effect, collecting the data and communicating it quickly to the hospital or any clinic under emergency.

(Patel, Asch & Volpp, 2015) have provided ideas regarding wearable technology and devices that offer profit in person health behaviour, and habits through digital applications that multiple technology companies are currently using. The authors have focused on using wearable devices to ease usage by adopting the new technologies. Further, to track any changes inhuman behaviour and their corresponding habits, the wearables must work on the ideas of design that make them efficient for use by any person. Therefore, people must be encouraged to connect with changes in human behaviours via wearable devices, and feedback must be considered.

In (Future is now), an idea regarding wearables being a channel via which one can understand the people's health has been put forth. Also, there are many wearables within the market; however, most of them belong to smartwatches and fitness trackers. Such wearables are able to gather person's data such as activities involving physical work, activity period, etc. Currently, multiple wearables are able to capture the heart rate and the blood pressure. Further, the authors have also mentioned evaluation of person's activity involving physical activity, which is evaluated by wearable sensors, which in turn aids in determining the mortality risk of any individual. The aforementioned was used on the USA population dataset gathered from the studies to find the relations between an individual's health and lifestyle behaviour.

Asthana, Strong & Megahed (2016) have surveyed the current market regarding wearables. They have stated the availability of many wearable devices which can be used to acquire multiple attributes of an individual, which help in analysing and evaluating a person's health attribute. However, the availability of many such similar wearables in the market leads to confusion amongst the consumers regarding the 'best' device for health risk monitoring. Hence, the authors have presented a model that recommends an individual the wearable device, which is most beneficial. Such a model is shown to work effectively as it first gathers all the related data such as, diseases, risk factor of the individual; individual's attributes (i.e., age, gender, state); and medical history, etc.; followed by the process of relating the diseases to the collected attributes, through a textual analytics model, to monitor or predict the diseases and risk factor for the individual.

Paul & Irvine (2014) have focused on the issues pertaining to privacy in regard to wearable devices. The authors state that people are ready to purchase the wearable(s) through companies without considering privacy. Hence, in the article, the authors have investigated and compared the privacy rules of 4 services viz., Fitbit, Jawbone, BASIS, Nike+Further, upon comparing every service's privacy features, the authors have evaluated the privacy score, and it is observed that Nike+ provides the highest privacy compared to the other services.

Jin (2019) has summarized how the AI technologies apply to wearable devices and the multiple application types enabled by AI. The article demonstrates the various types of available wearables within the market and collects the data, helping the model to be trained, including the related application. The authors have further categorized the various wearables types such as smartphones, watches, smart glasses, shoes, earphones, etc. Also, it is shown that such wearables are able to gather different data types such as sports data, environmental data, and communication data. Further, the article also demonstrates the various processing techniques such as ML, Convolutional Neural Network (CNN), Ensemble Learning, which use the collected data from the wearables and process them effectively. However, much research is still desired in this domain.

Wright & Keith (2014) have presented a survey on the wearable devices and the related technology used in an individual's clothes and accessories. Such devices could include glasses, jewellery, headbands, watches, etc., and have a major impact on healthcare, medicine, and fitness. In healthcare, there is availability of multiple components such as, Fitbit, wrist bands, etc., which aid in tracking various attributes such as activity, distance, etc. The authors also use the example of multiple healthcare firms having developed smart glasses used for gaming, viewing TV, or movies. The medical community is planning to utilize such smart glasses to (i) view the records of patients and enable the doctor to know the patient's attributes before entering the patient's room. However, such an application is observed to provide limited information, limited modification to the patient's information, and consume much battery power. Hence, research in this direction needs fostering.

Wearables Enabled by AI in Health Sector

Yu, Beam & Kohane (2018) have firstly described the AI technology as machine intelligence followed by the related applications such as education, AVs, etc. Specifically, the authors have stated that AI technology in healthcare plays a crucial role in medical diagnosis, which involves obtaining the data, processing the data, and transmitting the result to the individual. The data analysed by such AI technologies consists of implementing ML if the data is structured and DL or NLP if the data is unstructured. In general, the use of AI technology in the healthcare domain aids in the analysis of prevention or treatment techniques and the patient's results. Many medical agencies are developing new AI methods and predictive analysis techniques to improve the company's operations. Using AI technologies in healthcare provides best results and effective prediction in the treatment of every patient. Lastly, as a scope for future research, the researchers need to focus on developing the Brain-Computer Interaction, which aids an individual to obtain the complete information regarding movement, speech, high-risk injuries, etc.

Bayro-Kaiser, Soliño-Fermández, Ding & Ding (2019) have surveyed the availability of wearables in the USA market. They have identified that the majority population wishes to understand the incentives they would receive upon adopting the wearable technology. In this regard, the authors provide the results of a survey conducted under 6 scenarios, including health promotion, early detection of health diseases, prediction of health risks, obtaining specific diseases disorders, activity tracking, personalization of the applications, and processes which are automated. The results reveal that every two among four USA citizens are agreeing for the adoption of the wearables.

Angelides, Wilson & Echeverría (2018) have demonstrated that wearable technology can aid an individual in improving health by enhancing their daily routine and habits. The authors have developed a mobile application to support the data analytics and the ML method, which helps understand the data received from the wearable and also provide recommendation to a person regarding the lifestyle. The developed application includes a workflow in which the configuration and aim are set up inside a smartwatch—further, an aim set watch helps track an individual's activities. Additionally, the data is then synchronized via Bluetooth. The raw data is then analysed to generate recommendations for an individual, which are then forwarded to improve the habits or routines. Further, analysis of the aforementioned types is then interfaced with ML techniques to visualize the various activities. The wearables can also be connected with sensors to analyse a person's fitness under emergency.

Prabhu, Darshana, Kumar & Nazreen (2019) have described using the ML to predict health risks at an early stage. The authors have proposed a method that depends on an individual's medical history. In this regard, the authors have developed the algorithm using CNN based on the Multi-modal prediction method for structured and unstructured data from the hospital. When compared with existing models and algorithms, it is observed that the proposed technique provides faster prediction accuracy and performs better concerning the prediction of the risks due to diseases owing to the use of the ML algorithm.

Shinde & Rajeswari (2018) have provided ML techniques and related applications to predict health risk and health care systems. The article provides guidelines to the researchers working in the ML domain, provides a survey on ML, applying ML for predicting health risk, and directing research towards future health prediction systems.

Burnham, Lu, Yaeger, Bailey & Kollef (2018) have reviewed and analysed the existing literature regarding the wearables being used for health outcomes. The authors have surveyed wearable technology, which tracks peoples' health parameters and models the data to predict various parameters. The study conducted by the authors resulted in six scenarios, including a model for multiple admissions and two cases including a model applicable for mortality. However, the studies gathered only predictive data via wearable device, and hence, much research is required in the domain of prediction in the domain of health care system.

Repaka, Ravikanti & Franklin (2019) have focused on predicting heart diseases using the technique of data mining. For the prediction of heart-related diseases, the authors have used the Naïve Bayesian classification technique. The input is in various attributes (blood pressure, sugar, etc.) of an individual. To obtain the output, an individual must log in to a web portal of the developed application, ensuring privacy by using the Advanced Encryption Standard. The result demonstrates that the proposed system is able to operate systematically and efficiently predicts the heart diseases related risks.

Ambekar & Phalnikar (2018) have surveyed the use of data in the system of healthcare. The article states that even though an enormous data size exists that can be utilized for health disease prediction and care for the patient, the model accuracy reduces the model accuracy. Regarding the aforementioned, the authors have resorted to using the Naïve Bayes classification and k-Neural Networks (k-NN) algorithm, a data cleaning technique to convert the incomplete data into complete data. Further, for risk prediction, the authors have used structured data and the CNN method to predict the diseases.

Amin, Anikireddypally, Khurana, Vadakkemadathil & Wu (2019) have described the use of ML to identify diseases and diagnose the diseases. With a drastic reduction in physical activities, individuals face many health issues. The wearables can be used to overcome the same as they can monitor the data and notify the individual regarding the condition of their health. However, the accuracy of all wearables in evaluating the various parameters and prediction of the risks in health is not high. In this regard, the authors have proposed an ML based method that gathers the data obtained via a wearable device, processes the data, and performs prediction to find any risk of diseases.

Massaro, Ricci, Selicato, Raminelli & Galiano (2020) have demonstrated that the system used for supporting decisions enabled by AI algorithm and the wearable device aids in the prediction of health. The data gathered by the wearable devices are buffered on Big Data and are then processed using the Support Vector Machine (SVM) technique, which can predict the status of the health. The authors have also concluded that the data mining techniques can increase prediction analytics when applied within the healthcare industry, offering multiple advantages.

Salamon & Mouček R (2017) have performed a sentiment and heart rate analysis via 4 varied sources of data viz., Fitbit Charge HR, Basis Peak, ECG, HR. It is observed that the HR heart-rate data precision is better than the ECG heart rate data. Further, for analysis of sentiment, the authors conducted a literature survey in which the people had to express their sentiments via tweets, and Twitter was used as the medium to record. The result was then measured using the two hashtags viz., positive and negative, and the data is then merged to evaluate the human activity mutual dependence.

Overall, the existing literature has shown the AI-enabled wearables' potential for acquiring health-related data, accuracy in processing, and predicting to monitor the health effectively.

Wearables Enabled by AI in Health Insurance Sector

In (Intel insurance analytics), it has been surveyed that the wearables used by the insurance firms to enhance the profits and sales and minimize the cost incurred for customer retention and acquisition. In this regard, the authors have stated that Big data and wearables in life insurance can be used for a specific approach for attracting the customer and their retention. These devices capture the key attributes and then set a target for an individual to achieve a healthier lifestyle. Further, Big Data can also be used to identify new business opportunities and expand customer relationships.

The (Accenture ML insurance) has depicted the crucial role of data in the industry of health insurance. The authors have stated that multiple insurance firms are now engaged in identifying the advantages obtained from the massive collected data followed by the interface with AI technology to solve various business problems. This also includes predictive modelling and ML for enhancing customer satisfaction and increasing business. Lastly, the authors also state that by adopting AI technology, security issues related to data can also be solved.

(Qeli) has surveyed the usage of the wearables in the insurance domain using predictive analysis. The study demonstrates the manner in which business can be executed efficiently by adopting a model for prediction, recognition, and gathering the data via advanced technology such as wearables device, IoT, Blockchain, etc. Specifically, predictive modelling aids an insurance firm regarding processing of the claims, dynamic pricing, and efficient reserving decision.

The role of wearables in private medical insurance has shown that currently, AI technology is altering how insurance firms deal with their customers. The firms are interfacing IoT with AI technology for improvement in the firm operations and customer experience. Also, AI technology can be used within the insurance domain for prediction, pricing, processing, personalization, and prevention. Hence, the firms have started providing wearables to the customers for collecting the attributes and providing suggestions with targets to attain better health. However, as data plays a key role, research on strategies for data security needs much focus.

Balasubramanian, Libarikian & McElhaney (2018) have surveyed how insurance firms are expected to adopt AI technology in the near future to maximize profit. In this regard, the authors state that the firms will have to thoroughly understand the factors which will encounter variation and details of the applied AI technology. Further, upon using the AI technology, an alteration from distribution towards underwriting and a change from pricing to claim can also be automated. This can be amended with security and privacy by integrating blockchain technology. Overall, the study states that in the future, the insurance firms will have to adopt new AI technologies and will have to operate with an amalgamation of semi-automated and machine-enabled tasks.

Burri, Burri, Bojja & Buruga (2019) have provided ideas related to the important element in the insurance firm sector and the manner in which it can interface the ML technique with the insurance domain. Currently, the insurance firms have much interest in predicting such methods, which will result in a reduced loss in finance and will also optimize the business costs. The authors have stated that the prediction can be conducted using multiple ML techniques, and have compared the performance of each method considering multiple metrics. The results demonstrate that the Random Forest technique can outperform other methods by showing maximum accuracy.

Sabbah (2018) has compared the ML methods for predicting the customer retention amount. The study reveals that in the current scenario, customers need high quality of service. Hence, the firms need to develop customer relationship management system models that will maintain an effective relationship with the customers, ensuring high customer retention. The model can be based on ML approaches that help predict the customer's behaviour and personal data. In this regard, the authors used various models, including discriminant analysis, decision trees, ensemble-based ML method, neural networks, SVMs, etc.; and it was observed that the ensemble-based ML technique outperform the other techniques by achieving higher accuracy.

Rayan (2019) has presented how the insurance firms are going through fraud claims and processing. Hence, for analyzing and detecting such fraudulent claims, the authors state that data mining and the ML approaches can be used. However, the existing methods demonstrated inefficiency due to handling extensive databases in the manual mode; hence, the authors introduced a new data mining method that uses a workflow to analyze and detect the frauds using supervised and unsupervised learning that demonstrates better results compared to the existing techniques.

Boodhun & Jayabalan (2018) have focused on underwriting, which results in the risk of evaluation in the presence of extensive data. Hence, the authors have proposed a supervised learning enabled method, which aids in prediction of the risk. The authors implemented ML techniques, such as random forest, artificial neural network (ANN), on a dataset for predicting the risk level, and it was observed that the multiple linear regression method outperforms the other techniques by demonstrating higher accuracy.

AI USE CASE IN THE DOMAIN OF HEALTH INSURANCE

Thus far, the reviewed literature helps in summarizing the involvement of the wearables and AI in domain of insurance, which is represented in Figure 1 and Figure 2.

Figure 1. Applications of the wearables.

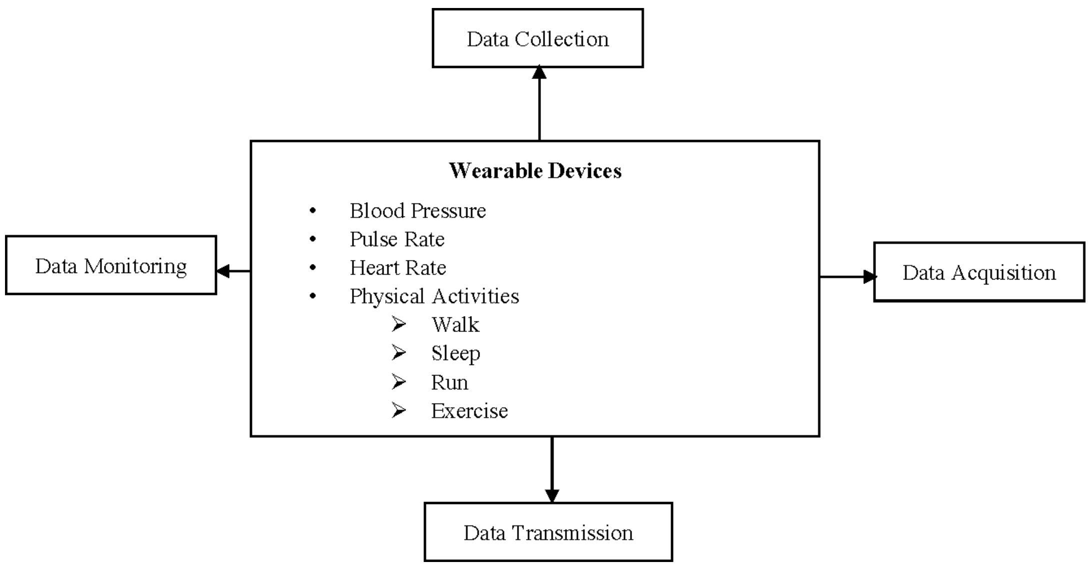
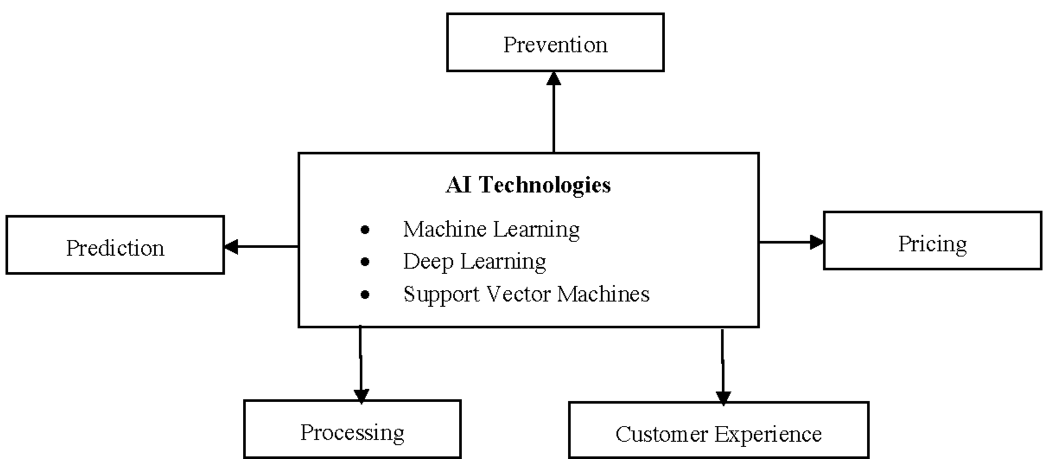


Figure 2. Applications of AI health insurance.



a. Wearables Enabled by Artificial Intelligence (AI)in Disease Prediction

The AI technology also finds applications in the domain of disease prediction. We present the following selected disease prediction use cases as follows:

- **Acquisition of Health Data**: Wearables are used to gather vital attributes of the people, which aids in the enhancement of the claim cost prediction.
- **Incentivization**: Helps in ensuring that the lifestyle of the people is healthier, and in turn, the individuals obtain rewards through the wellness program.
- **Health monitor**: The system sends alert messages or notifications to the people through the wearables to aid them in knowing their health status.
- **Health predictions**: The developed system can help predict health problems, customer retention, fraud detection, etc.
- **Improved competitive position**: It aids an insurance firm in obtaining a competitive edge over the other firms in the market.

i. Analysing the Essential Findings and the Limitations Within the Domain of Insurance

We present the work conducted and the limitations of few latest studies that focused on wearable devices for healthcare insurance.

Table 1. Review of major studies.

Reference	Year of Publication	Work Conducted	Limitations of the work
Dunn, Runge, & Snyder	2018	Application of wearable technology aids in health monitoring for improving the healthcare	The cost of wearables is very high, and the accuracy of attributes measurement is low.
Jin	2019	Summary of the AI technology enabling the wearable technology, including the different types, applications, and models used.	Ineffective prediction results in inaccurate measurements.
Prabhu, Darshana, Kumar & Nazreen	2019	Identification of early detection of disease risk using the neural network algorithm.	The collected data was extensive, which results in inaccurate predictions.
Repaka, Ravikanti, & Franklin	2019	Proposed an advanced method based on data mining and used the Naïve Bayes classification technique to predict the heart disease	The method was limited as only the patient can identify the occurrence of any heart disease.
Amin, Anikireddypally, Khurana, Vadakkemadathil & Wu	2019	Used the machine learning technique via the FitBit wearable device to predict heart diseases	The collected data is used only to detect heart diseases.
Massaro, Ricci, Selicato, Raminelli & Galiano	2020	The health status prediction was conducted using the AI method of support vector machine through the data collected from a wearable.	The comparison of measured and predicted values is not conducted.

b. Wearables Enabled by Artificial Intelligence (AI) for Anti-Covid-19 Applications

i. Wearables Enabled by AI in COVID-19 and/or Alternate viral Prediction

Recently, the entire globe has been severely affected by COVID-19 pandemic. Colloquially known as the coronavirus, Covid-19 is caused due to contagious virus belonging to the coronaviridae family (Cascella, Rajnik, Cuomo, Dulebohn & Di Napoli, 2020). The common symptoms of Covid-19 are breath shortness, fever, cough, smell and taste loss, head and muscle ache (Razai, Doerholt, Ladhani & Oakeshott, 2020). As the virus progresses, it has been observed to create many difficulties in human life, and new problems have emerged with the passing of time.

To provide solutions to the rapidly emerging problems due to Covid-19, new techniques enabled by AI technology are being developed continuously (Vaishya, Javaid, Khan & Haleem, 2020). We present the most popular wearables in this regard as follows (Krishnamurthi, Gopinathan, & Kumar, 2021):

- The study of **Stanford Covid-19 Detection** has addressed individuals' fitness by tracking their activities. The wearables used in the study include Fitbit, Apple Watch, Garmin, and Oura ring. The study has focused on predicting Covid-19, with an individual's health-related data being collected via the wearable, which is then processed to analyse and predict.
- The **Duke Covidentify** has a goal to analyze wearable devices and find their ability to identify covid-19 and influenza-like symptoms. The study measures the severity of viral infection via wearable devices such as Fit bit and Garmin.
- The study of **Scripps Detect** conducts analysis of different vital information such as, heart rate, sleep length, and fitness activities. The study utilizes wearables, such as, Apple Watch, Fitbit, Beddit, Oura, and Garmin.
- The **UCSF TemPredict** operates on the principle of body temperature measurement and identifies the alterations in the temperature compared to a pre-set threshold. The study uses the Oura ring as a wearable device.

Tripathy et al. (2020) have proposed a wearable device, "EasyBand", for handling mobility of the user based on safety parameters during Covid-19. EasyBand is enabled via programmable microcomputing on chips with IoT technology and can perform smart functions such as, identifying and communicating with similar peer devices. Further, proposed device is able to gather data in regard to the nearby contacts and store relevant information for approximately fifteen days. Additionally, the device provides individuals with safety alerts.

Mohammed et al. (2020) have proposed a smart helmet for combating exposure effects of Covid-19 in public areas. This wearable smart helmet comprises of the optical and thermal camera. The thermal camera senses body temperature of any person who passes by within detection zone. Henceforth, if any passerby's body temperature exceeds minimum threshold temperature, optical camera captures an image and performs digital image processing to fetch information of the person. Lastly, person's details such as, image and temperature are recorded and intimated to concerned health care officials via a mobile communication module.

Mujawar et al. (2020) have discussed a nanomaterial-based biosensor for healthcare monitoring and diagnosis of Covid-19 in suspected patients. The nano biosensors include Geno-sensor and immune-sensor, which are embedded on-chip to assess the covid-19 patients. The data gathered from sensors are then analyzed via an AI-supported data processing and analysis technique. This Internet of Bio-Nano Things (IoBNT) is used for applications such as, data sharing with healthcare centers, faster assessment of covid-19, contact tracing, quarantine management, and specific covid-19 patient sensing.

Kanis et al. (2004) have proposed a wearable bracelet, 'iBand', which exchanges information between individuals and their close contacts. When an iBand user comes in close contact with anyone, the handshake and proximity are detected via an infrared detector. The iBand also allows an individual to his/her bio vital signals and senses such as, touch.

Many wearable devices, such as Lovegety, groupware, Synchro beat, Digital Proxies, and Smart-Its Friends, disseminate similarly interested groups of people (Kanis et al., 2004; Swatch, Synchrobeat, SpotMe, nTag, Charm Tech Badge). These wearable devices gain immense popularity as they are lightweight and track continuously in view of improvement of people's lives. This has been possible due to such devices becoming the basic building block of the Wearable IoT, which collects data from sensors processes, analyses this data using an intelligent algorithm, and then transmits the pertinent information to the individual. In this regard, a robust technology framework enabled by the IoT aids in data collection and storage by integrating key technologies such as, cloud computing (Khan, Shakil & Alam, 2018), and Big Data (Qi, Yang, Min, Amft, Dong & Xu, 2017). Further, the IoT framework has also enabled the connection of the medical infrastructure to assess patient's condition irrespective of the location (Huang et. al., 2011).

ii. Wearables Enabled by Artificial Intelligence (AI) in Covid-19 Social Distancing Monitoring and Gathering Prevention

To develop an efficient disease predictive model to aid in the allocation of medical resources and ensure that the social distancing norms are followed more strictly, three ML models viz., hidden Markov chain model (HMM), hierarchical Bayes model, and long-short-term-memory model (LSTM), have been proposed by (Tian, Luthra & Zhang, 2020). Further, four types of forecasting ML techniques are proposed by (Rustam, Reshi, Mehmood, Ullah, On & Aslam, 2020) which include Linear Regression, Least Absolute Shrinkage and Selection Operator (LASSO), SVMs, and Exponential Smoothing. These models operate on three prediction types viz., the newly infected cases amount, deaths numbers, and recoveries numbers within ten days.

An important method to prevent the spread of covid-19 is social distancing. A CNN-based method is proposed by (Uddin, Shah S & Al-Khasawneh, 2020) to monitor whether the people follow the social distancing guidelines. The proposed method performs a check on people to obtain information on symptoms. A machine vision method is proposed by (Yang, Yurtsever, Renganathan, Redmill & Özgüner, 2020), which is enabled by the AI methods to monitor individuals who do not obey the social distancing rules. (Punn, Sonbhadra & Agarwal, 2020) have proposed a DL framework for monitoring social distancing through surveillance video. The authors demonstrate that the social distancing measures demonstrate varied consequences in different countries. To study the aforementioned, a hybrid ML model, namely SIRNet, is proposed by (Sources et. al., 2020), which models the Covid-19 pandemic using Spatio-temporal data from the mobile phones, which are used as a surrogate for physical distancing and a measure for social distancing. The study reports suggest that social distancing and wearing face masks reduce transmission risk. A machine vision and AI algorithms that monitors the workers and detects any violations is proposed by (Khandelwal et. al., 2020). In this method, the DL and classic projective geometry techniques are used in conjunction.

Another method to control covid-19 is wearing the facemask properly. (Qin & Li, 2020) have proposed a facemask wearing condition identification consisting of four steps viz., image pre-processing, face detection and crop, image super-resolution, and facemask wearing condition identification. Further, social media reflects important information regarding public opinion on the issue of facemasks. To study the same, DL-based text classification models are presented by (Sesagiri Raamkumar, Tan & Wee, 2020) to classify the social media content during covid-19.

DISCUSSION

Application of Using Wearables and AI in the Healthcare and Insurance Sector

Wearable technology also helps the health and insurance sector industry by provisioning solutions to human health behaviour. There exist multiple use cases of the AI technology enabling wearables in healthcare and within the insurance sector. Such wearables help to monitor multiple attributes of an individual (Miyashita, & Brady, 2019). Further, the AI technology, when connected with the wearables, provides the solution for the following:

- **Prediction** - It aids the insurance firms to provide novel methods for predicting real-time events, such as fraud detection, customer retention, early detection of health risk, etc., which benefit the business in predicting real-time events benefit such as.
- **Customer Experience** – It helps the insurance industry understand the customers by using chatbot and provides offers and additional services to the customers, ensuring the firm's better progress.
- **Pricing** - In this regard, the individual may be required to pay less for the insurance policy if he/she adopts the wearables.
- **Prevention** – The insurance firm may obtain profits by preventing illness and fatigue through activity tracking, in turn rewarding the customers who maintain a healthy lifestyle.
- **Processing** – Using an AI-enabled system, the insurer's claim can be settled quicker, document processing can be faster, and time for underwriting the policy can be reduced.

Further, a few benefits and application of the adoption of wearable technology are as follows:

- In addition to tracking, it aids the doctors in remote monitoring of the patient.
- It helps fitness-conscious individuals to follow a healthier lifestyle by obtaining the alert notifications regarding their health status.
- The patients can receive incentives with the minimization of the paying claim cost.
- It ensures improvement in the business competency of the insurance firms through the provisioning of the wearables to the registered customers and maintains a strong presence within the market.
- Individuals can obtain rewards, for every program related to good health maintenance they undergo the wearables.

The early success of efforts that have been directed towards using the wearables with the AI technology in healthcare has been:

- A focus on impacting the critical metrics such as reducing the costly hospital readmission rates.
- The reduction of the risk by depending on new kinds of partners.
- The use of AI to collaborate rather than to compete with highly-trained professionals.

As a real case scenario, in USA, a leading life-insurer is already utilizing wearable-enabled products for the customers. The insurer, operating in many countries over Asia, Africa, Europe, etc., has announced that a new approach will be implemented for the life insurance which will be rewarding to the people who hold the policy(s) and demonstrate improvement of their health. The rewards include, discounts on premium for leading a healthy lifestyle, and rewards in regard to the travel, shopping, and entertainment by various retailers upon improvements shown in leading a healthy lifestyle. Further, the new customers will be provided with free 'Fitbit' for tracking their health progress. The aforementioned works by accumulation of the vitality points, earning the vitality status, and then enjoying the savings and the rewards. The overall benefits to the customers include financial protection to the customers provided by the insurance industry, significant savings on the annual premiums based on the vitality points, discounts on premium upon improvement of health, and earning of valuable rewards from various retailers.

Further, Apple's HealthKit and Google Fit are amongst the new mobile health-tracking platforms which focus on the fitness and the wellbeing by permitting the storage and inter-change of health data between various applications. This in turn enables techniques used by the Quantied Self (QS) community to be accessible to a large population since, the QS trend quantifies in detail, the aspects within the human lives so as to permit reflection, learning, and improvement on collecting data and analysing the same. Further, automated recording of the aforementioned aspects eases the process and the analysis simultaneously being able to prevent tracking fatigue and failure.

Ubifit, a mobile application which includes an ambient and glancable display, permits a non-literal representation of the physical activity of the user. The user is able to gain higher incentives by more exercising, and this data is collected from the sensors on the user's body for the analysis. Further, Apple's ResearchKit is a research focused interface to access large scale of health data of the consenting patients thereby ensuring wide accessibility of the study.

Overall, the use cases of AI-enabled wearable technology will ease claim processing and customer retention and ensure real-time fraud detection and prediction of human health risk. The various AI techniques which could be used are CNN, SVM, random forest, logistic regression, etc. However, much work needs to be conducted regarding the limitation of the results due to the limited availability of the data set, selection of apt techniques, and low accuracy to predict the risks in health. Also, incentives are an excellent method to ensure that the majority population adopts the wearables.

Application of Using Wearables and AI in the Anti-Covid-19 Applications

This section elaborates on the multiple challenges regarding using the AI-enabled wearables for curbing the covid-19 infection.

Many AI-enabled devices have been introduced in the market, which enabled in combating the Covid-19 infection. A new AI-powered solution that can triage the individuals requiring further testing for SARS-CoV-2/COVID-19 using physiological sensors data derived from wearable devices has been detailed in (HospiMedica International staff writers, 2021). In (Researchers eye smart bands for virusdetection, 2021), the scientists have created a digital platform that can detect covid-19 symptoms up to three days before they show up using the Oura ring, wearable fitness, and activity tracker. Biofourmis has developed a technology to remotely monitor and conduct disease surveillance programs among patients with the diagnosed or suspected novel coronavirus (COVID-19) (B. Siwicki, Biofourmis 2021). Our survey identifies the following key challenges:

- Quick identification of virus, and obtaining guidelines which are clinical based.
- Software development, which is simple, efficient, affordable, and is applicable for the long-term.
- Energy-efficient protocol standards and networking capability.

CONCLUSION

In this chapter, we have surveyed the manner in which smart wearables enabled by the AI techniques are used for multiple applications in the healthcare and the health insurance domains. We have demonstrated that these wearables aid the healthcare system by providing the health status and the activities of an individual so that early detection of any disease(s) can be conducted. Further, we have also shown that the wearable technology helps the insurance firms to obtain profits by transforming their relationship with the customers. We have also surveyed the various applications of the AI-enabled wearable devices in combating the covid-19 pandemic.

We believe that the applications of wearables lie in the development of the analysis of new algorithms for health data and providing support to the consumers for understanding the data and obtaining the feedback to adopt a healthier lifestyle. We also envision an inter-disciplinary research collaboration between the medical professionals and the engineers to serve as a key to the success of the new emerging wearable applications. Lastly, we are of the opinion that the survey in this chapter presents many open research problems to the researchers and the health firms, including creating an effective health care ecosystem, and addressing the privacy and security issues of the customers.

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Chapter 3
A Review of Generative Adversarial-Based Networks of Machine Learning/Artificial Intelligence in Healthcare

Anilkumar C. Suthar
https://orcid.org/0000-0003-3267-8636
L.J. Institute of Engineering and Technology, India

Vedant Joshi
L.J. Institute of Engineering and Technology, India

Ramesh Prajapati
L.J. Institute of Engineering and Technology, India

ABSTRACT

Machine learning has been proven to be a game-changing technology in every domain since the late 20th century. There have been many advancements in healthcare not only for the diagnosis of disease but advanced in the prognosis of the diseases. Artificial intelligence/machine learning (AI/ML) has progressed a lot in the medical domain in just a couple of decades and played a very important role in exploring human data to understand human body behavior better than ever before, for predicting and classifying all kinds of medical images or videos. A recent and best-used application is detecting COVID-19 by just checking the chest x-ray in a very accurate manner that can be used without human presence and stop the spread of the virus resulting in fewer doctors getting affected. It is known as generative adversarial networks. Some of the types of GANs used for differentiate domains without human supervision and many such mutations of GANs are useful in the health sector. This is simply a quick review of various technologies that will become more in-depth as time goes on.

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INTRODUCTION

Deep Learning is known to be a promising way in all the eras of business and life. It is a promising way to discover rich and hierarchical models (Bengio,2009). Deep Learning is a concept that is inspired by the architecture of the human brain's neural network and so it can also be called an Artificial neural network. Similar to the brain, the neurons in Deep Learning models are interconnected with each other in a layered pattern which means that there are multiple layers where the initial layer is known as the input layer and the last layer is known as the output layer. All the layers between the above mentioned are known as hidden layers. The layers are composed of n number of neurons where n can be anything and can be found out experimentally, the same applies to the number of layers as well, it can be found out experimentally. The process of experimenting is known as hyperparameter tuning where the model is trained (made to learn the pattern from existing data to predict new data) and is evaluated based on metrics which is also based on the use case and the model which performs the best amongst all the models is considered. The main process is data mining incorporated with the healthcare of Machine Learning (Sayeedakhanum Pathan,2020).

The most used Deep Learning technique in the last couple of years was the discriminative model which maps high dimensionality and rich sensory data as an input to a class label (Bengio,2009), (Bengio,2013a). but now researchers are using a technique known as Generative adversarial networks (GANs) where the input data is mapped to itself so that it can learn the features and create a similar image when fed with other images, then a classifier classifies the image as real or fake in the same pipeline (Zhang,2019). It is mostly used in the healthcare industry to generate fake or synthetic images which can't be distinguished from real images. Then the synthetic images can be used as inputs in classifiers and to perform analysis of the human body. There are many variations of GANs which work on similar architecture but the model's changes and the way of learning and mapping images.

Application of Machine Learning/Deep Learning

Machine Learning is used to work with numerical data with a comparatively smaller dataset. Whereas Deep Learning is used where we have images and multimedia to classify or regenerate. The work with images using Machine Learning models but Deep Learning is preferred as the accuracy obtained is more as compared to Machine Learning when working with images. The way to work with images using machine learning is by converting the image to metrics and feeding the metrics to a machine learning algorithm (Zhang Lei,2017). Deep Learning works similarly but the artificial neural network-like architecture makes it much easier and efficient for the model to learn the features of the image (Najafabadi,2015).

Deep Learning is used in the medical sector in many ways, one of which is to detect breast cancer from screening Mammograph (Li Sen,2019). Here the authors developed a method to detect cancer just using the basic availability of data. The process used here supports either the label of the whole slide which is benign or malignant or complete clinical annotations. But here too if the complete annotations are used it only is used till an initial step from where only the image labels are considered to train the Neural net. The metrics used by the authors to find the performance of the model were Area under the curve and the value they obtained on the test set containing screening mammograph from a single model was 0.88. and when a combination of 4 models was used, the Area Under Curve (AUC) value obtained was 0.91 on the same test data. The results obtained on another test dataset that contained a full-field digital mammograph were mind-blowing and the Area Under Curve (AUC) score for that was 0.95 when used a single model and was able to improve to 0.98 when the combination of 4 models was used.

Another recent usage of Deep Learning image classifiers was in COVID-NET, a deep neural network used to detect covid-19 from chest x-ray images (Linda Wang,2020). It was observed by doctors in the initial days of covid that the chest radiology of covid infected patients had some abnormalities when compared to radiology results of normal patients (M. Arun,2020). COVID-NET is a neural network made using a combination of deep neural networks and convolutional layers and is one of the only such models which is open source, which means anyone can use it without asking for permission. The dataset used for training COVID-NET consisted of 13975 images gathered from 13870 patients.

Another use case of Machine learning is in epileptic seizure detection. The human brain is a very complex structure and it can communicate with all the organs of the human body. When a message is conveyed to any of the organs from the brain, a signal is generated by the brain, and by using that signal Epilepsy can be detected. The device used to monitor these brain signals is known as Electroencephalogram (EEG). The data which is obtained is in huge quantity however, the usefulness of the data can't be determined by the quantity as there is a lot of noise in the signals and are non-linear which has to be analyzed before feeding to any Machine Learning model for classification. This is the only reason why it is very challenging to work with human data. Researchers across the globe have been working on creating image classifiers that can address this issue but the main problem is to select the important features which can be used to feed in the neural networks (Siddiqui, M. K.,2020).

MIT has created an algorithm that can predict Cancer 5 years ahead of time (Adam Yala,2019). Cancer has been the most researched domain in recent times and with Machine Learning algorithms it has been possible to find the anomalies in cancerous cell images. Researchers from Massachusetts General Hospital and MIT's Computer science and Artificial Intelligence laboratory have with collaboration created a Deep Learning model which can predict breast cancer 5 years ahead of time from a mammogram, which would be able to save a lot of lives due to the 5-year window. The mammogram had been a promising way to reduce breast cancer but the dilemma of what the monitoring frequency should still exist which adds to a major drawback to a mammogram. At the MIT lab, the Deep Learning model was remarkably better at risk predictions when compared to the existing models and methods. The accuracy was noted in terms of how many patients were classified at high risk and the recent model shows that 31% of the patients were classified as high-risk patients as compared to only 18% in the earlier traditional existing methods.

The Deep Learning model created at MIT's laboratory was trained on 90,000 mammogram images and was able to detect the pattern which was indistinguishable from a naked human eye. The patterns which were used as features by the Deep Learning model were from the breast tissue of the patient which represented the hormones, lactation, bodyweight parameters, diet, pregnancy, etc.

It is observed that black women were 42% more likely to die from breast cancer. One of the main problems faced by previous models was the imbalance of training data. The data gathered years back wasn't covering all the races and so the model wasn't able to detect the pattern in different skin tones. The majority of the data in the training dataset consists of white women and as a result, there was a problem of underfitting or bias leading to not performing as per the standard in black women. So, the training data gathered in MIT's project consists of all the major races along with all the minor races too. This resulted in the unbiased performance of the model where it was able to perform equally for all the races (AdamYala,2019).

The other advancement is by using Natural Language processing. Alexa, Siri, Google Assistant, and other similar virtual assistants use Natural Language Processing (NLP), which is a part of Machine Learning which is capable of extracting Artificial Intelligence understandable knowledge from English, French, German, or any other human language. Virtual assistants initially convert the speech to text and then NLP is applied to the generated text to extract its meaning. Recently Alexa has teamed up with the NHS to provide medical advice using NLP. One of the examples of this can be, in case of fever you can ask Alexa which using its NLP techniques can study the meaning and other medical features of fever and extract medical data from a drug database which can then let you know which drug can be consumed. This being a critical domain, the output can't be very promising, and is advised to consult a doctor before taking steps based on virtual assistants.

At the rate of cell damage of 2 million cells per minute, it's very important to treat the patient as soon as possible, but this can't be done without an initial diagnosis as mentioned by doctors. Due to the time consumed in the diagnosis, there are chances of paralysis, speech problems, loss of memory, and at times death. A startup named Qure.ai is working to prioritize the patients based on the CT scan which can diagnose the CT scan in less than 10 seconds resulting in being able to prioritize the patients effectively by doctors. The AI is capable of identifying defects like fractures in the head, brain bleeding, and blood clots (Jamie Beckett, 2018), (Sasank Chilamkurthy,2018).

Why Generative Adversarial Networks Over Traditional Machine Learning

As discussed above, Deep Learning is used when there is a lot of data and it performs better than traditional machine learning techniques. But what if having lesser data which is not even satisfactory for training a machine learning model? This was the main reason why Generative adversarial networks were developed as they address this challenge very effectively. GANs can generate synthetic data based on real image data. It can study the pattern in images along with generating nearly indistinguishable synthetic images. There are many domains where the data obtained is not satisfactory in quantity, one of such being microscopic image analysis where the image patterns are rare.

A recent study shows that GANs architecture can be used to classify whether the image belongs to a particular class or not, i.e., it can find outliers in images. The approach used for such use cases is known as Adversarially Learned One-Class Classifier for Novelty Detection (Mohammad Sabokrou,2018). It has been proved to be one of the best one-class classifiers where the data on which the model is trained is a set of images of a single class, let's say the dataset is a flower dataset, so the model is trained to classify flowers and NOT-flowers. So, whenever an image other than a flower is fed in, the model classifies it as an outlier.

APPLICATIONS OF GENERATIVE ADVERSARIAL NETWORKS

There are many use cases of GANs, some of them are as follows:

- Generate synthetic images
- Converting grayscale image to colored image (Qiwen Fu,2017)
- Generating cartoons/anime characters (Fathy Rashad,2020)
- Generating images from text (Shibsankar Das,2019)

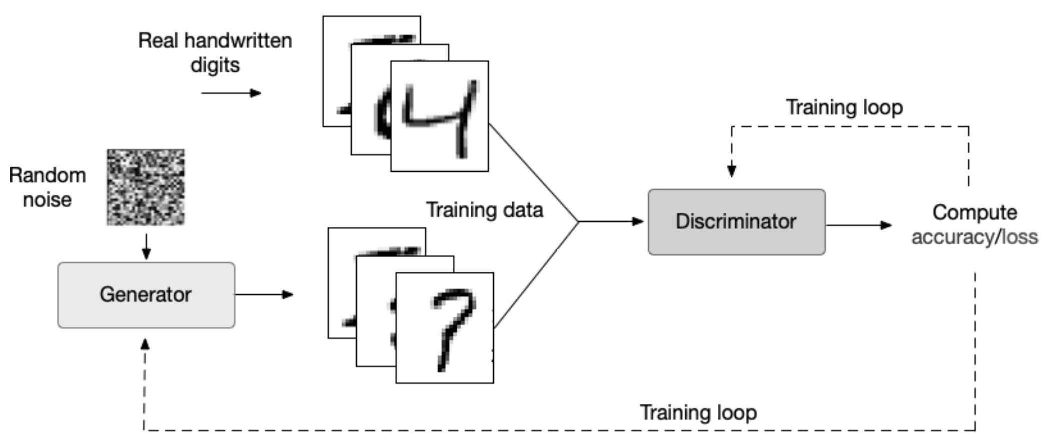
- Changing day time in photographs (Jun-Yan Zhu,2020)
- Adding filters to photographs in social media apps
- 3D object generation (Edward J. Smith,2017)

The explanation and usage of the above are beyond the scope of this chapter.

Architecture of Basic Generative Adversarial Networks

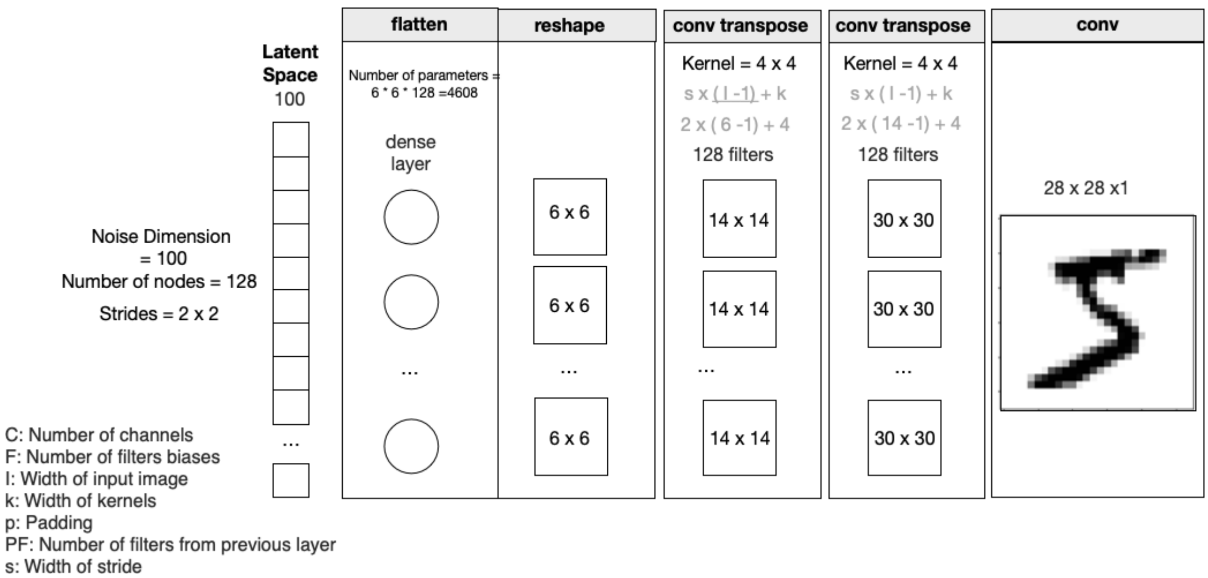
Generative adversarial networks are a combination of a generator and discriminator where the generator is used to find patterns in the image and generate a fake image which is similar to the original images and the discriminator is a basic image classifier model which is used to classify the images as fake or real. Here the generator takes noise as input where the noise is a metric consisting of random numbers ranging from 0 to 255 which are the pixel values for generating images. Eventually, as the image is normalized, this value is divided by 256 and is converted in the range of 0 to 1. Let's talk about an example of a simple GAN considering the dataset as MNIST. (MNIST dataset is a collection of image dataset where the images are of handwritten digits and the labels associated with every image tells us the number written in the image). Here the generator is responsible to generate the images of each class which is similar to the dataset image. The initial process starts with the input to the generator as a noised image or simple noise, noise image here resembles the image where a set of random numbers are added to the image to distort the image by a little. Then the image which is generated by the generator is fed into the discriminator to differentiate it as fake or real. The more the image is classified as fake, the more the generator learns and makes the successive image clearer. The below figure shows how the GANs architecture works on the same dataset.

Figure 1. The GAN learning framework, which has the generator and the discriminator simultaneously trained (Mahammed Alhamid,2020)



As seen in the above figure 1, metrics are constructed using noise (random numbers between 0 to 255 which forms an image like metrics) which is then fed to the generator model which tries to form an image from the noise and try to make the discriminator believe it is a real image, but as the image is not properly constructed the discriminator marks it as fake which results in the generator learning how to create an image that can be indistinguishable from a real image. The model's architecture when considering the image which has the number 5 as the label is as shown in figure 2, after a couple of epochs of training the model on every label combined.

Figure 2. The architecture of the generator model showing each layer



Here the loss function which is used in the discriminator model is binary cross-entropy where the input is 1 for real image and 0 for generated images and the output is what the model thinks of the image as. (0 can be considered as the image is classified as fake and 1 can be considered as the image is classified as a real image by the discriminator or vice-a-versa). There is no loss function unlike the discriminator part in the generator model so the generator model learns from the same loss of discriminator. Yet 2 more losses can be added to the experiment as per the use case one of which being "Wasserstein loss" (Charlie Frogner,2015) and the other being "least square error" which can measure the difference between the pixel values of the real image and the generated image.

TYPES OF GENERATIVE ADVERSARIAL NETWORKS

There are multiple types of GANs, some of them are advanced versions of the basic architecture while some of them are extended versions (Lan L,2020). The advanced version is Wasserstein Generative Adversarial Network (WGAN), Big Generative Generative Adversarial Network (BigGAN), Progressive growing Generative Adversarial Network (Progressive GAN), cycle-consistency Generative Adversarial Network (CycleGAN), Style-Based Generative Adversarial Network (StyleGAN), etc. While the examples of extended versions are Conditional Generative Adversarial Network (CGAN), Stacked Generative Adversarial Network (StackGAN), Auxiliary Classifier Generative Adversarial Network (AC-GAN), Context encoders, Pix2Pix, etc. They all have different use cases and the architecture depends on what you want it to do. Meaning, it's all data and uses case-dependent. The detail talks about the extensions of basic GANs as that is more popularly used these days.

Wasserstein Generative Adversarial Network (WGAN)

WGAN was introduced *(Martin Arjovsky,2017)*, it is an extension that trains the GANs in a different way than traditional as to get a better approximate distribution of data. The main difference is in the discriminator part where unlike traditional image classifier uses a critic model that scores the image generated based on reality. This change was led due to the mathematical theories that stated that the distance between the distribution has to minimize at the time of training, as per figure 3. So, a Wasserstein GAN name comes after Wasserstein distance which is used to calculate the difference between the data distribution (Jason Brownlee,2019*)*. Mostly the optimizer used in this variance in RMSProp, an example of a summary of training loop is as shown below (Charlie Frogner,2015).

Figure 3. Training loop for WGAN (Martin Arjovsky,2017)

Algorithm 1 WGAN, our proposed algorithm. All experiments in the paper used the default values $\alpha = 0.00005$, $c = 0.01$, $m = 64$, $n_{\text{critic}} = 5$.

Require: : α, the learning rate. c, the clipping parameter. m, the batch size. n_{critic}, the number of iterations of the critic per generator iteration.
Require: : w_0, initial critic parameters. θ_0, initial generator's parameters.

```
while θ has not converged do
    for t = 0, ..., n_critic do
        Sample {x^(i)}_{i=1}^m ~ P_r a batch from the real data.
        Sample {z^(i)}_{i=1}^m ~ p(z) a batch of prior samples.
        g_w ← ∇_w [ (1/m) Σ_{i=1}^m f_w(x^(i)) − (1/m) Σ_{i=1}^m f_w(g_θ(z^(i))) ]
        w ← w + α · RMSProp(w, g_w)
        w ← clip(w, −c, c)
    end for
    Sample {z^(i)}_{i=1}^m ~ p(z) a batch of prior samples.
    g_θ ← −∇_θ (1/m) Σ_{i=1}^m f_w(g_θ(z^(i)))
    θ ← θ − α · RMSProp(θ, g_θ)
end while
```

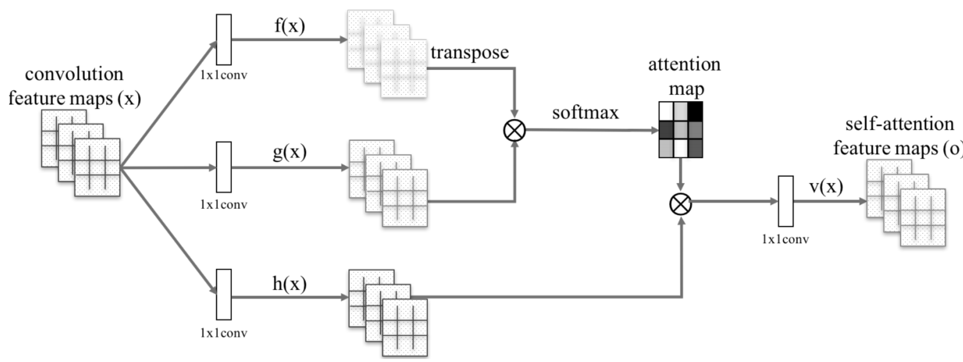
The critic loss here is equal to the difference between average critic score on real images and average critic score on fake images and the generator loss is negative of average critic score on fake images. This is precisely how the loss is implemented for graph-based Deep Learning frameworks such as PyTorch and TensorFlow.

One of the use cases of WGAN in healthcare is as shown in the paper Ensuring electronic medical record simulation through better training, modeling, and evaluation. When dealing with EMR (Electronic medical records) need to make sure that the data is safe and is not used otherwise. So, when the data is less in quantity, generate synthetic data using GANs which are similar to original data but while dealing with EMR this is not the case, the generator model doesn't learn much and is not able to generate proper data resulting in abnormal data. So as shown in (Ziqi Zhang,2020) the authors used WGAN as it showed much more promising results when compared to regular GAN.

Big Generative Adversarial Networks (BigGAN)

BigGAN is used to create high-quality and high-fidelity images from original images. It includes some more things around the basic GAN such as model params, larger batch sizes, and some architectural changes which enhance the ability to super-resolute the images (Brock A.,2019). The number of parameters is increased by 2 to 4 times and the batch size is increased by 8 times the original batch size. The architecture also introduces new trich known as the "truncation trick" when generating an image which results in a drastic improvisation in image quality and along with it the authors also had to add a regularization technique that supports the trick better. This is the heart of the experiment which is capable of generating images of size 256x256 or 512x512 pixels.

Figure 4. Architecture of SAGAN (Zhang, H.,2019)



Progressive Generative Adversarial Network

Progressive GANs is similar to BigGAN where it generates images of higher quality but unlike BigGAN, it has layers that gradually add the sizing to the image. This came into existence as the basic GANS are good at creating smaller size images, they don't work on large size images. Progressive growing GAN is a stable approach to training GAN models to generate large-high-quality images that involve incrementally increasing the size of the model during training. Generating larger images is difficult as the loss function lags in determining the basic building block for this model is Self-Attention GAN (Zhang H.,2019) in SAGAN introduced a new way of mapping the features known as attention mapping which allows the discriminator and the generator to focus on different parts of the image rather than the whole, the basic architecture shown in figure 4. The loss used here is Hinge Loss (Lim,2017), which is mostly used to train support vector machines (SVMs). Here both the generator and discriminator have trained alternatively which results in minimizing the hinge loss. There are even 2 versions of BigGAN, one is the normal version as discussed above and the other is BigGAN-deep which uses Resnet modules at the discriminator part which achieved more accuracy as compared to the original model's discriminator.

a large number of pixel matrices and hence is difficult for it to find the difference between original and generated images. Here due to the large size of images, uses smaller batch sizes which are also known as minibatch. And as the name suggests the initial layers are for the smaller image size and it "progressively" increases the output size to generate a large image. The start can be with an image size of 4x4.

As seen in figure 5 the output dimensions increase gradually as a result the model learns to discover patterns in the images much better. The new layers are added as shown in figure 6. For generating images of size 1024x1024 from an image of size 1x1. Table 1 shows the model architecture used in the paper itself. A pixel-wise normalization is performed in the generator after each convolutional layer that normalizes each pixel value in the activation map across the channels to a unit length.

Figure 5. Example of Progressively Adding Layers to Generator and Discriminator Models (Karras T.,2018)

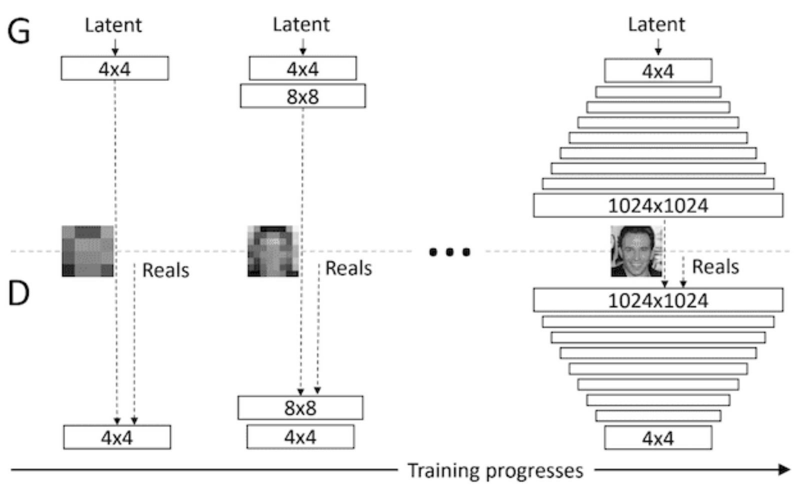
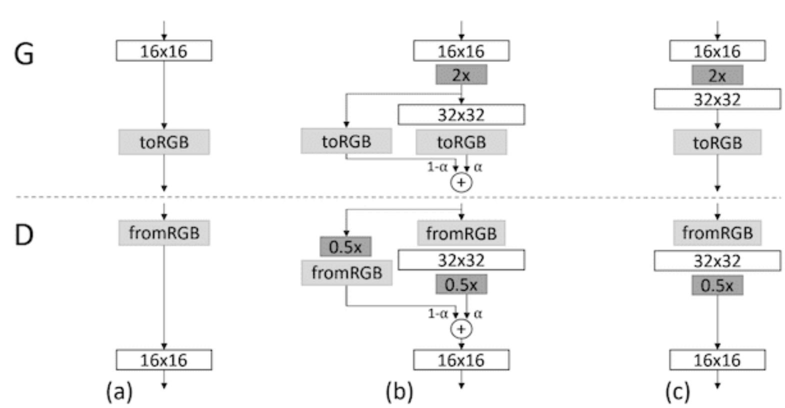


Figure 6. Example of Phasing in the Addition of New Layers to the Generator and Discriminator Models (Karras T, 2018)



The best use case of this can be in generating images that are to be precise, for example, it can be used to create pathological whole slide images which are mostly 2000x2000 pixels. As the information in that image is very critical, every single pixel is used to train the model to classify the images or to analyze them. Mostly the images can be enlarged and super-resolution can be obtained using this approach to make it easier for the model to learn. But this comes with the cost of needing extensive resources to train such a model as the parameters are in millions if not in billions and it's difficult to accumulate such a model on a personal GPU, but it can be used on a commercial Datacenter where the resources are available to train such heavy models. Also, one way to train this is by reducing the batch size as discussed earlier.

CYCLIC-CONSISTENCY GENERATIVE ADVERSARIAL NETWORKS (CYCLEGANS)

(Brock A.,2019; Jun-Yan Zhu,2020)

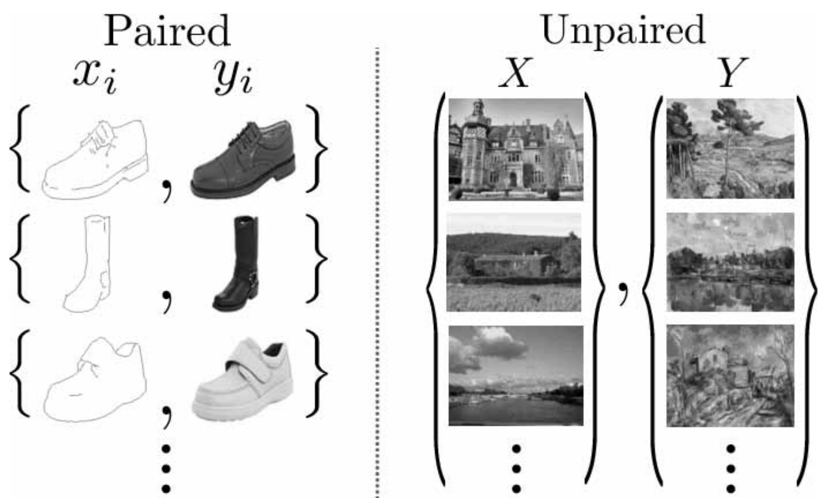
Unpaired Image to image translation is recent research that is capable to convert the images of one domain to another. This type of GAN uses 4 models in total, 2 generators, and 2 discriminators. One generator generates an image from one domain to another and one of the discriminators classifies it whether the translated image is similar or not. Once again, the other generator is fed the output of the first generator and the second generator tries to generate the image as it was initially, this is before translation which is then fed to the second discriminator which classifies it as the initial image or not. Before CycleGANs the method used for this purpose was pix2pix translation but it needed paired images as input and that is not possible every time as the training data is not available as paired image and are in some cases even scraped from the internet where pairing can be very time consuming and that too only if possible. here there is no pairing in the images which means that you can input 2 folders/directories of images one of which will be the image to be translated and the other will represent the target class of image. Let's say want to transform a zebra image to a horse image then it is not at all possible to find a dataset that has an image of a horse and zebra with the same background and lighting conditions in the same pose. Here both the generators and both discriminators are trained simultaneously. An example of how the dataset differs in paired translation and unpaired translation is shown in figure 7.

Cycle consistency is a concept from machine learning mostly used in text translation where if required to translate a sentence from English to french then the model will first translate the text from English to french and then will again try to transform that text into English which if generated properly will be considered as a success, other all the outcomes are considered as fail. Here a loss function is used to check the similarity between the generated image from the second generator and the image which is fed to the first generator. The loss function can be somewhat like mean squared error where every pixel of both images is compared and the mean squared of the difference is calculated to check the ability of the generator model. Let's take an example of converting images from summer to winter so the cycle would be such as;

- **Forward Cycle Consistency Loss**:
    - Input photo of summer (collection 1) to GAN 1
    - Output photo of winter from GAN 1
    - Input photo of winter from GAN 1 to GAN 2
    - Output photo of summer from GAN 2

    - Compare the photo of summer (collection 1) to photo of summer from GAN 2
- **Backward Cycle Consistency Loss**:
    - Input photo of winter (collection 2) to GAN 2
    - Output photo of summer from GAN 2
    - Input photo of summer from GAN 2 to GAN 1
    - Output photo of winter from GAN 1
    - Compare the photo of winter (collection 2) to a photo of winter from GAN

Figure 7. Paired training data (left) consists of training examples and unpaired training data (right) (Jun-Yan Zhu,2020).



The use cases of this type of GANs can be many, one of which is in the entertainment industry where you can change the background and the lighting of the scenes as per figure 8. Another example is to convert photos to paintings as mentioned in (Brock A.,2019) also another interesting use case is in converting maps from grid view to satellite view. The comparison of different translation algorithms is shown in figure 9. There is however an issue of change in color of images in simple translation for which have an identity loss function in cycle gans which prevents it from changing the color in an image.

Style Based Generative Adversarial Networks (StyleGANs)

Style generative adversarial networks or as known as StyleGAN is an extended version of basic GANs where the generator model is modified largely including the latent space's mapping points which are here mapped in an intermediate latent space that can be used to change the style of the generated image. The modified architecture not only can generate clear and photorealistic images but also gives us full control of how the image should look (Karras T.,2019).

Figure 8. Given any two unordered image collections X and Y, automatically "translate" an image from one into the other and vice versa:(left) Monet paintings and landscape photos from Flickr;(center) zebras and horses from ImageNet;(right) summer and winter Yosemite photos from Flickr. Example application(bottom): using a collection of paintings of famous artists, the method learns to render natural photographs into the respective styles (Brock A.,2019).

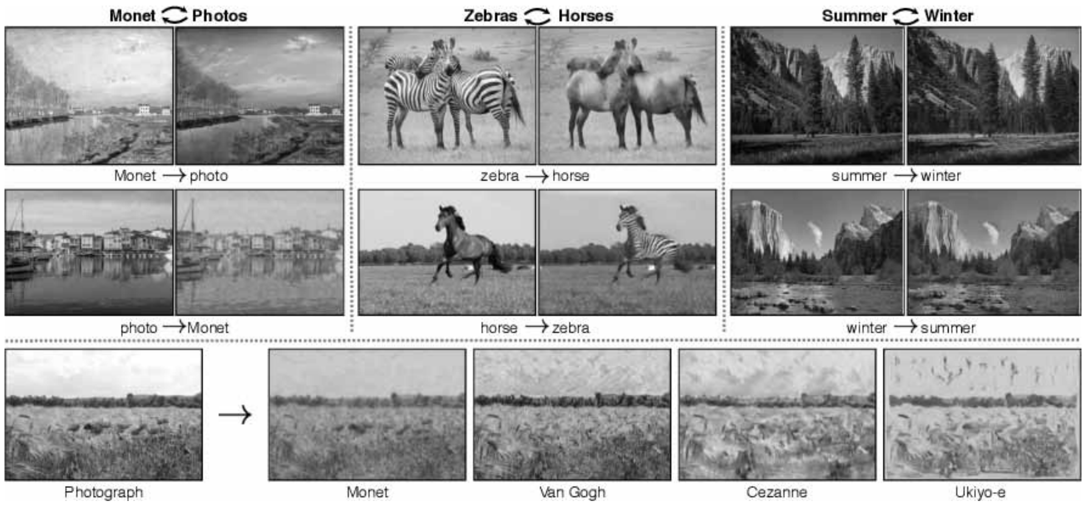
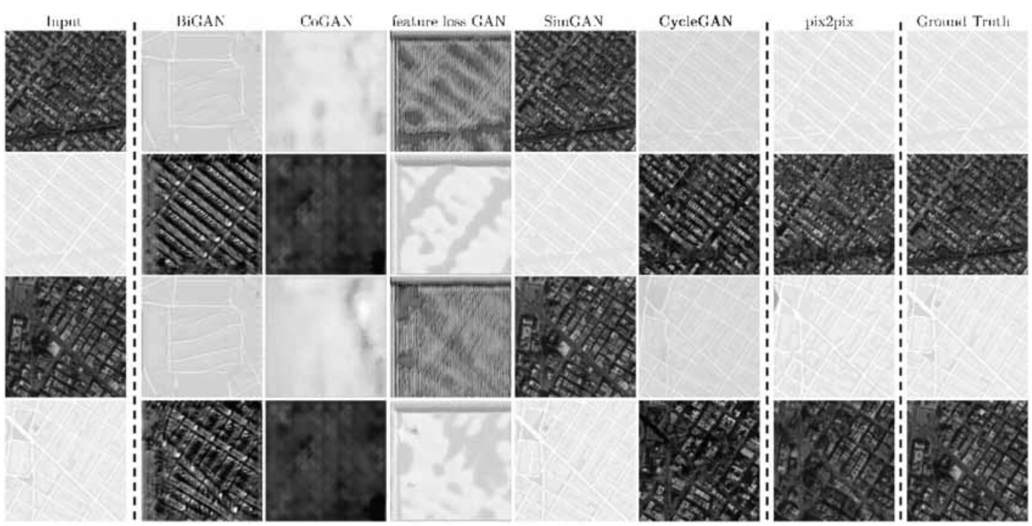


Figure 9. Comparing different methods to translate the image of ariel photos to google maps satellite view



There are many advancements in the discriminator model over the years but people don't tend to change the architecture of generator models which is focused on in this paper. Here the generator starts the learning process from constant input and then it changes the style of the image at every convolution layer which gives the model control over the feature learning at different scales. The modifier version leads to an unsupervised learning method where the model automatically learns the separation of high-level features such as the pose, lighting, etc. And the stochastic variation in generated images. The architecture of StyleGAN is as shown in figure 10.

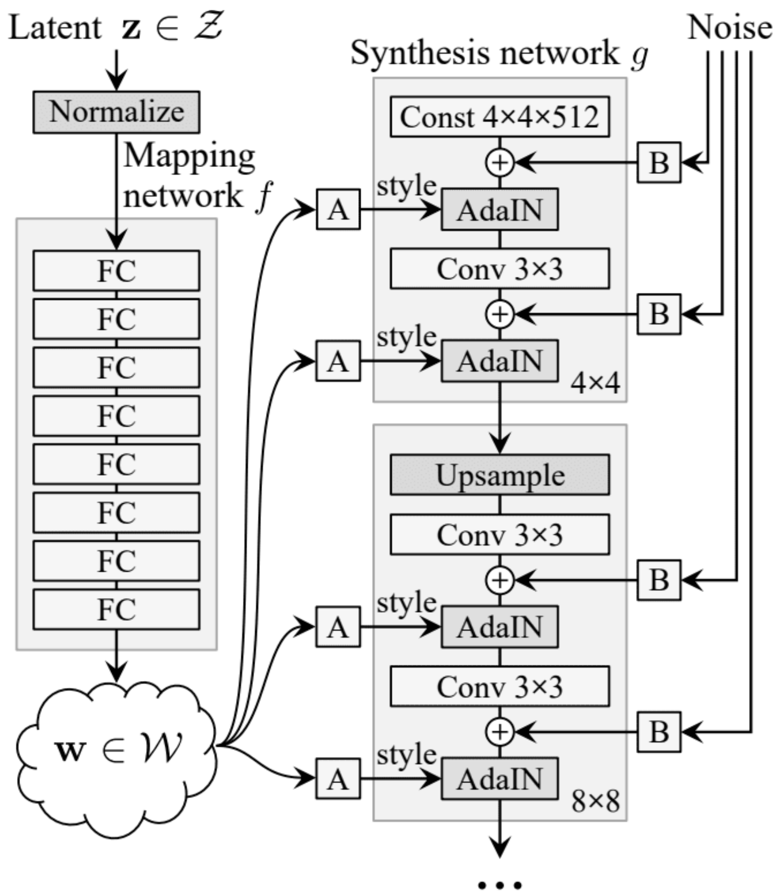
Table 1. Generator and Discriminator Configuration for the Progressive Growing GAN.

Generator	Act.	Output shape	Params	Discriminator	Act.	Output shape	Params
Latent Vector Conv 4 × 4 Conv 3 × 3	- LReLU LReLU	512×1× 1 512×4×4 512×4×4	- 4.2M 2.4M	Input Image Conv 1 × 1 Conv 3 × 3 Conv 3 × 3 Down Sample	- LReLU LReLU LReLU -	3×1024×1024 16×1024×1024 16×1024×1024 32×1024×1024 32×512×512	- 64 2.3K 4.6K -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	512×8× 8 512×8×8 512×8×8	- 2.4M 2.4M	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	32×512×512 64×512×512 64×256×256	9.2K 18K -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	512×16×16 512×16×16 512×16×16	- 2.4M 2.4M	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	64×256×256 128×256×256 128×128×128	37K 74M -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	512×32×32 512×32×32 512×32×32	- 2.4M 2.4M	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	128×128×128 256×128×128 256×64×64	148K 295K -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	512×64×64 256×64×64 256×64×64	- 1.2M 590K	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	256×64×64 512×64×64 512×32×32	590K 1.2M -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	256×128×128 128×128×128 128×128×128	- 295K 148K	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	512×32×32 512×32×32 512×16×16	2.4M 2.4M -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	128×256×256 64×256×256 64×256×256	- 74K 37K	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	512×16×16 512×16×16 512×8×8	2.4M 2.4M -
Up Sample Conv 3 × 3 Conv 3 × 3	- LReLU LReLU	64×512×512 32×512×512 32×512×512	- 18K 9.2K	Conv 3 × 3 Conv 3 × 3 Down Sample	LReLU LReLU -	512×8×8 512×8×8 512×4×4	2.4M 2.4M -
Up Sample Conv 3 × 3 Conv 3 × 3 Conv 1 × 1	- LReLU LReLU Linear	32×1024×1024 16×1024×1024 16×1024×1024 3×1024×1024	- 4.6K 2.3K 51	Minibatch stddev Conv 3 × 3 Conv 4 × 4 Fully Connected	- LReLU LReLU Linear	512×4×4 512×4×4 512×1× 1 1×1× 1	- 2.4M 4.2M 513
Total trainable parameters			**23.1M**	Total trainable parameters			**23.1M**

Here this model is trained using the progressive GANs method that is by taking a very small image size and then gradually increasing the size of an image. Here unlike Progressive GAN's near-neighbor up-sampling/down-sampling, bilinear sampling is implemented which is done by lowpass filtering the activation layers with a separate 2nd order binomial filter after every up-sampling and before every down-sampling. Both the latent and the intermediate spaces are set to 512 dimensional and a standard deep neural network is implemented.

One of the use cases of this type of GANs can be in creating facial images or changing them. Another major use case is to generate cartoon images by animators so that they don't need to design a whole new character from the start. In healthcare, this can be used in generating different structures and networks of the drugs which can then be tested in the lab (Vikram Jeet Singh,2015). The side effect of this technology is that people can create deep fakes that are faces that look like real people but don't exist in real life and as a result, it can be broadcast on the internet with some modifications to spread negative news, etc. The figure11 shows some examples of how this technique is used to create human faces.

Figure 10. StyleGAN Generator Model Architecture (Fathy Rashad,2020)



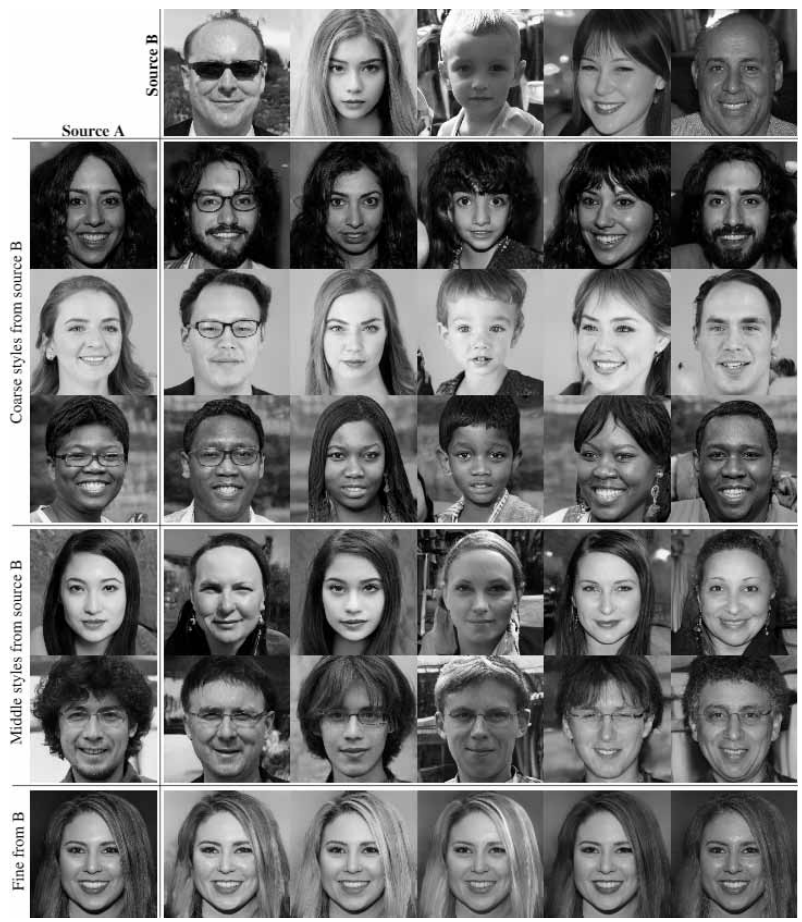
APPLICATION OF GANS IN HEALTHCARE

Creating Magnetic Resonance Imaging From Computed Tomography Scan

Currently, Computer Tomography (CT) based radiotherapy is used to plan radiotherapy for a patient. Considering the segmentation of tumors and organs then Magnetic resonance imaging plays a very vital role. But the disadvantage to that is the high expense and the usage of metal implants which can be harmful during the Magnetic Resonance Imaging (MRI) scans. Some of the metal implants which can be a hurdle here are cardiac pacemakers and artificial joints. Whereas there are some advantages of Computer Tomography (CT) scans over MRI such as differentiating the tissue with higher resolution and fewer motion artifacts due to the enormous imaging speed.

So, to address this problem, a team of researchers from South Korea along with Pusan National University Hospital have used Generative adversarial networks (GANs) to create Magnetic Resonance Imaging (MRI) from Computer Tomography (CT) scan images which are known as Manifold Regularized-synthetic generative network (MR-GAN). The GAN was trained in such a way that it can take a 2-dimensional brain Computer Tomography (CT) image and transform it into 2-Dimensional Magnetic resonance image slices. The losses used here to evaluate the performance of the GANs included adversarial loss, voxel-wise loss, and dual cycle-consistent loss. The cycle-consistency loss is used when required to transform images in an unpaired manner, which means that the image fed into the GAN is not paired with any output image making it more generalized to transform. Considering dual cycle-consistency loss, there are a total of 4 cycles that are performed while training the model. The cycles are: forward paired-data, backward paired-data, forward unpaired-data, and backward unpaired-data. During the training, both the generative and discriminator model were trained simultaneously where the generator generates a synthetical image as identical as the output class which here is the Magnetic Resonance Imaging (MRI) image and the discriminator classifies it whether the image is from the original Magnetic Resonance Imaging (MRI) images or a synthetically generated image.

Figure 11. Sample human faces created by Progressive GAN.



After the training of the Magnetic resonance Generative adversarial Network, the model was tested in the wild on different Computer Tomography (CT) images and Magnetic Resonance Imaging (MRI) images of 202 patients. And the results observed here were amazing where unlike traditional existing models the MR-GAN utilized the discriminator's adversarial loss whereas the cycle-consistency loss was obtained from the unpaired and paired training data and voxel-wise loss based on the synthetically generated image data to that of the original Magnetic Resonance Imaging (MRI) images. The lowest obtained mean absolute error was 19.36 ± 2.73 and the highest Peak signal-to-noise ratio obtained is 65.35 ± 0.86 (Jin C.,2019)

Medical Image Synthesis for Data Augmentation and Anonymization Using Generative Adversarial Networks

Machine learning is used to generate synthetic MRIs to advance medical research. A challenge in medical research was the imbalance meant in data to perform experiments on, which has been easier than ever before by using Generative adversarial networks (GANs). GANs are used to recreate images with the features matching the original image with the least error. The medical researchers for the first time are using GANs to generate unusual MRI images to train a neural network to distinguish between real and fake or abnormal images. A team of researchers has used deep-learning methodologies to generate accurately reliable synthetic images (Nefi Alarcon,2018).

In 2018, an American biotech firm named Insilico Medicine was specializing in drug discovery and aging research. They used GANs and a method is known as reinforcement learning where the agent that is the model learns all by itself and combines them. They used this technique to build an Adversarial Threshold Neural Computer (ATNC) model which was used to design the de novo organic molecules which come with some defined set of pharmacological properties. In 2018, a group of researchers from the Institute of Electrical and Electronics Engineers also showcased that an artificial intelligence model when trained using GAN-generated synthetic data for classifying tissue reached an accuracy of 98.83%.

Generating Synthetic Retinal Images

Synthetic generation of eye fundus image is a challenging task in today's era. It has been addressed previously too but the methods were very complex as they used the features extracted by the anatomy of eyes (Costa P.,2017). Images can then be generated using these features. But it requires some method that can do the work without performing the anatomy of the eye and can learn the features just by looking at the image. For this method, the researchers paired the eye fundus images with their respective vessel tree using vessel segmentation techniques. Then a mapping from the binary vessel tree is used to generate images from the pairs generated above. And for this image-to-image translation is used. When checking the images generated by GANs, they were visually different from original images but were mapped to the same vessel tree.

Generating Multi-Label Discrete Patient Records Using GANs

Access to EHR data has motivated the advancements in computation in healthcare research (Edward Choi,2017). However, there are some problems that are still a barrier in medical research. One of them is patient privacy which needs to be the main concern when sharing data with a research lab. The data cannot mention the name of the patient and has to be anonymous. This is possible in the textual data but is not easy in image data where sometimes the name or identity is mentioned on some part of the image. So, cleaning the image is a huge responsibility, but is not easy when dealing with thousands of images. So, a recent study has created a GANs which is known as MedGAN which can solve this problem and is healthcare-specific. MedGAN is a GAN that can generate real-like data from patients' data which can be used in collaborative research. Based on input real patient records, medGAN can generate high-dimensional discrete variables (e.g., binary and count features) via a combination of an autoencoder and generative adversarial networks.

Skin Lesion Synthesis With Generative Adversarial Networks

Skin cancer is the most diagnosed cancer type compared to others. Early detection of it can save many lives by increasing the chances for successful treatment. Currently, the most used technique is a Deep neural network for classifying skin cancer images. But the problem is the lack of annotated data which requires experts in the field and is expensive. To bypass this, generative adversarial networks are used to generate realistic skin lesion images.

Controlled Generation of High-Resolution Mammograms for Radiology Education

During the training phase, radiology trainees are supposed to interpret thousands of mammograms to become an expert in knowing the patterns which can mention whether the slide image contains benign or malignant cells (Zakka C., 2020). But unfortunately, the trainees are not given access to real images due to legal issues. So, in a recent study, researchers created a GAN to solve this issue, the output of these GANs is 512x512 high definition as the image can be clear and the trainee can perform the best of experiments on it. The resulting model leads to the unsupervised separation of high-level features (e.g. the standard mammography views and the nature of the breast lesions), with stochastic variation in the generated images (e.g. breast adipose tissue, calcification), enabling user-controlled global and local attribute-editing of the synthesized images. Here the researchers demonstrate the model's ability to generate medical mammograms by obtaining an AUC of 0.54 in a double-blind study on four expert mammography radiologists to distinguish between generated and real images, ascribing to the high visual quality of the synthesized and edited mammograms, and their potential use in advancing and facilitating medical education.

Chest x-rays are a very important and critical tool that is used for diagnostic diseases in many patients. It is capable of visualizing combinations of conditions (Segal B.,2020). The diagnostic tools (Kanupriya Verma,2019) require a lot of labeled data and the needs are never satisfied due to the lack of image data. Previous research and study show that GANs were used to create such synthetic data which can be shared without any permissions and so there are no concerns of patient's privacy. These approaches cannot be scaled as they introduce computational trade-offs between model size and class number which places fixed limits on the quality that such generates can achieve. This can be solved using multimodal sampling GANs with getting labeled data. The authors used Progressive growing GAN to process the images in an unsupervised way where after generating images the radiologists would check it manually.

CONCLUSION

In this article summarized a brief overview of different applications of Deep Learning/Machine Learning techniques in the healthcare/medical sector. Followed by is the introduction of Generative Adversarial Networks along with an answer to the question "Why GANs over traditional Machine Learning?" and what can be different applications of GANs in the various sectors? Covered various types of GANs along with the loss function and usage of each variation along with the applications of different GANs concerning the medical domain. In the end, the future scope is discussed as the technique of generating synthetic data is still in the research phase and as discussed above, many limitations still need to be addressed to make it accessible in every domain.

Future Scope

There are many use cases where GANs have been proved to be a game-changing technology but still, there are some problems that need to be addressed in the future. Some of them can be changing the architecture of the generator to a mutation of autoencoders which can be beneficial in obtaining the images as well as extracting the information from the bottleneck and using it for clustering purposes. Another possible scope is to change the architecture to a somewhat less resource-hungry process where the resources and the inference time can be shortened.

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Chapter 4
An Intelligent Approach for Detecting and Preventing Heart Attacks Using Wearable Technology

Boopathi Raja G.
Velalar College of Engineering and Technology, India

ABSTRACT

Health-related parameters and issues are extremely important to man's existence and influence. Diabetes mellitus, high cholesterol, and high blood pressure can all cause a blockage of the coronary arteries, resulting in heart palpitation. Various systems use an alarm to display the current state of a patient and are capable of tracking the human body's medical parameters. A defibrillator device with an alert system has been implemented for low-cost, efficient, and flexible heart rate detection and control. The sensors monitor and calculate heart rate, body temperature, and sweat and send the signals to the control device for processing. The local system will issue an alert if there is a significant difference between the normal and measured heart rates, body temperature, or sweat rate. This system monitors heart rate in a constant, real-time, stable, and precise manner. If an abnormality in the patient's heartbeat is observed, the defibrillator can deliver a shock to the patient's external body as a buzzer emits a beep to warn nearby people.

1. INTRODUCTION

Presently, heart failure is considered the most important factor for the rising mortality rate that strikes unexpectedly. Predicting a heart attack in the first instance is difficult, but it is still possible to heal as much as possible, (Lee J, 2011). Heart disease suffers will experience a dramatic improvement in their quality of life. If emerging innovations are broadly employed, improved healthcare systems are possible.

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People's lives are being transformed by the emergence of smart wearable IoT systems for health monitoring. In recent years, medical services have advanced dramatically. Wireless communication technology has the potential to expand the range of services available to patients, (S. Jagtap, 2017). The quality of patient's life would improve as a result of this innovation, and a large segment of the population would benefit.

The idea of interconnected healthcare systems and advanced integrated IoT devices may benefit both businesses and individuals. The objective is to use new technology research to support new design, development, and extension of extended medical systems, with the target of establishing a solution that enables individuals better understand the medical status and provide prior healthcare suggestions as well as recommendations, (G. Kavitha, 2017).

With the growing popularity of wearable technology, the possibility of supplying an IoT solution has grown, (G.Boopathi Raja, 2021). People who have suffered abrupt cardiac arrests have a dismal likelihood of survival outside of the hospital. The goal of this project is to create a multimodal system that collects Body Area Sensor data and provides immediate notification of sudden cardiac arrest using an intelligent IoT framework. The goal is to design and build an embedded Internet of Things system that includes a low-power communication module. This module can gather body temperature and pulse rate using a smartphone without interfering with daily life. By integrating machine-learning and signal processing techniques, this research shows how to employ sensor predictive analytics to accurately forecast and/or diagnose abrupt cardiac arrests.

Patients can monitor and change their lifestyle factors according to the accessibility and innovation of wearable IoT devices. One of the advantages is that a patient may be informed about the condition of their ailment at any moment using such gadgets. The information may subsequently be shared with the on-site medical expert, allowing them to act immediately in an emergency or save the user's life. The application of new technologies in connected health has been demonstrated to be a significant use case.

The purpose of IoT is to allow things to connect with anything and anybody at any time and in any location, preferably via any network and any service. More advancement in a variety of areas, including communication and applications, is required to achieve this goal. Development efforts are carried out by several research and development organizations.

The proper definition of the Internet of Everything (IoE) was provided by Cisco. It is nothing but the integration of people, data, things, and processes in networks of connections. Also, it is defined as a network of computers and devices of all sorts and sizes interacting and exchanging information. Cisco predicts that 50 billion devices will be connected to the Internet in the year 2020.

According to a special dedicated IEEE standard, the Internet of Things (IoT) is defined as the framework having the integration of physical objects along with interconnected people, (G.Boopathi Raja, 2021). Through smart networking, pervasive data gathering, predictive analytics, and optimization, it may be able to handle ICT facilities to create, run, and manage the physical environment. This standard defines a reference model of IoT that specifies architectural building blocks and permits the formation of relevant systems, (M. Soliman, 2016).

One of the critical facilitators as the Internet develops is the universal adoption of IPv6, which allows for the pervasive identification of any connecting "smart device". It will enable new IoT connectivity and integration models by connecting customers to billions of smart devices. As the network grows, new requirements for network services, network administration, and network composition will emerge.

IoT security is one of the most important concerns due to the need to secure the rising amount of integrated devices. For example, ensuring that IoT devices only share data with authorized people is critical. Although many recent devices were developed with advanced technologies, most of them are miniaturized in size and have a low power requirement. However, almost all IoT hardware development faces several significant research challenges. Furthermore, communication protocols must be used to connect IoT sensor devices to the Internet. These protocols must take into account the sensor battery's low energy capacity, which is especially important when sensors are installed in remote places, (G.Boopathi Raja, 2021 & E.Sardini, 2015).

To manage the usage of decreased power in IoT devices, several protocols have been established, with more to come in the future. For IP-based ubiquitous sensor networks, for example, a reliable service announcement and discovery protocol is recommended. To provide optimal acquisition speeds, minimal energy consumption, and minimum produced overhead, the protocol uses a completely distributed method with rapid topology modifications. The protocol may achieve ideal acquisition times while consuming the least amount of energy and generating the least amount of produced overhead, making it suited for mobile networks.

Many devices may accept User Data Protocol may run Constrained Application Protocol (CoAP), and the network architecture that uses this protocol is a significant research area. Bluetooth, Zigbee, and other protocols and networks such as Wide Area Network (WAN), Local Area Network (LAN), etc., are used by IoT devices. As a consequence, an IoT platform consists of three distinct elements: IoT-based systems use cloud computing as an enabler, allowing a large number of devices and sensors to be linked. Instead of developing separate procedures for every sensor to connect directly, IoT-based smart technologies can leverage Cloud Computing platforms to simplify sensor connection, (G. Shanmugasundaram, 2017 & Poorejbari S, 2016).

The patient who received the first attack could be subjected to a second attack as well. Four parts from this package are attached to the patient's body (Heart rate sensor, temperature and sweat sensor, Defibrillator electrodes). The heart attack diagnosis is achieved here by combining the values of three sensors. The heart rate sensor, temperature sensor, and moisture sensor threshold values have been pre-programmed into the Node MCU 12E module; if those threshold values are met, a heart attack is detected, and the appropriate minimum amount of shock is applied to the victim. One android program is used to track the heart rate and current position of the caregiver (relative). The measurements from the sensors, as well as the GPS position, are continuously posted to the cloud firebase website, which can be accessed through a web browser using the created URL connection, (G. Boopathi Raja, 2021).

The outline of the chapter is described as follows. Section 2 explains cardiovascular diseases and also, overview, symptoms, and diagnosis of a heart attack. Section 3 describes the various heart assist devices such as Implantable Cardioverter Defibrillators, Biventricular Devices, Pacemakers, and Implantable Cardiac Loop Recorders. The various existing works related to the framework for the detection of heart attack were described in section 4. Section 5 explains the concept of the proposed framework along with a block diagram and circuit diagram. Section 6 describes the results and discussion of the proposed system. The chapter ends with a conclusion and future work in section 7 and 8 respectively.

2. CARDIOVASCULAR DISEASES (CVDs)

Coronary heart disease, cerebrovascular illness, peripheral arterial disease, rheumatic heart disease, pulmonary embolism, congenital heart disease, and deep vein thrombosis are all examples of cardiovascular illnesses. In 2016, CVDs claimed the lives of 17.9 million people globally, accounting for 31% of all deaths. Heart attacks and strokes were responsible for 85 percent of these fatalities, (https://www.who.int/india/health-topics/cardiovascular-diseases).

Over 75% of CVD fatalities occur in low- and middle-income countries, with high blood pressure being one of the most significant risk factors for CVDs. In 2016, India accounted for 63 percent of all fatalities related to NCDs, with CVDs accounting for 27 percent of all fatalities. CVDs are also responsible for 45 percent of mortality in those aged 40 to 69.

People who are at the critical stage of CVD have high blood pressure, glucose, and cholesterol levels, as well as being overweight or obese. Identifying people who are most at risk for CVDs and ensuring that they receive adequate treatment can help to reduce early deaths.

2.1 HEART ATTACK

2.1.1 Overview

A heart attack may occur usually whenever the supply of blood in the heart is cut off. Plaque (coronary arteries), deposition of fat, cholesterol, and other materials in the arteries feeding the heart, is the most common cause of obstruction, (https://www.mayoclinic.org).

When a plaque ruptures and forms a clot, bleeding becomes blocked. If blood flow is interrupted, heart muscle segments may be injured or destroyed. Even though a heart attack is otherwise called a myocardial infarction. This can be fatal; treatment has significantly improved over time.

2.1.2 Symptoms

The following are some of the most common signs and symptoms of a heart attack:

§ a crushing or painful feeling in the chest or arms that may extend to the neck, jaw, or back
§ Fatigue
§ Cold sweat
§ Lightheadedness or sudden dizziness
§ Nausea, gastritis, acidity, or stomach discomfort
§ Shortness of breath

Some people have moderate discomfort, while others have very severe suffering. Some persons have no signs or symptoms. Acute cardiac arrest may be the first sign for others. Although some heart attacks occur unexpectedly, many people have warning signs and symptoms hours, days, or weeks before they have a heart attack. The initial symptom might be recurrent chest discomfort or pressure (angina) that is brought on by exertion and relieved by rest. Angina is a condition in which the blood flow to the heart is restricted for a short length of time.

2.1.3 Diagnosis

The following tests can be used to identify a heart attack, [12]:

1. **Electrocardiogram (ECG).** This is the first test used to diagnose a heart attack. It captures electrical impulses as they travel through the body, including the heart. The chest and arms are covered in electrodes (adhesive patches). Signals are captured in the form of waves that can be viewed on a computer screen or printed on paper. Because the injured cardiac muscle cannot transfer electrical impulses normally, an ECG may indicate that a heart attack has occurred or is happening.
2. **Blood tests.** Some cardiac proteins gradually leak into the circulation after a cardiac arrest. Doctors in the emergency room will examine these proteins, or enzymes, in the blood.

2.1.4 Additional Tests

1. **Chest X-ray.** The doctor can assess the size of the heart and blood arteries, as well as look for fluid in the lungs, using chest X-ray imaging.
2. **Echocardiogram.** The beating heart is visualized via ultrasound waves. The doctor can perform this test to observe how blood flows through the heart's chambers and valves. If the heart has been damaged in any manner, an echocardiogram might disclose it.
3. **Coronary catheterization (angiogram).** A long, thin tube (catheter) is introduced into the arteries of the heart through an artery, usually in the leg or groyne, and a liquid dye is injected into the arteries of the heart. The dye makes the arteries visible on an X-ray, showing obstructions.
4. **Cardiac CT or MRI.** During these tests, images of the heart and chest are generated. Cardiac MRI uses a magnetic field and radio waves to generate pictures of the heart. In cardiac CT scans, X-rays are employed. Each one may be used to determine the severity of heart attack damage and detect cardiac problems.

In Table 1, the most frequent forms of CVD are given, along with often used alternate descriptors. It is better to constantly improve on some of the more prominent keywords that humans may come across, as well as their meanings, (https://www.open.edu).

Table 1. Most dominant category of cardiovascular illnesses, along with acronyms and/or other names

Disease	Abbreviations and alternative names
Arrhythmia	Abnormal or irregular heart beats
Cardiovascular Diseases	CVDs
Heart Failure	congestive heart failure, acute or chronic heart failure
Myocardial Infarction	MI
Stroke	cerebrovascular disease
Coronary Heart Disease	CHD
Hypertension	high BP or elevated blood pressure
Congenital defects	Defects in heart or valve during birth onwards
Atherosclerosis	Furred up or hardened arteries
Angina Pectoris	Chest Pain or angina

BROAD DEFINITIONS OF CARDIOVASCULAR DISEASES

The preceding are some general definitions that might help people understand the many types of CVDs, (https://www.open.edu).

- § Arteries, veins, and smaller vessels are the blood vessels that are referred to as vascular, while the deployment of blood vessels inside the body is known as vasculature.
- § The fat deposition or accumulation of cholesterol inside of the blood vessel wall causes atherosclerosis (hardened or furred-up arteries), which can constrict the artery and impede blood flow.
- § Ischaemia occurs when the blood flow within the blood arteries is restricted, causing tissue injury.
- § Angina pectoris is a term for chest pains caused by ischaemia, which are common during activity.
- § The most prevalent kind of heart disease is Coronary heart disease (CHD). In this case, the blood flow to the heart muscle is reduced due to narrowing or blockage of the coronary arteries. Myocardial Infarction, Angina Pectoris, and Atherosclerosis of the coronary arteries are common symptoms, leading to sudden failure of the heart.
- § When the blood supply to a portion of the heart is blocked, myocardial infarction (MI) develops. If the heart's blood flow is not restored, a section of the heart will perish, resulting in incapacity or death. The most common cause of sudden heart failure is myocardial infarction.
- § Heart failure is a medical ailment that occurs as a result of a heart attack and is frequently misinterpreted. It occurs when an organ is unable to pump properly and create enough blood flow to fulfill the body's demands, whether at rest or during exercise. When there is external swelling related to fluid build-up, it is referred to as congestive heart failure.
- § Acute heart failure is sometimes referred to as a heart attack. It is caused by myocardial infarction, which occurs when a coronary artery is blocked, but it can also be caused by other events that disrupt the heart's organized electrical activity spread (e.g. arrhythmia, electrocution).
- § Heart attack, heart failure, and myocardial infarction are all words that are sometimes used interchangeably when they have various meanings.
- § Arrhythmia is a heartbeat that is uncontrolled, disorganized, or irregular. It might be quicker or slower than usual.
- § Palpitations are a type of heart problem. When patients perceive a distinct heartbeat, it might be normal, faster, or slower than usual.

Blood pressure is the force created by the heart's pumping as blood is pumped around the body, pushing blood against the walls of the arteries. The greater systolic pressure (when the heart contracts) and the lower diastolic pressure are seen in the measurement of blood pressure (when the heart relaxes).

Blood pressure in adults should be less than 140/90 mmHg (systolic/diastolic). If a person's blood pressure is continuously over 140/90 mmHg, or over 140/80 mmHg if they have diabetes, they are said to have risen or high blood pressure, also known as hypertension. High blood pressure that persists is a risk factor for a variety of cardiovascular illnesses. Excessive pressure can harm an artery's lining, enabling blood clots to develop and causing blockages.

Strokes are caused by blood vessels in the brain that are either blocked or burst. Nearly 50% of all strokes can be avoided by bringing high blood pressure into the normal range. Strokes can vary depending on which part of the brain is damaged, but there is not enough space to get into all the necessary brain anatomy and neuroscience. Strokes can be deadly or profoundly debilitating, although a small stroke can result in a full recovery.

Other less common types of heart disease are congenital heart defects, which some people are born with. Problems with the heart valves or the rhythm of the heart are examples, and these are more common in younger people. People with these diseases may have long-term difficulties or even death if they undergo untreated.

Another term that is alternately used is SADS, which stands for Sudden Arrhythmic Death Syndrome and Sudden Adult Death Syndrome, both of which refer to the same disease. Because SADS may impact youngsters, the first is more correct.

Unexpected cardiac death in young individuals can have a variety of reasons, but occasionally no diagnosis is revealed when a young person dies suddenly. A rapid, uncontrolled heart rate is considered to be the cause of a part of instances (arrhythmia). Long QT syndrome is one of the arrhythmias detected, and it explains why the heart's electrical system takes longer to recharge, leaving the person prone to an abnormal heartbeat rhythm.

If the disease is detected early enough, a tiny defibrillator (to restart the heart) can be implanted, or medications to decrease the heart rate can be taken (for the remainder of the person's life). Without treatment, the brain runs out of oxygen, resulting in fainting or, in rare cases, collapse and death. Because QT syndrome can be carried down from parents and can be triggered by exercise, it has been suggested that all young athletes be tested for the condition.

Many scientific researches have investigated a variety of behavioral cardiovascular risk factors, including smoking, high blood cholesterol, and high blood pressure, as indicated in table 2. A modifiable risk factor, unlike chance, maybe addressed once found to reduce its potential negative influence on the present or future health, decreasing the risk of cardiovascular disease. Because they may be changed by human decision, several of these risk factors are also known as modifiable risk factors.

Table 2. Three types of cardiovascular risk factors: non-modifiable biological risk factors, modifiable biological risk factors that can be changed by therapy or lifestyle changes, and modifiable lifestyle risk factors.

Biological risk factors: non-modifiable	§ Occurs mostly for male § Genetic factor is a major reason § Increasing age § Type-1 diabetes § Race/ethnicity
Biological risk factors: modifiable by treatment or altered lifestyle	§ Due to hypertension(High BP) § Increased cholesterol level in blood § Obesity and overweight § Type-2 diabetes § psychosocial factors, e.g. stress, depression, anger
Lifestyle risk factors: modifiable	§ Due to unbalanced or unhealthy diet § Smoking habit § Sedentary lifestyle or inactivity § Excessive alcohol consumption

3. HEART ASSIST DEVICES

Pacemakers, implanted cardioverter defibrillators (ICDs), biventricular pacemakers, and cardiac loop recorders are some of the cardiac implantable electronic devices used to regulate or track irregular heartbeats in patients with particular heart rhythm disorders and cardiac arrest, (www.nyulangone.org).

Doctors may prescribe using one of these devices if the patients have a ventricular arrhythmia, bradycardia, or a supraventricular arrhythmia like atrial fibrillation or atrial flutter.

After the device is implanted, it gathers data on cardiac rhythm continually. This information is wirelessly transmitted to the cardiac device team, either manually or automatically when abnormalities are identified. They can check the heart's electrical activity remotely whenever they need to, eliminating the requirement for a doctor's visit.

3.1 Implantable Cardioverter Defibrillators

Ventricular arrhythmias, which are life-threatening rapid, irregular heartbeats, are common in people with severe cardiac disease, heart failure, and specific hereditary arrhythmias. In some circumstances, an ICD (implantable cardioverter defibrillator) may be necessary to restore a normal heart rhythm.

For patients with ventricular arrhythmias who haven't responded to previous treatments such as catheter ablation or medication therapy, an ICD is frequently advised.

3.2 Pacemakers

Pacemakers are divided into two categories. The conventional type is implanted beneath the skin and uses electrical leads to connect to the heart. A smaller, leadless pacemaker is implanted into the heart without the need for transvenous leads.

Bradycardia is a condition in which the heart beats too slowly—less than 60 times per minute. Pacemakers are used to treat this disease. The pacemaker transmits electric signals to keep the heart beating regularly.

3.3 Biventricular Devices

A biventricular pacemaker operates similarly to a traditional pacemaker, except it resynchronizes the contractions of the heart's left lower chambers, or ventricles, by sending electrical impulses to the heart through a third wire.

When prescriptions fail to treat the symptoms of heart failure, a disease in which the heart does not pump enough blood to the body and the left chamber does not beat in a coordinated manner, a biventricular pacemaker, also known as a cardiac resynchronization device, is placed. As a result of this, the two ventricles contract at different times. The contractions of the left ventricle are coordinated by a resynchronization device.

Biventricular defibrillators are available for patients who might benefit from resynchronization but also require defibrillator protection. This hybrid device helps to maintain a steady heartbeat while also speeding up or slowing down a heart that is beating too quickly or too slowly. It also records the heart rhythm so that the specialists can analyze overall heart health and adjust the treatment as needed.

3.4 Implantable Cardiac Loop Recorders

A loop recorder is known as a wireless cardiac monitor, it may be recommended by the cardiac electrophysiologist. For up to three years, this gadget captures information on the heart's rhythm.

Similar to an electrocardiogram, or EKG, an implanted cardiac loop recorder, about the size of an AA battery, is placed beneath the skin of the chest area to contain information about the electrical activity of the heart. It's utilized to figure out what's causing arrhythmia and how to fix it.

This device may be useful for those who have experienced unexpected fainting spells or heart palpitations that haven't been recognized by short-term cardiac rhythm monitoring devices like Holter monitors. Doctors may recommend an implanted cardiac loop recorder for patients with atrial fibrillation, which causes a rapid and irregular pulse. This gadget is also utilized in patients who have suffered a stroke for whom the aetiology is unknown.

4. RELATED WORK

The literature available within the context of the study's objectives is summarized in this chapter. There have been several previous studies on the identification and warning mechanism for heart attacks. Previous work on heart attack prediction and warning systems has assisted us in generating more ideas and successfully executing our project. Here are a couple of them that have aided us in generating ideas for our new prototype on detailed detection and alert system.

They used the Internet of Things to incorporate heart rate tracking and heart disease warning technology in this project. The abundance of heart disorders, including an elevated risk of heart attacks, is a threat to human life these days. The sensor is then connected to a microcontroller, which allows the heart rate data to be processed as well as shared through the internet. The maximum and minimum heart rate thresholds will be set by the customer. The system then starts checking, and when the patient's heart rate reaches a certain amount, the system sends an alert to the dispatcher, who then sends it to doctors and other concerned parties over the internet. The computer also alerts to faster heartbeats. When the customer logs up for testing, the system also displays the patient's live heart rate. As a result, concerned people will monitor pulse rhythm and get an alert of a heart attack from everywhere, causing the patient to be saved quickly (Aboobacker sidheeque, 2017 & Vaishnave A.K, 2019).

Health-related criteria and problems are extremely important to man's life and power. Various systems that can catch and track changes in health parameters have been developed. In this article, real-time remote control of heart rate is introduced. The heart rate can be monitored using an alarm and LCD on this system, (S. Banerjee,, 2018). This paper uses a wireless module to incorporate a low-cost, reliable, and scalable heart rate monitoring and warning system. The sensors detect and analyze the heart rate, and the signals are sent to the control system for further study. The heart rate is shown on the LCD by the processor and is then passed on to the warning system. The machine will issue an alarm if there is a significant deviation between the normal and calculated heart rhythms, (Irawati, N., 2020).

Diabetes mellitus, high cholesterol, and high BP may obstruct coronary arteries, resulting in heart palpitation or missed heartbeats in this method. Chest pains can lead to a heart attack if they occur frequently. A prospective heart attack survivor will benefit from timely updates. This work describes a method for measuring heart rate, detecting missed heartbeats produced by premature ventricular contractions (PVCs), and sending heart rate and skipped beat data over the internet to a distant person or physician. The photoplethysmography (PPG) method is used to monitor heart rate by utilizing a pulse sensor and a microcontroller. Since positioning the heart rate sensor on a fingertip, earlobe, or hand, the gadget begins to take real-time values, allowing someone to track their heart rate while on the go, (M. R. K. Badhon, 2019).

In this approach, the period between each heartbeat will change if a patient has atrial fibrillation. These fluctuations in cardiac rhythm can be detected with a non-invasive Photoplethysmography (PPG) sensor. The sensor, which consists of an LED and a photodetector, can detect changes in blood volume or pressure in the body and is connected to heart rate. The signal must be filtered several times because it contains a lot of high-frequency noise as well as low-frequency motion distortions. A portable continuous heart rate monitoring system that increases the diagnosis of atrial fibrillation can be made using the advantages of a lightweight, low-cost Wi-Fi module, (J. B. Bathilde, 2018).

Remote health monitoring systems built along with IoT framework are needed to track and analyze the health of elderly people without interfering with their desire to remain at home. On the other hand, such systems can generate a vast volume of data. The key point of concern is how to efficiently transport healthcare data within the constraints of present network infrastructure, particularly in rural locations, (Pandey, S.K, 2021). This method can be used to move data to a real-time network. The essential network features of a contemporary remote health management system in terms of authentic event updates, bandwidth specifications, and data creation are discussed in this article. We also looked at network communication protocols like HTTP, CoAP, and MQTT, to better understand the requirements of such a system, particularly the bandwidth requirements and data created. After that, IReHMo, Internet-of-Things-based remote health management architecture has been proposed that effectively transmits healthcare data to servers, (Al-khafajiy, 2019). In a healthcare situation, the CoAP-based IReHMo implementation can minimize the quantity of generated data by up to 90% for a single sensor case and the required bandwidth by up to 56%.

Health-related issues and criteria are the fundamental significance to person and are essential to his/her existence and strength. As a result, he or she has been looking for a better system that can detect and track improvements in health indicators independent of time or location, allowing for actions to avoid abnormalities and respond to emergencies. This concept discusses a system that can monitor the pulse remotely in real-time, as well as provide an alarm and SMS warning. This project aims to develop and deploy an economic, accurate, and scalable cardiac monitoring and alarm system using GSM technology. This framework may be set up such that the sensors detect and monitor heartbeat/pulse rate, then send signals to the control system for suitable treatment and display of heartbeat rate on an LCD. If and only if the pulse rate threshold is maximally surpassed, it begins to inform with an alerting and message sent to the mobile phone of a medical expert or health experts, (Arumugam M, 2015). As a consequence, this technique offers continuous, real-time, remote, constant, and exact pulse rate monitoring, which can help with patient identification and early cardiovascular disease therapy, (Miller, J.C., 2021).

It is now possible to link various devices that can collaborate and share data thanks to recent technological advancements and the availability of the Internet. IoT is a relatively recent phenomenon that allows people to link a variety of sensors and mobile devices to their settings to collect data in real-time. However, it has been revealed that the e-Health and m-Health designs lack a stable interface for tracking and transmitting essential data relevant to a patient's well-being via mobile sensors. For patient e-Health, a new semantic framework has been offered. The proposed "k-Healthcare" platform is made up of four layers: a sensor foundation, a network layer, an Internet layer, and a facilities layer. Both layers work together to create a platform for obtaining patient health data via smartphones securely and efficiently, (Bansal S, 2020 & Bayer S, 2021).

4.1 Currently used list of mobile applications for heart beat

Many heart-related disorders, such as arrhythmia, coronary artery disease, and heart infections, are referred to as heart disease. Heart disease affects both men and women for diverse causes, and early diagnosis of cardiac episodes can save lives. There are applications particularly intended to efficiently monitor the heart rate, blood pressure (BP), heart rate, and more, according to advances in technology. People may track their heart activity everywhere they use these applications, and can be used on Apple watches or mobile devices.

a. Qardio

Because of its extensive range of measures, Apple named Qardio the Best Health and Best Medical App in 2017. Blood pressure, irregular heartbeat, BMI, heart rate, weight, BMI, body composition (% of body fat, muscle, bone, and water), heart rate variability (HRV), EKG, respiratory rate, heart rate variability (HRV), calories, steps, and skin temperature are just a few of the parameters that it can measure.

b. Blood Pressure Companion

Blood Pressure Companion allows the users to keep track of their blood pressure readings, analyze them, and share them with their physicians. Other major risk factors for heart disease are heart rate and weight. The app's comprehensive yet easy-to-use charts, graphs, and histograms assist in tracking and analyzing development over time. The data that is input into the programme, such as blood pressure, is visually assessed and may be simply saved as a PDF for simple dissemination to doctors.

c. PulsePoint

PulsePoint transform the way life-saving assistance is provided to cardiac arrest patients. If a medical emergency occurs in a public place, the app employs sophisticated location-based technology to notify trained individuals in the vicinity that CPR is required. The programme also alerts these Rescue Workers to the nearest public access Automated External Defibrillator's exact location (AED).

d. Instant Heart Rate

Instant Heart Rate has been rated the best heart rate app, and it can test the heart rate in less ten seconds. When user presses their finger on the camera on smart phone, the software detects a color change every time your heart beats. The heart rate is then calculated using a sophisticated algorithm. Similar to pulse oximeters used in hospitals, Instant Heart Rate contains a chart that shows users each heartbeat.

e. Cardiio

Cardiio uses MIT-licensed technology to measure heart rate in a unique way. It measures changes in blood flow in user's face to compute heart rate. The blood flow in the face rises with each beat of heart, allowing more light to be absorbed. Cardiio calculates heart rate using the camera on the phone, which captures tiny changes in reflected light from the face.

4.2 Currently used list of mobile applications for temperature

There are several popularly used mobile applications are available for measuring body temperature effectively. Some of them are Finger Body Temperature, Smart Thermometer, Smarttemp, iCelsius, Thermo, iThermonitor, Real Thermometer, and Fever Tracker.

iCelsius.

iCelsius is an excellent thermometer software for Android and iOS that allows users to obtain the temperature on their smartphone quickly and simply. It is a popular digital thermometer that can quickly determine the temperature of a fever.

5. PROPOSED SYSTEM

The proposed work is designed with a Node MCU board, LCD monitor, ATMega 328p, Firebase cloud database (webserver), Heart rate sensor, Temperature sensor, Moisture sensor, and External Defibrillator. The Kodular programme is also used to create a transmitter and receiver app that is connected to the cloud through the Firebase network.

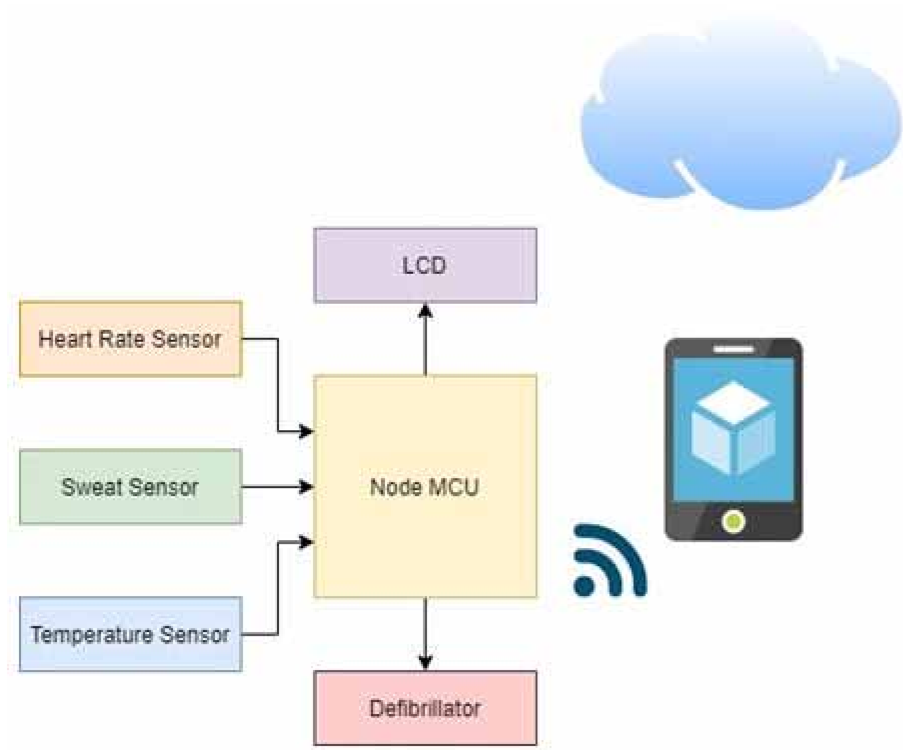
5.1 Block Diagram

Figure 1 specifies the block diagram of real-time heart attack detection and control using a defibrillator device with an alert system.

The proposed system consists of Node MCU, Defibrillator unit, Heart rate sensor, Sweat Sensor, temperature sensor, and other accessories including display unit as well as a communication module. The Node MCU plays an important part in the proposed framework. This proposed setup is attached with a patient who is suffering from severe cardiac problems and the continuous tracking of health status is required. It takes the readings from three sensors. In the Node MCU controller, these values are compared to previously set threshold values. If a match is found, the controller activates the defibrillator while concurrently uploading data to the cloud via the transmitter app, which can be accessed on the receiver app and the Firebase website.

A defibrillator device with an alert system has been implemented for low-cost, efficient, and flexible heart rate detection and control. The sensors monitor and calculate heart rate, body temperature, and sweat, and send the signals to the control device for processing. The control unit in this proposed method is the Node MCU module, which collects data from a heart rate sensor, a temperature sensor, and a sweat (moisture) sensor. The heart rate, body temperature, and sweat rate are displayed on the firebase web server as these values from sensors are continuously uploaded. They have been forewarned by the alert system. The local system will issue an alert if there is a significant difference between the normal and measured heart rates, body temperature, or sweat (moisture) rate. This system monitors heart rate in a constant, real-time, stable, and precise manner. Another application is added to this machine for prevention, and its name is Automatic External Defibrillator (AED). If an abnormality in the patient's heartbeat is observed, the defibrillator can deliver a shock to the patient's external body as a buzzer emits a beep sound to warn nearby people.

Figure 1. Block diagram of the proposed system



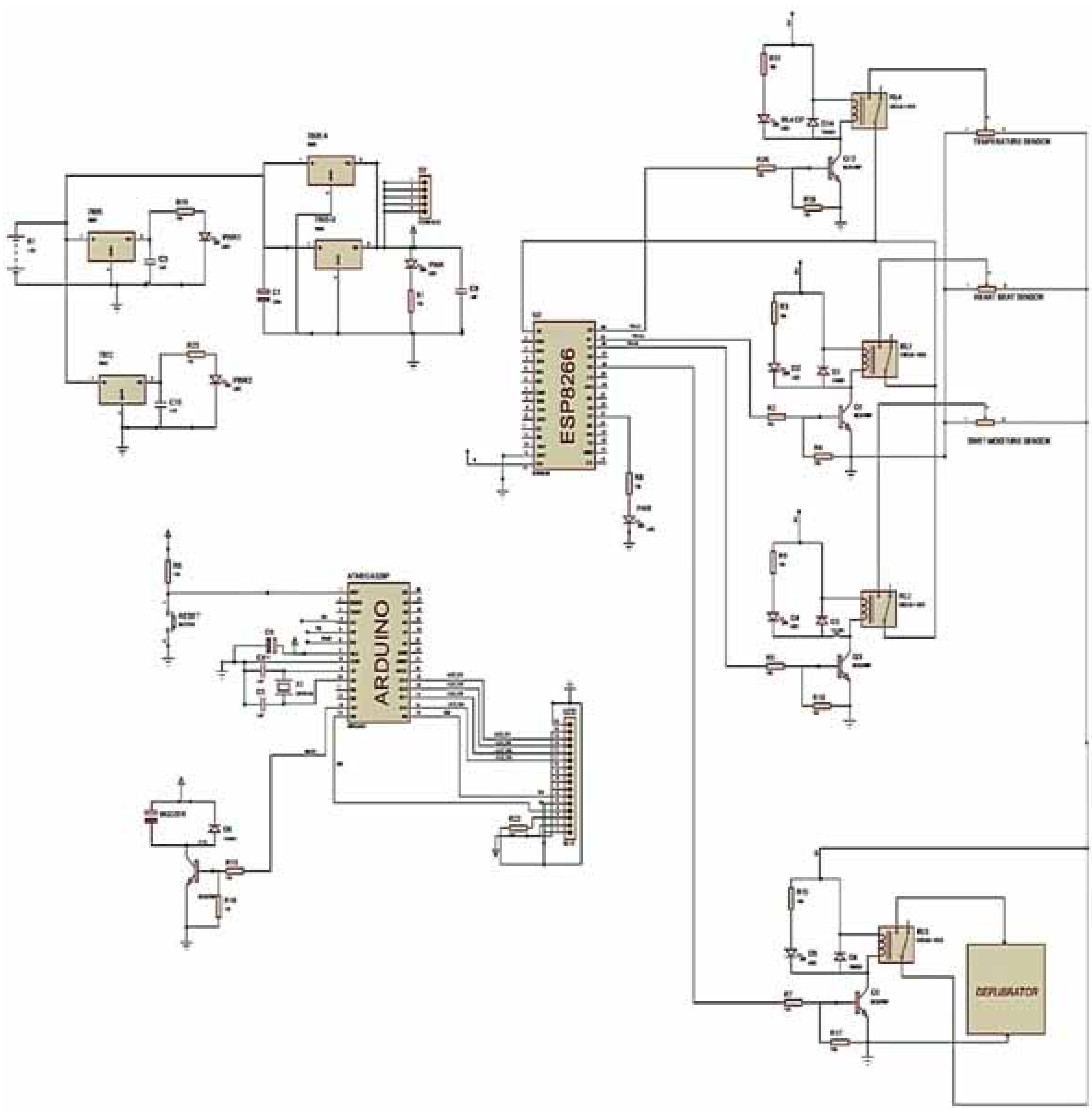
5.2 Circuit Diagram

The circuit diagram for real-time heart attack monitoring and monitoring using a defibrillator unit with an alarm mechanism is shown in Figure 2.

Heart rate is a significant health metric since it is closely related to the human cardiovascular system. A heart attack is triggered by a restriction in the blood supply to the heart. Heart attacks are most common in the elderly. When they had a heart attack, a scheme has been proposed to provide emergency support to them.

The proposed device uses a temperature sensor, a sweat sensor, and a heart rate sensor to continuously track heart rate levels. Heart failure was observed using certain sensor parameters, and first aid was delivered by an automatic external defibrillator. The warning will be shown if the heart rate level reaches the usual level, alerting the doctors or in-charge who are caring for the patient, while the patient's wellbeing is tracked and passed via the firebase web server. The patient's position was conveyed simultaneously by our established application in advance for safety reasons. We will see the patient's health status, such as pulse rate, temperature, and sweating level, from anywhere in the world using our application.

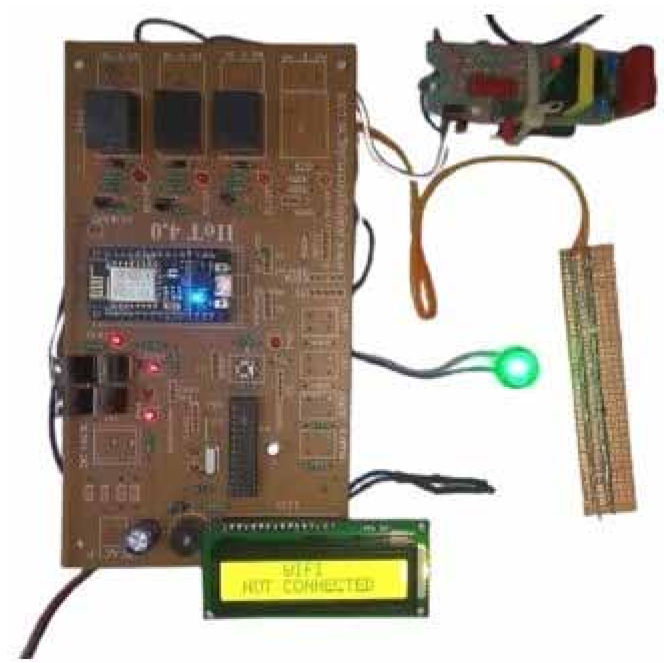
Figure 2. Circuit diagram of the Proposed Framework



6. RESULTS AND DISCUSSION

The following figure shows the hardware module of Real-time heart attack detection and control using the defibrillator. Figure 3 shows that the wifi connection is not established between the host and Node MCU. Figure 4 shows the status of the Wifi connection is displayed in the LCD unit.

Figure 3. Hardware Module while WiFi not connected



The Kodular programme is also used to create a transmitter and receiver app that is connected to the cloud through the Firebase network. Figure 5 shows the interface of sender applications. The status of patients is continuously uploaded to the cloud by providing an IP address to the Sender.apk display of the mobile application. Figure 6 shows the interface of receiver applications. On the receiver side, the doctor can able to read the heartbeat rate, sweat rate, body temperature as well as GPS location of the patient.

7. CONCLUSION

The heart rate can be tracked in this proposed framework using the Firebase data server. If the heart rate sensor, sweat sensor, or temperature sensor all meet a certain threshold value, it warns the paramedics, who automatically monitor the patient's health and provide first aid with an automated external defibrillator, potentially saving their lives.

Figure 4. Hardware Module while WiFi connected

Figure 5. The GUI design of Heartbeat app - Sender side

Figure 6. The GUI design of Heartbeat app - Receiver side

8. SCOPE FOR FUTURE WORK

By replacing the automated external defibrillator module with a hand pumping unit, the system's possible potential can be expanded. Also, the use of precise sensors in this project yields the best results and allows for a lightweight product for the patient. This initiative will be extended by adding a screening area, so that if a patient has a heart attack; he must be monitored at all times through that monitoring room. The current state of the patients is shown on the screen in the monitoring room.

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Chapter 5
Augmenting Mental Healthcare With Artificial Intelligence, Machine Learning, and Challenges in Telemedicine

Sandhya Avasthi
https://orcid.org/0000-0003-3828-0813
ABES Engineering College, India

Tanushree Sanwal
Amity University, Noida, India

Puja Sareen
Amity University, Noida, India

Suman Lata Tripathi
https://orcid.org/0000-0002-1684-8204
Lovely Professional University, India

ABSTRACT

Artificial intelligence is a huge part of the healthcare industry, having applications and uses in oncology, cardiology, dermatology, and many other fields. Another area where AI is constantly attempting to improve is mental healthcare by integrating machine learning to evaluate data generated by mobile and IoT devices. AI aids in the diagnosis and tailoring of therapy for mentally ill individuals at various stages. The artificial intelligence and machine learning methods utilize electronic health records, mood rating scales, brain images, mobile devices monitoring data in prediction, classification, and grouping of mental health issues, mainly psychiatric illness, suicide attempts, schizophrenia, and depression. The goal of this chapter is to review the literature on artificial intelligence and machine learning algorithms for detecting a person's mental health by utilizing patient health records. In addition, the chapter explains the use of artificial intelligence in curing and monitoring a patient with mental illness through telemedicine.

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1 INTRODUCTION

The healthcare industries are nowadays dominated by Artificial Intelligence and other technologies. With increased dependency on computing devices, the Internet of Things, digital data, AI applications have entered all parts of the biomedical world. We have entered industry 4.0 known as the "digital revolution" characterized by a fusion of technology types (Pang et al., 2018; Schwab, 2017). Although many influential segments of society are ready to accept AI's potential, medicine, including psychiatry, remains cautious, as indicated by recent reports in the news media such as "A.I. Can Be a Boon to Medicine That Could Easily Go Rogue" (Simon, 1991). Despite obvious reservations, AI's use in medicine is gradually growing. The rising incidence of health issues and costs in the aging population in the current pandemic is putting strain on the healthcare system. New technology, such as artificial intelligence (AI), may improve outpatient and inpatient treatment, emergency services, and preventative care in health care facilities.

Artificial intelligence (AI) and related breakthroughs are gaining traction in business and culture, and they're starting to make their way into healthcare. Many aspects of patient care, as well as administrative operations within providers, payers, and pharmaceutical companies, benefit from these improvements.

This chapter provides an overview of AI in healthcare, a description of recent studies on AI and mental health (methods/results), and a discussion of how AI might supplement mental health clinical practice while taking into account existing flaws, areas that need more research, and ethical concerns. Scientists are now developing a speech-based mobile software that can compartmentalize a patient's mental health status better than a professional can do.

Further, this chapter discusses the scientific, technical, and theoretical basis of automatic mental state detection systems. It gives us some descriptive examples of systems capable of automatically detecting a range of mental states that are predominately pertinent to mental health care (e.g., stress, depression, pain). The chapter winds up by looking at the existing condition of artificial intelligence and focuses on the key challenges that need to be addressed before these health care systems can get benefit from its widespread use. In the upcoming years, AI will have a meaningful impact on people's lives by improving their mental health is proper laws are framed in the country.

1.1 AI History and Evolution in the Biomedical Field

One of the early application areas for AI was medicine, many researchers in the twentieth century contributed to expert systems and other clinical decision support systems (Onari et al., 2021; Shaikh et al., 2021). A lot of development in clinical support systems during the mid-twentieth century took place, and it was one of the popular research topics. The success of rule-based approaches in the 1970s in interpreting ECGs and diagnosing diseases became a milestone in the field of AI. This method also provided appropriate treatments, performed clinical reasoning, and assisted physicians in producing diagnostic hypotheses in intricate cases. Initially, the AI systems relied on the curation of medical knowledge by experts and the formulation of robust decision rules. Recently machine learning (ML) learning methods becoming a part of AI research has proved effective in finding patterns even from complex situations. The algorithms in machine learning fall into two main categories supervised and unsupervised based on the problem area. The first category models on the large collection of samples or training set based on the label on them, on the other hand, unsupervised there is no such parameter. Supervised algorithms can easily identify the optimal parameters in the models that can minimize the difference between predictions in the training set and observed outcomes in these cases. Some of the most widely used supervised learning tasks are classification, regression, and characterization of the training set based on labels (Derke, 2020; Rayan et al., 2019). In unsupervised learning algorithms, sub-clusters or groups can be identified from the unlabeled training dataset. The AI applications development is possible by using machine learning methods to discover previously unknown patterns in data without the need to specify decision rules for each specific task.

AI applications have influenced all domains, but the major concern lies in medicine, including psychiatry as described in headlines by news media like “AI Can Be a Boon to medicine That could easily Go Rogue” (Manyika et al., 2015; Metz & Smith, 2019). AI-enabled tools have a wide range of applications in clinical and administrative areas improving patient treatment and helping health practitioners by providing decision-making capabilities. New technology, such as artificial intelligence (AI), may improve outpatient and inpatient treatment, disaster services, and preventive care in health care facilities. The use of AI-enabled devices in health care, on the other hand, poses a slew of legal, economic, ethical, and social issues.

1.2 AI in Mental Healthcare

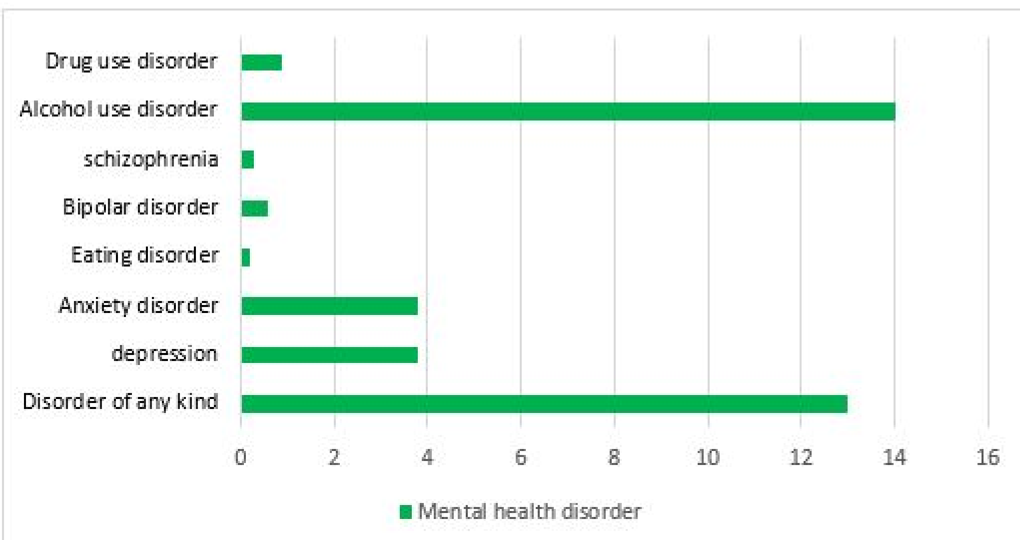
AI term, first used by John McCarthy, a computer scientist in his research paper, defined it as “the science and engineering of making intelligent machines” (McCarthy, 1989). The use of AI techniques is very common in the healthcare industry, but the use is limited in mental health and is adopting very slowly. The common practice to provide care to mental health patients is generally patient-centered and relies more on forming a relationship with the patient such as observing their behavior, emotions (Gabbard & Crisp-Han, 2017). The data related to mental health is often present in form of narratives, statements, and written notes. According to the WHO, 44.3 million people in Europe suffer from depression, while 37.3 million suffer from anxiety. Several health apps powered by Artificial Intelligence which are developed for individual use have been shown to enhance patient outcomes by forecasting outcomes based on a huge quantity of granular, real-time, and individualized behavioral and medical data.

Table 1. Estimated figures worldwide affected by different mental health disorders (in 2017)

Mental condition	Mental health issue (2017)	Number of people in billion	Male (%)	Female (%)
Mental health disorder of any kind	10.7%	792	9.3	11.9
Depression	3.4 [2-6%]	264	2.7	4.1
Anxiety disorder	3.8 [2.5-7]	284	2.8	4.7
Eating disorders(bulimia)0	0.2 [0.1-1%]	16	0.13	0.29
Bipolar disorder	0.6 [0.3-1.2%]	46	0.55	0.65
Substance use disorder	13 [11-18%]	970	12.6	13.3
Schizophrenia	0.3 [0.2-0.4%]	20	0.26	0.25
Alcohol use disorder	14 [0.5-5%]	107	2	0.8
Drug use disorder	0.9 [0.4-3.5%]	71	1.3	0.6

AI technology in healthcare systems is quite common but the discipline of mental health is slowly evolving (Brault & Saxena, 2021) and it is helping mental healthcare in different ways (Figure 2). The practitioners rely on patient-centric information acquired through interactions with them in form of narratives or through observing patient behaviors and emotions. AI can re-define the overall diagnosis process of a mentally ill person and understanding the mental illness (Bzdok & Meyer-Lindenberg, 2018). Mindfulness-based mobile applications on iPhone have the potential in delivering training on mental health (Mani et al., 2015). Such applications provided mindfulness training and guidance related to mental health. As a result, mindfulness has been shown to have positive psychological, somatic, behavioral, and interpersonal effects (Brown et al., 2007), including the development of tolerance, acceptance, patience, confidence, openness, gentleness, humility, empathy, appreciation, and loving-kindness, all of which are important for the personal recovery of people with mental disorders, as well as positive well-being in general (Slade, 2010). Mindfulness can become a habit provided a person gets proper training regularly. Table1 provides the number of people suffering from different mental conditions all over the world according to gender (Figure 1).

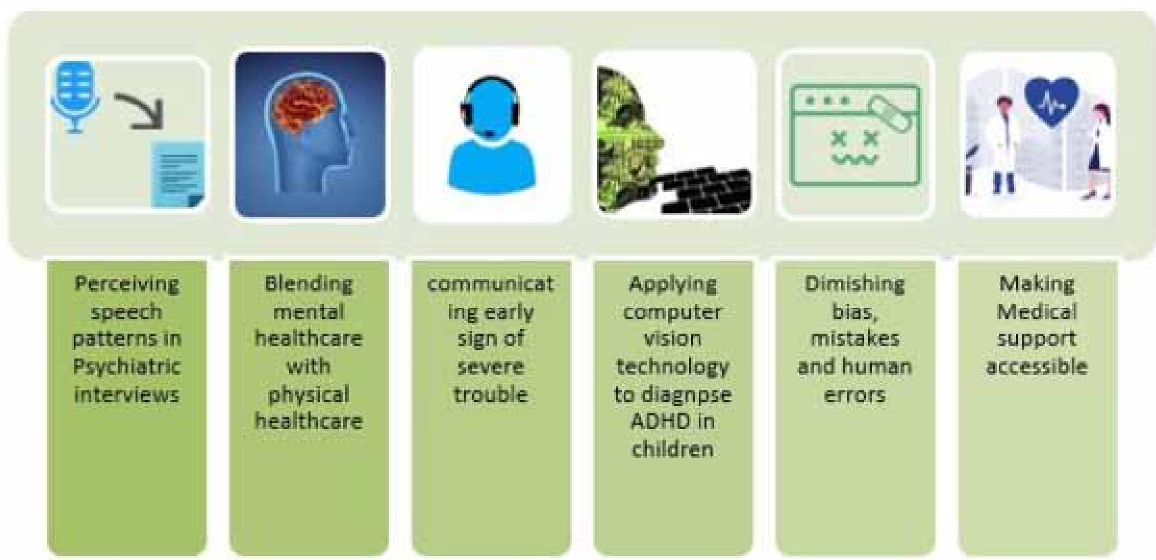
Figure 1. Bar chart showing different mental condition worldwide.



The contribution of the chapter is as follows:

- Review on AI history
- Study of various AI applications
- Study of AI in mental healthcare
- Mental health issues and machine learning techniques
- Telemedicine and challenges in telemedicine
- AI development and challenges

Figure 2. Six different ways AI is changing mental healthcare.



We studied AI and machine learning usage in healthcare applications, machine learning in mental illness, telemedicine services, and challenges in this chapter. In section I, we present an introduction to AI history in biomedical field and AI in mental illness. In the section II and III, we present machine learning usage in mental illness such as psychiatry and depression. The section IV and V discusses telemedicine, services and, challenges in telemedicine, respectively. The research directions, challenges in AI development and conclusion are given in section V, VI, last section, respectively.

2 ROLE OF MACHINE LEARNING IN MENTAL ILLNESS

Machine learning (ML) techniques have proven to be successful in the diagnosis and prediction of mental disorders in individuals. The practitioners and technicians helping a patient having mental health issues rely on all sorts of data like speech, narratives, brain images, and questionnaires (Chandler et al., 2020; Cohen et al., 2019). A large amount of collected data becomes a base for building machine learning models. The models further can be used in the classification and prediction of mental illness or even suggesting proper treatment for the illness. Machine learning is a collection of techniques that learn from gathered datasets and a model for classification and prediction is built. The same model can be used to predict or classify any unseen data or new data. Table 2 gives a summarized view of ML techniques in the diagnosis and detection of mental conditions.

ML in psychiatry: The application of ML in psychiatric research has grown over the last decade due to the availability of multivariate and multimodal data sets. The psychiatric practitioners and researchers have gathered a large amount of data of patients dealing with psychiatric disorders to check and monitor the status of patients and to provide personalized treatments. In the paper, a broad range of psychiatric symptoms mainly depression, positive and negative symptoms were found to be related to vocal acoustics (Janssen et al., 2018).

ML in depression: Depression is a mental disorder affecting the quality of life and socioeconomic status, its diagnosis depends on statistical and diagnostic measurement and treatment response of the mental disorders (Zhang et al., 2020). In many situations' phenotypes across mental disorders and major depression overlap, because of this mood disorders are confused with depression, and the patients must face the wrong drug trial. In such confusing situation brain imaging and classification, techniques provide measurements of brain function and structure (Gao et al., 2018). The paper proposed a technique to test and differentiate between cognitive biases among depression and subclinical anxiety in patients. In the paper, experiments were performed on a total of 125 individuals showing symptoms of both anxiety and depressions. Machine learning algorithms like Random forest and bagged decision tree classification methods were used to classify individuals based on their cognitive-emotional biases by detecting unique patterns (Richter et al., 2020).

Table 2. Summary of ML methods in assessment of mental conditions

Application	ML method	Type of data/input
Depression	Bayes Classification, k-mean clustering, Linear discriminant Analysis, Neural Network, PCA, Regression analysis, Topic modeling, Sentiment Analysis	Audio, Electronic health records, clinical notes/narratives, survey, video/picture, social media, mobile/sensors data, brain images
Anxiety disorder	Multivariate analysis, regression analysis, Support Vector Machine	Imaging, clinical notes/narratives, mobile sensors data
Substance use	Random forest, regression analysis, SVM	Imaging, survey, audio
Bipolar disorder	Support vector machine, regression	Clinical notes/narrative, imaging
Stress	k-means, kNN, regression, SVM, AdaBoost	Imaging, wearable sensors data, survey, clinical assessment
Schizophrenia	Naïve-bayes, Random Forest, Neural network, RF, LDA	Biological data, audio, video, pictures, clinical assessment
Suicide/self-harm	NLP, AdaBoost, Regression, topic modeling, LDA, RF, SVM	Clinical notes, assessment, audio, Electronic health records
Post-Traumatic stress disorder (PTSD)	k-means, pattern analysis, topic modeling	Electronic health records, imaging, survey
Attention Deficit Hyperactivity disorder (ADHD)	Genetic algorithm, Support vector machine	Notes, narratives, imaging
Dementia	Ensemble learning, Naïve-bayes, RF, neural network, SVM	Survey, clinical notes, narratives, conversation audio
Autism spectrum disorder	Classification, k-means, RF, SVM, kNN	Imaging, clinical notes
Behavioral and Emotional problems	Probabilistic techniques, regression, SVM, RF, NN	imaging
Wellness and Mindfulness	HMM, Naïve-bayes, Regression, SVM	Survey, audio, wearable sensor data, clinical assesment

ML in ADHD: Presently more than 10% of pediatric populations are suffering from attention deficit hyperactivity disorder (ADHD) and the figure continues to rise. ADHD is often confused with autism spectrum disorder (ASD) and in many cases results overlaps (Duda et al., 2016). To identify cases of

ASD end ADHD, extensive examination and evaluation by pediatricians and psychologists are done. To distinguish between ASD and ADHD, machine learning methods can be applied. Classification algorithms such as support vector machine and logistic regression are quite successful in classifying ADHD.

ML in posttraumatic stress disorders: PTSD is considered a psychiatric disorder often found in people witnessing a traumatic event, loss of a closed family member, sexual violence, or a terrorist act. A framework is proposed in the paper (Avasthi et al., 2021a; Liu et al., 2015) to identify PTSD based on functional MRI data at multilevel measures. Application of ML model such as classification techniques can provide a clinical diagnosis of PTSD using fMRI data.

ML in schizophrenia: Schizophrenia is a mental disorder affecting more than one percent of the population, the common symptoms include delusions, hallucinations, disorganized speech, and many other behavioral symptoms. The most common vital sign pointing to schizophrenia is disturbances in thinking and speech. The paper provides a natural language processing and ML framework to classify schizophrenia and distinguish it from psychosis (Avasthi et al., 2021b; Ratana et al., 2019). The linguistic models such as cohesion analysis, syntactical analysis, and textual analysis of discourse are very relevant in the analysis of this mental illness.

3 TELEMEDICINE

When a physician and a patient are not physically together with each other, telemedicine came as a solution to observe and provide necessary care to patients remotely. Through online video-conferencing tools or other applications on mobile devices, patients can consult a doctor thanks to modern technology. The telemedicine industry is primarily made up of communication platforms that link patients with doctors. However, as the industry develops, AI and machine learning are becoming more widely used. Chatbots, diagnostics, and care advice are the most common use cases. Chatbots are well-suited to substitute or supplement humans in collecting data, sending updates and motivational messages, and providing a sense of security when a doctor is unavailable. The most basic and widely used chatbot is rule-based, which means that the responses that a user can provide are restricted. These chatbots can be effective if they are programmed with carefully thought-out rules, but they lack the natural feel of a conversation. Telemedicine has made healthcare more affordable, cost-effective, and has significantly improved patient participation (Decenciere et al., 2013; Mahajan et al., 2020). Since its inception in the late 1950s, telemedicine is fast gaining popularity due to the COVID-19 pandemic and restriction in movement in cities. Moreover, patients in rural areas who previously had difficulty finding a physician can now contact them virtually. The market size of telemedicine is predicted to reach 72.7 billion in 2021.

The combination of AI, Machine learning, and telemedicine has the potential to significantly reduce hospital wait times and deliver quicker treatment to those in need. Although the artificial intelligence component is currently being used more than the telemedicine component, remote evaluations are expected to play a much larger role in the future. The increase in the telemedicine market in India and worldwide is huge, and Covid-19 has contributed a lot to this growing trend (as shown in Figure 3).

3.1 Telemedicine Services

There are three main types by which telemedicine services can be provided to a patient over a distance.

§ *Interactive medicine:* In this patients and practitioners communicate in real-time complying with HIPAA rules. The methods include video conferencing and phone consultations. The practitioner performs diagnosis through psychiatric evaluations.

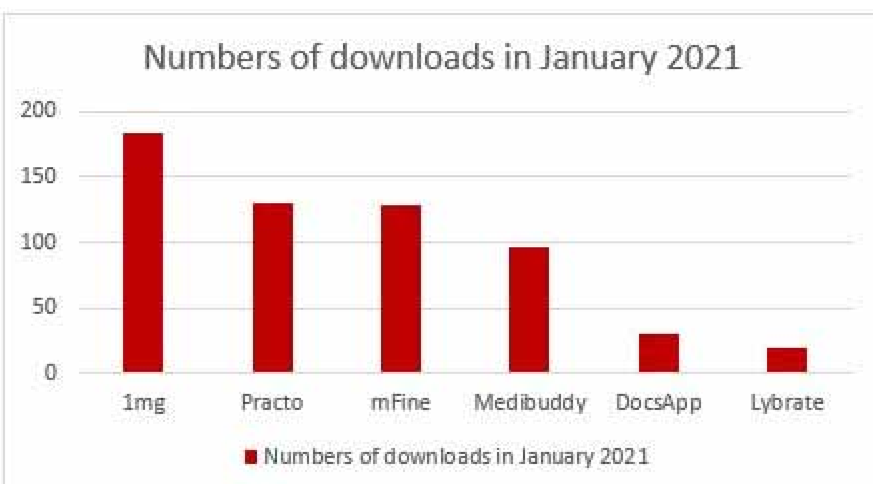
§ *Store and forward:* The practitioner gets access to patient information from another location. A physician share patient information from one location to another specialist in a different location. The patient information can go across geographically different locations so a physician can share what they already know about the patient.

§ *Remote patient monitoring:* In the current scenario, a pandemic has taken over the world, telemedicine provides care to patients in the safety of their homes. The physician can send and acquire information with patients through patient portals and IoT devices. Medical devices such as EKG, ultrasound, dermatoscopy, and pulse oximeter are some devices making this possible (Washington et al., 2020).

3.2 Telemedicine in COVID-19 Pandemic

In the current pandemic situation, telemedicine has proved to be an effective method to provide quality care to a person in need. Telemedicine support healthcare providers and medical professional maintaining social distancing. The telemedicine market is expected to grow at the rate of 30% between 2020-2025. Due to the lockdown and social distancing rules people have shifted to telemedicine for consultancy, and so the downloads of many telemedicine applications such as 1mg, Practo, myUpchar, and mFine have increased (Figure 3). A novel technique to analyze the fetus wellbeing of pregnant women is proposed in the paper (Ashu & Sharma, 2021; Cuffaro et al., 2020; Hau et al., 2020) based on the heartbeat and uterine contractions values. The data is collected through wearable monitors and IoT devices worn by women and analyzed through machine learning techniques.

Figure 3. Total number of downloads of different telemedicine mobile apps.



3.3 Challenges in Telemedicine

In the delivery of healthcare services telemedicine play an important role because distance becomes a critical factor. Generally, people suffering from mental illness or disorder avoid going to the clinic personally. The caregivers of such patients also avoid taking them out of the house. In such situation's telemedicine plays a mammoth task of healing and caring for patients. The health care expert uses information and communication technologies for the exchange of valid information for the diagnosis of the patient, their treatment, and prevention of any diseases or injuries. The provider and the patient are not physically present with each other in such cases. Telecommunication technology is used in telemedicine for the evaluation, diagnosis, and treatment of the patient. There are many drawbacks and limitations which must be managed by training protocols and by issuing guidelines.

Privacy issues: The electronic record shared through telemedicine devices hold intimate details of a patient which magnifies the privacy issues. The privacy laws across states and countries are not uniform in addressing patient privacy issues. The concern increases more in the case of using telemedicine across borders. During the pandemic, certain regulations were relaxed under HIPAA and allowed practitioners to use video-conferencing platforms such as Skype, Zoom, google hangouts, and Apple Facetime. Such practice may give rise to data breaches and risk patient-protected information because many of these technological platforms do not comply to HIPAA standards.

Ethical issues: There are many ethical issues related to the conduct of practitioners, relationships, protection of patient autonomy, patient safety, cultural diversity, and human value system. Currently, measures taken to control ethical issues are not sufficient (Avasthi et al., 2021c).

Informed consent: Informed consent in form of electronic records needs to be filled by patients before using health services through telemedicine. The focus should be given to providing clear and unambiguous information to the patient to collect consent (Langarizadeh et al., 2017).

Malpractice and liability by the practitioner: The malpractice case is based on the relationship between consultant and patients which needs to be formed. A patient can never file a suit for malpractice without proof of physician-patient relationship. Training of doctors and other healthcare workers is one of the many challenges facing telemedicine which can give rise to telenegligence (Schlachta-Fairchild et al., 2010).

Cybersecurity in telemedicine: The cyber-security experts have talked about vulnerabilities associated to telemedicine practice due to relaxation in HIPAA regulations. Cyber-attacks can cause many types of devastation such as ransomware, stolen data, loss of data, and delay in providing services by exploiting vulnerabilities in the telemedicine system (Monteith et al., 2021). In this pandemic situation, such forms of cyber-attacks are increasing because people are falling into tricks or scams under stress and mental pressure.

4 AI DEVELOPMENT AND CHALLENGES

The healthcare sector has found new ways of safely providing quality care to patients. This sector has gone digital. The rise of digital mental healthcare has also brought up the use of a technology that has remained somewhat elusive in the medical space– typically in the form of telehealth services and artificial intelligence. In the mental health field, it has become particularly prevalent. Mental health is one area of healthcare that can be delivered via telehealth without losing its essence. There has been a significant shift. Also, with the onset of COVID-19 and all the stressors that have come with it organizations have turned to Artificial Intelligence to potentially broaden access to and availability of mental health services. If there is one chief benefit of using AI in clinical care, the technology can obtain insights from massive amounts of data. This advantage still stands when AI is applied to the mental health space. Artificial intelligence and machine learning techniques have become prominent in healthcare in two important areas:

§ **Clinical AI** tools providing health trajectories of patient prediction, treatment recommendation, guiding surgical care, health management, and monitoring of patients. The health management tools help in improving the health outcomes of a community. Such AI tools are still adapting to varying needs and have not achieved widespread use (Kelly et al., 2019; Mushtaq et al., 2021; Smith, 2020).
§ **Administrative AI** tools optimize operational processes and automate various tasks performed by medical personal involved. These tools have changed the way practitioners work and have significantly reduced the burden on healthcare providers. By including AI and advanced computational techniques, the medical processes have matured and adapted to changing needs.

In mental health, there are several innovations. There is a genetic revolution where this new genetic data unlocks the key to understanding mental health. Then there is neuroimaging to help us and understand how the brain works. Intuitively, we know that these tools contain important information that we could use to personalize care for patients, but it has been very hard to unlock that data for clinical insights on a routine basis.

The application of artificial intelligence to mental healthcare can expand access and reduce costs, but it has several challenges which need to be addressed.AI systems could help providers go through many data resources and collect clinically actionable targets that will improve patient care. This may be able to offer more personalized and preventive care and hopefully, these mental illnesses can be approached in a more targeted way. While the use of AI comes with several potential benefits, it will be critical to maintaining care approaches that are focused on the patient-provider relationship. There will always be a need for human-to-human connection. AI's role in this space should not be to replace humans; it should be to support them. AI is designed to work in partnership with counselors. This is the most feasible application of AI in the mental healthcare field. AI is also supporting human therapists.

4.1 Where AI and Mental Health Will Meet in the Future

While the future application of AI in any area of healthcare is still unclear, this reality may be especially true in the mental health space. The use of AI in therapy is dependent on several factors, and even if the industry can overcome some major challenges, the technology is not likely to appear in front-facing mental healthcare delivery. In the future, AI may be helping us with research – sorting through data to find new patterns that may help us understand how mental health illnesses develop, how they spread, and how we can prevent them. For AI to take on a more central role, investigators will need to refine research and analysis in this area. There are several significant barriers to using Artificial Intelligence in mental healthcare. With smartphone apps and chatbots, patient engagement is a key factor in determining the success of the technology. One challenge for mobile health applications is making sure people come back and interact with it regularly. Typically, the more the individual uses it, the greater the benefit they will get from it. Additionally, developers and researchers need to make sure they equip these tools with appropriate protections for high-risk patients.

Woebot does have some safety features built into it, like language detection and rules for risk management but it does state explicitly that it is not a suicide prevention tool. The data used to train AI models is a crucial aspect of clinical utility and data quality can be particularly challenging when it comes to mental healthcare. AI is only as good as the data it is trained on and the people that are using it. It is especially hard to have a gold standard in mental health because the current clinical definitions used are not ideal. A very careful approach to how to train the algorithms and scoring people's symptoms is needed (Brown et al., 2021; Denecke et al., 2021; Floridi et al., 2018; Molnár-Gábor, 2020; Wang & Preininger, 2019).

The importance of partnerships between industry and academia to develop AI systems that will effectively address the complexity of mental illnesses must await in today's scenario. Solving very easy problems will not lead to advanced care. Having an algorithm that can tell whether someone has schizophrenia or not, is useful, but it is not going to advance the field. This is a very small improvement. There is also a need to have diverse samples on which to train these models because if experts only take one region, one clinic, or one population, these algorithms are going to have very limited utility. These tools must be built from the ground up with a very diverse approach – experts must work with the patients, as well as consider input from clinicians, data scientists, and regulators. It is necessary to build partnerships with patients, stakeholders, and therapists around the data that is going to be necessary to build these tools. The chat platform that a patient is using is capturing the data, and the people behind that platform are trying to use this data to improve care. Similarly, providers are generally not interested in being recorded, so it is difficult to collect information.

4.2 Ethical Implications

Artificial intelligence in healthcare has a lot of ethical implications. Human beings have used digital technology in the past in the health care industry, but these have raised issues related to accountability, privacy, transparency, and permission. Among these, the issue of transparency in the technology is very difficult to address when it comes to the healthcare sector. The deep learning algorithms which are used for the analysis of image are virtually not possible to explain or interpret. Suppose if a patient is diagnosed with abnormal health care or mental issues like schizophrenia, he or she would like to know how it happened and why. In such cases even the expert health physicians and deep learning algorithms are failed to provide any explanation to the caregivers and the patients (Bhaskar et al., 2020; Ramkumar et al., 2020; Sunarti et al., 2021).

Mistakes in the AI system in patient health diagnosis will occur. Further, these mistakes will lead to a false treatment or wrong handling for which it will be difficult to establish any accountability. A patient and caregiver would always like to receive advice from an expert clinician who is empathetic and has compassion rather than have information from an artificial intelligence system. Machine learning systems in healthcare also lead to a lot of wrong diagnoses. It may lead to predicting results based on gender or race, but these are not the actual causal factors.

There are lots of technological development and ethical changes that have come with artificial intelligence in healthcare. The government and private institutions related to health care have to take important steps to establish regulatory bodies to monitor issues related to the wrong diagnosis. They must examine the key issues and react responsibly and further establish governance mechanisms to overcome these kinds of harmful implications in society. The policies maker must give attention to artificial intelligence in the healthcare industry especially mental care where people are facing so much of stress during the time of pandemics.

5 FUTURE OF AI IN MENTAL HEALTHCARE AND TELEMEDICINE

The studies in the field of AI applications related to mental healthcare have their limitations. AI application performance degrades according to the increase in the size of data and quality of data (Miotto et al., 2018). Implementing ML algorithms on a small sample size faces an overfitting problem and testing the ML models within the same sample limits the generalizability of the results (López-Cabrera et al., 2021). The ability to predict has its limitations in features such as clinical data, demographics, and biomarkers when used as input for the ML models. Among ML models, binary classifiers are more popular as compared to the regression models where numeric scores are required (Jordan & Mitchell, 2015). It is a challenge to model events such as suicide or events that rarely occur, only a small portion of records mentions it.

Artificial intelligence has a mammoth task, and it will play an important role in the healthcare industries in our near future. It has given a lot of help in imaging analysis but in the future, it will provide diagnosis and treatment recommendations to the patients. In the future, most of the radiology and pathology images will be examined by machines. There will be increase usage in speech and text recognition for capturing clinical notes and patient communication. The biggest channel these technologies will face in the healthcare system is their daily adoption in clinical practice. Artificial intelligence in healthcare will be capable enough to be useful but it must be approved by regulators. The machine used in artificial intelligence must be standardized and updated from time to time. These challenges can be overcome but it will take a longer time because these technologies will take time to come in practice in daily usage. Moreover, a system can never replace human doctors and health care professionals on a large scale, but it will enhance their efforts to care for patients. The human skills that a doctor or a health professional has been unique to him or her who can never be brought about by any artificial intelligence or digital technologies. Health care professionals are unique as they have skills like empathy and persuasion.

6 CONCLUSION

The use of technological innovations and advances in the field of mental healthcare is vital in the search to address the system's current inefficiency, particularly given the fact that the estimated burden of mental illnesses is expected to rise over time. Machine learning techniques have transformed mental health care in numerous ways such as in the field of administration, diagnosis, treatment, and analysis of health records. As AI along with ML is becoming more prevalent and widely adopted in health care, clinicians and scientists can broaden the reach to the patients with the use of telemedicine. Overall, AI and ML models can improve the detection, diagnosis, and monitoring of mental health issues in patients. One of the most debated concerns about the use of AI in applications like healthcare is the quality and quantity of data available, as well as the likelihood of biases in the data being replicated or amplified.

The role of AI and ML applications in telemedicine is becoming important in the current pandemic situation due to the large population relying on digital platforms for consultancy. In addition, the importance of telemedicine services and their challenges is studied, which has become a preferred method of practice in the COVID-19 crisis. The decrease in the cost and accessibility of healthcare may improve due to the presence of the latest technological innovations but we must address the various issues related to privacy along with social, legal, and ethical challenges.

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Chapter 6
Mental Health Detection Using Transformer BERT

Kuldeep Kumar Patel
Indian Institute of Information Technology, Nagpur, India

Anikesh Pal
Indian Institute of Information Technology, Nagpur, India

Kumar Saurav
Indian Institute of Information Technology, Nagpur, India

Pooja Jain
Indian Institute of Information Technology, Nagpur, India

ABSTRACT

The COVID-19 pandemic has affected the daily life of each individual drastically at global level. The adverse effects of the pandemic on an individual and people around them have created an anxious and depressive environment. The virus has changed the way of living for most people and increased the distance between individuals. As the COVID-19 spread, people have been constantly in bad mental health which includes fear, boredom, sadness, and stress. Based on this situation, in this chapter the authors have analysed the mental health of people affected due to COVID-19 by analyzing two parameters of mental health, boredom and stress, from social media posts by detecting different emotions and feelings expressed in the form of text. The authors have utilized the BERT pre-trained model on preprocessed data to create classification models of boredom, stress, and consequently, determining the emotion of the person. These models are used to determine the emotions (i.e., stress and boredom) during different stages of the COVID-19 pandemic.

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1. INTRODUCTION

Emotion detection-based research is closely associated with sentiment analysis and text-based recognition. Emotion recognition is used to analyze and capture the feelings like sadness, happiness or anger, etc. whereas sentiment analysis (Rahman, 2017) is performed to simply categorize the given content into positive, negative, or neutral feelings.

In this chapter, the emotions or mental health of people have been categorised like stress and boredom

This chapter depicts these mental state changes that have occurred before and during different stages of the COVID-19 pandemic. Datasets were collected from Twitter. As this text was in raw format, so it has been processed from the mental state-based class to emotion-based classes which give us the flexibility to get the state of mind in a broad view. Not only emotion but people's viewpoint over things and daily work-life is also considered and deeply analyzed whether their mental stress level or their eagerness to do things has affected or not, this state is also represented in the form of boredom which is then categorized in emotional state class also.

As much work over health state classification is performed, like analyzing people's state of mind by analyzing their behavior with some digital means. Talking about text-based research, different models and their modifications have been proposed. This chapter also focuses on text-based analysis but with an attempt to modify it for the better. By using embedding techniques of transformers, models have been created and trained over this dataset. Transformers have the ability to translate the text and summarize it in a more meaningful way so that a simple machine can analyze it. One of these transformers is Bert which is a perfect fit to embed and translate this given dataset and turn it into some meaningful context. Bert as a transformer has the ability to embed in a much more optimal way. Using the vast pre-trained model of Bert which has been trained over Wikipedia, a large library for text analysis is obtained. BERT contains text which has been trained in different scales, here a large version of that pre-trained model is used.

Analyzing textual (Shaheen, Shadi, 2014) emotion comes with major difficulties even for machines. Humans also suffer to describe their state of mind at certain times. In the case of machines, there is a need for a proper model which can classify these textual matters in a well-defined manner and with correct labeling. The need for advanced natural language processing for developing these models is a must. So to minimize the effort, a survey has been developed about these text-based analysis using natural language processing. Here in this chapter, a Natural language processing-based informational approach to detect and analyze the state of text which depicts the mental state of humans.

2. BACKGROUND AND RELATED WORK

Most of the Emotion or Mental state classification works nearly the same as Sentiment analysis. Sentiment classification generally has to identify the positive, negative and neutral nature of the text which also describes the mental state of the person who has written that text. Boredom and Stress which depict the mental state of a person can be classified with the same procedure as for sentiment or emotion. Using transformer-based techniques like BERT these classifications have been performed.

2.1 Transformer

The Transformers are architecture in Natural Language Processing that are used to solve tasks related to sequential input data like translation and text summarization. While doing so, it also handles long-range dependencies easily. The main idea behind the usage of Transformer is to take care of the dependencies between input and output with attention and recurrence.

Figure 1. Transformer

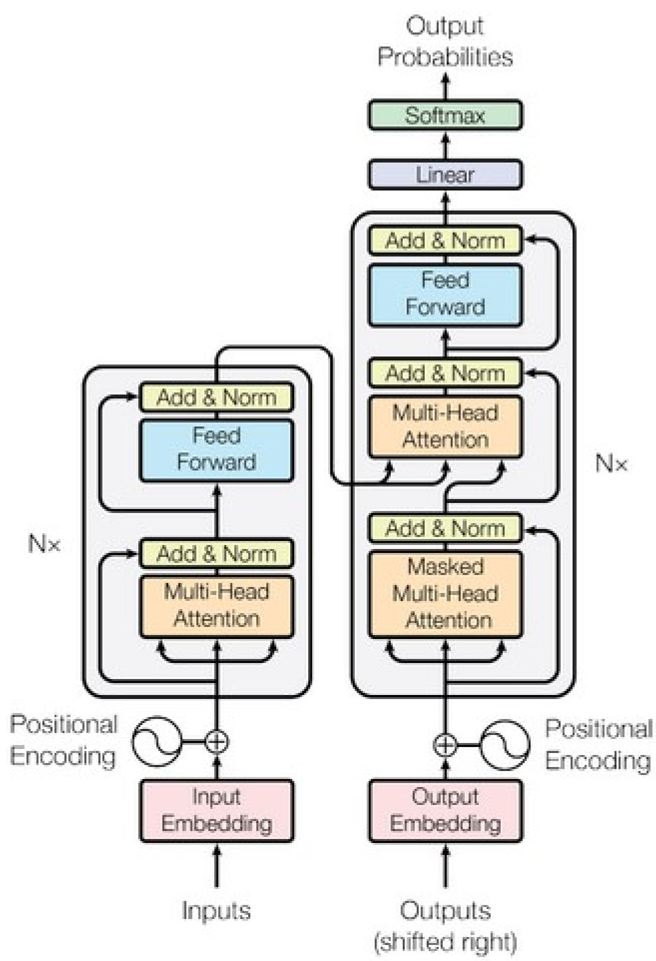


Figure 1, describes the transformers architecture. For the encoding part, these are actually multiple blocks of Encoder and Decoder stacked together.

These stacks for encoding and decoding works as follows:

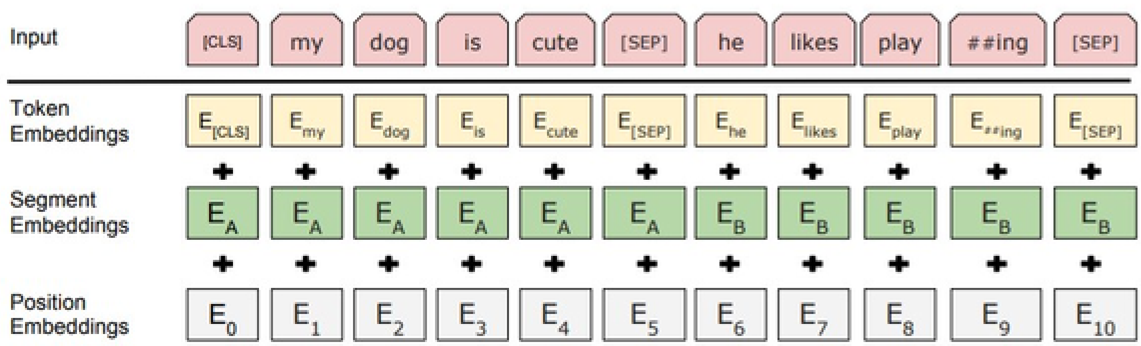
- The first encoder takes the word embeddings of the input sequence..
- Then their transformation takes place and they are propagated to the next encoder.

- The last encoder in the stack generates output which is then passed to all the decoders in the stack. Number of units in the encoder and the decoder stack are the same and it is a hyperparameter in the transformer.

2.2 BERT

BERT (Bidirectional Encoder Representations from Transformers) is a transformer based ML technique that completely fits to embed and translate data into some meaningful context as shown in the Figure 2. BERT as a transformer has the ability to embed with a much more optimal way. Using the vast pre-trained model of Bert which has been trained with general language dataset, there is a large library for text analysis. BERT is a bidirectional model. It simply means that BERT tries to learn from both sides of the token's context, that is the left and the right side during training.

Figure 2. Bert



Suppose one has two sentences with a common word which has different meaning in both sentences then If one tries to predict the identity of the word by only taking either the left or the right context then it will produce error in at least one of the given sentences.

Whereas BERT considers both the left and the right context before making a prediction.

2.3 Literature Survey

The authors in the paper (Agrawal et al., 2012) propose a context-sensitive unsupervised approach of detecting different emotional states from content. From the experimental results of both the context-free and context-based approach, it is found that the latter is better than the former.

The author (Liu et al, 2003) introduced an approach about the inherent affective nature of day-to-day conditions for classification of sentences into "basic" emotion categories using real world information.

In the paper (Winata et al, 2018) to classify the psychological stress from interview transcriptions, the author presented Long Short-Term Memory with an attention mechanism. Automatic labeling of tweets based on hash-tag is performed hence applying distant supervision and expanding the corpus size.

In the paper (Turcan et al, 2019), for the identification of stress, the author presented a new test corpus of multi-domain social media data and also introduced supervised learning methods for the same. Authors analyzed characteristics of each category of stress.

Table 1. Comparison of related work

Paper	Year	Approach	Dataset	Labels
Liu et al.	2003	Common Sense Affect based approach	OMCS	Happy, Surprise, Sad, Fear, Anger & Disgust
Alm et al.	2005	Supervised Learning (SNoW learning Architecture)	Children Fairy Tales	Happy, Sad, Fear, Anger, Disgust, Positively & Negatively Surprised
Strapparava & Mihalcea	2007	Supervised corpus based, Unsupervised knowledge based, rule based and Naive Bayes	News headlines	Joy, Sad, Fear, Anger, Disgust, Surprise &/or valence (positive, negative, neutral)
Yang et al.	2007	Supervised Learning (SVM and CRF)	Web-blogs	Positive and Negative
Alm	2008	Supervised Learning	Tales	Happy, Sad, Fear, Anger, Disgust, Neutral, Positively & Negatively Surprised
Strapparava & Mihalcea	2008	Supervised Learning (NB) & Unsupervised (variation of LSA) Learning	News headlines	Joy, Sad, Fear, Anger, Disgust, Surprise
Ghazi et al.	2010	Hierarchical classifier, SVM	Web-blogs, children Stories	Joy, Anger, Disgust, Sad, Surprise, Fear, Neutral
Balahur et al.	2011	Common Sense Knowledge	ISEAR, Documents	Surprise-anticipation, shame, Disgust-trust, sad-joy, anger-fear, guilt
Battersby et al.	2012	Supervised Learning (multi class SVM)	blog	Anger, Disgust, Fear, Joy, Sad, Surprise, neutral
Agrawal and An	2012	Unsupervised Learning (context based)		Anger, Disgust, Fear, Joy, Sad, Surprise
Calvo and Kim	2013	Unsupervised(LSA,PLSA), NMF(Non-negative Matrix Factorization)	Headlines, ISEAR, Fairy tales, USE	Anger, Disgust, Fear, Joy, Sadness
Kang and Ren	2016	Hierarchical Bayesian Model	Chinese Blogs	Anger, Hate, Sorrow, Expect, Love, Joy, Surprise Anxiety
Lin et al.	2014	Deep Sparse Neural Network	Sina Weibo	Stress
Lin et al	2014	Deep Neural Network	Sina Weibo, Tencent Weibo, Twitter	Stress
Zhao et al.	2015		Tencent Weibo	Stress
Saha et al.	2017		Reddit	Stress
Winata et al.	2018	Attention-based LSTM	Twitter, Interview	Stress
Turcan and McKeown	2019	NB, SVMs, Logistic Regression, GRNN, CNN and BERT-base	Reddit	Stress

3. METHODOLOGY

The methodology used is depicted in Figure 3. In this approach, the input text has been categorized into two emotion related labels like positive and negative, for each of the two categories of dataset i.e. Boredom, Stress. To find the state of mind of a person it is needed to find the emotional content from the given input text. These contents can either be verbs, phrases or any combination of different keywords describing state of mind. For example, “I am sad. This pandemic has troubled me a lot”. The keyword “sad” represents “sadness” or “not happy”, similarly there are many such words which represent emotions and because of this text can be classified. Dataset has been taken from social media platform twitter and through their reviews, comments etc. In order to classify text, a proper approach is needed so that algorithms can classify the text.

The structure and flow are given below:

1. Data extraction from sources.
2. Extracting sentences and labels.
3. A sentence is formed by a list of tokens.
4. These tokens are converted to a format according to input taken by the transformer.
5. Tokens are converted into input ids.
6. Feed to the transformer with more changes accordingly.

For example: “I am sad”, this sentence after converting to a token looks like {‘I’, ‘am’, ‘sad’} then after there input ids are processed where for each word corresponding ids are decided.

3.1 Data Extraction

Data is extracted from different social discussion platforms mainly from twitter using extraction libraries.

Categories that have been used for extractions are boredom and stress.

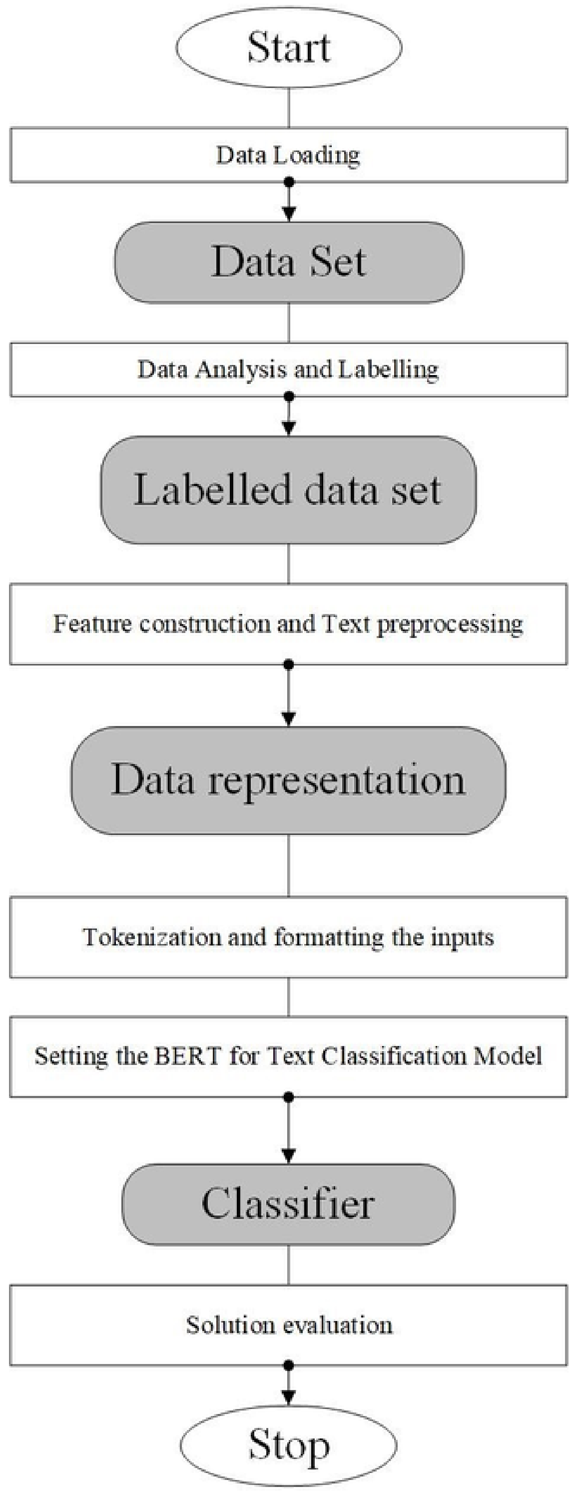
For the Boredom dataset, 8988 entries have been annotated manually after extraction.

Below are the keywords for each dataset used for extraction:

1. Boredom
   a. Positive = {‘bored’, ‘boring’, ‘boredom’, ‘boredaf’, ‘boredomMood’, ‘boredomsucks’, ‘boredomstrikes’, ‘boredome’, ‘bore’, ‘nothingtodo’ }
   b. Negative = {‘excited’, ‘energetic’, ‘confident’, ‘excitement’, ‘pleasure’, ‘confidence’, ‘blessed’, ‘fitness’, ‘hardwork’}
2. Stress
   a. Positive = {‘stress’, ‘stressed’, ‘stressful’, ‘frustration’, ‘workstress’, ‘stresslife’, ‘feelingstressed’, ‘stresslife’}
   b. Negative = {‘happy’, ‘blessed’, ‘comfort’, ‘nostress’, ‘peaceful’, ‘relax’, ‘relaxing’}

	Boredom Data	Stress Data
Data entries count	8988	32146

Figure 3. Methodology



This is how our data looks after extraction as shown in the Figure 4.

Figure 4. Extracted Data

	Datetime	Tweet Id	Author	Text	Label
0	14-02-2021 00:06	1.360000e+18	kuirag_	RT @thegoodss: Niggas really bore tf out of me	1
1	14-02-2021 02:44	1.360000e+18	___onlytink	RT @thegoodss: Niggas really bore tf out of me	1
2	14-02-2021 07:41	1.360000e+18	jacayla2001	RT @thegoodss: Niggas really bore tf out of me	1
3	14-02-2021 06:52	1.360000e+18	justudynow	RT @yongxqi: new carrd :D preview is the borin...	1
4	16-02-2021 10:58	1.361630e+18	youdebunked	RT @noirroadbluesky: @haayemerijan Good questi...	0

3.2 Cleaning Text

Before visualizing text data it is needed to make it more understandable and processable by model with some cleaning techniques to remove things like: html tags, URLs, punctuations and Emojis. These transformations will make text more efficient and easy to be processed. Normalization of text and drawing out useful information is an important task for classifying given text. After cleaning different methods and algorithms are used for processing it which always works better if text is properly cleaned as shown in the Figure 5.

Figure 5. Uncleaned Text

```
'@ReggieUnthank A pleasure. It was a really good read.'
'RT @ADHDelaide: Hello, I have ADHD and my greatest skills are being exhausted from nothing else but my thoughts, thinking about doing somet…'
'RT @CAROLINACV: tw // body image \n\ni felt so confident dancing this ngl :) https://t.co/ZTEhhkrzWm'
'i'm bored, shall we kiss?'
'RT @kthyqs_: sagittarius \n- THE FUNNIEST SIGN\n- you're so cool \n- loud \n- extroverted\n- fun to be around \n- anger issues \n- gets bored too…'
'RT @indiaforums: Simply cannot contain our excitement to watch these two together again! 😍😍\n#RubinaDilaik #AbhinavShukla #RubiDilaik #ashuk…'
'@AdityaS_Indian Exp when u have a boring teacher with boring matter😆😭'
'RT @HopelessPupp: Stay happy and stay blessed thalaivaa 😂🔥\n\n#HBDPrinceSivaKarthikeyan https://t.co/03XmYQVkNf'
'RT @thegoodss: Niggas really bore tf out of me'
'@pinxcx #loonatheworld @BVsmtown and yukika too\n\ni do be digging into showa jpop cos kpop kinda getting boring this february'
'RT @atothelia: This is why I say capitalism made people boring cause it has. People don't have hobbies. They don't have shit else to talk a…'
'RT @KhushmumaKashmi: So What comes to your mind seeing it?\n\nTo my mind, #Allah has blessed each soul of #Kashmir with sacred-ness and he is…'
'RT @joeboyofficial: Always a pleasure ✨🤍'
'Energetic\n\n#icelandicsheepdog\n#isländskfårhund\n#islenskurfjárhundur\n#islandskfårehund\n#dogsofinstagram\n#Sweden… https://t.co/JnEbwVgqja'
'RT @gershawncoetzee: Home gym! #GorillaSports 🔸💪 \u200d♂🔸💪@GorillaSportsSA #HomeGym #HomeTraining #Fitness #kettlebell #PushUpBar #Resistanc…'
'How can a mfer be this confident https://t.co/efiK2eGV8O'
```

3.2.1 URL Removal

URLs are unwanted text which doesn't define any meaning that must be processed. This process converts text to normal english text. To remove these URLs thier identifiers like "https" are taken in account and then replaced by nothing with a proper string translator.

3.2.2 Punctuation Removal

Punctuations are not processable by models as there is no literal meaning to them other than sentence forming. So they are removed by defining several punctuations and then scanning them in the given text which is replaced by nothing using some string translator.

3.2.3 Emoji Removal

Emojis are removed using a predefined text-preprocessor. This identifies emojis as a code with a specific format and replaces these with an empty string.

3.2.4 Converting Text to Lowercase

Keeping character cases of text the same is important and efficient as machines process different cases of the same character differently which causes overhead.

3.2.5 Word Contraction Removal

Machine isn't able to understand something if it hasn't been trained for the same. SAme is the case for contraction, words which are written in contracted form are not processed properly so to resolve this they are expanded to their original or removed if they come out to be any stop word. To remove contraction a dictionary is maintained which stores contracted words with their expanded form, and then these words are replaced with any replacement mechanism to their expanded form.

For example: don't: do not

3.2.6 Stop Word Removal

Main goal of data cleaning and processing is to remove unnecessary words which are of no use to model. They simply increase text size and processing time to analyse them. Different systems have different types of stop words which are considered in this model and removed from the text. If it is required to remove some more unnecessary words then that has been done also. Below are some english language stopwords:

"The", "is", "at", "can", "of", "a", "an", etc.

All words like these are removed from text saving space and processing time. They can be removed by using either a predefined algorithm or by simply storing a collection of different stop words and replacing them with empty strings.

3.2.7 Lemmatization

Part of speech tags are applied to given text (like verbs, nouns etc.) for lemmatization. After that the text format is converted to wordnet and then a lemmatizer was applied as shown in the Figure 6.

Figure 6. Cleaned Text

```
'love the new badges that have introduced to demonstrate the inclusivity of scouting in the uk'
' i keep thinking about albert camus description of being stuck in a plague  the boredom the hopelessness the feeling of be'
' look out tomorrow for ballet classes from and  laura teaches claras solo from act i grades  la'
' it was my cross you bore so i could live in the freedom you died for and now my life is yours and i will sing of yo'
' please atleast give'
' ikonics group hug hardwork will never really betray us keep on going and we will be getting that screen ad for ikon'
'im so bored'
' excitement at the peak to see new stadium'
'i am a homework slave with a graduate degree available to do your assignments and busywork eg discussion posts'
' universal features of lockdowners1 an income that doesnt go away under lockdown2 a life that was at least as borin'
'listen  the girls can look back on graham fondly because he got murked early on in season but that man was bor'
' very much excited for this'
'you have a taste boo'
'best energetic and enthusiasticworse no consistency and more gossipy'
```

3.3 Tokenization and Formatting the Inputs

Before feeding the text to BERT, first tokenization of the text is required along with mapping of each token. BERT's own tokenizer is used for the tokenization process. For padding and truncation, the maximum length required is calculated in accordance with the tokenized sentences, then an encoder is used which splitted the sentences into tokens. After this special token is added at the starting of the sentence which is CLS, it is required to be present as the first token of the given tokenized sentence. Then SEP, which is also a special token, is added at the last of each sentence. SEP acts the same as separator, in this context it simply separates the two sentences which are not related.

For example: "i want embeddings": {'{CLS}','i', 'want', 'em', '##bed', '##ding', '##s','{SEP}'}

Now the tokenizer maps the tokens to their respective IDs and also does the truncation and padding to the equal length (maximum length is used for this part).

If any sentence gets shorter than the maximum decided length then padding will be performed which adds pad tokens to make sentences equal. If the sentence is longer than the decided maximum length then it will get truncated. Then an attention layer is created containing 0's and 1's to differentiate between actual and pad tokens.

These steps are performed for each train and test set and then converted data is obtained for our BERT model as shown in the Figure 7.

Finally, the method of loading the data into the model for training purpose is defined, this is performed due to memory restrictions.

Figure 7. Tokenized Content

```
 Original:   another big thank you to all atinys for continuing to twt rt qrt amp reply for stmwrld you are all wor
king so hard fo
Tokenized:  ['another', 'big', 'thank', 'you', 'to', 'all', 'at', '##iny', '##s', 'for', 'continuing', 'to', 't',
'##wt', 'rt', 'q', '##rt', 'amp', 'reply', 'for', 'st', '##n', '##wr', '##ld', 'you', 'are', 'all', 'working', 's
o', 'hard', 'f', '##o']
Token IDs:  [2178, 2502, 4067, 2017, 2000, 2035, 2012, 24300, 2015, 2005, 5719, 2000, 1056, 26677, 19387, 1053, 533
9, 23713, 7514, 2005, 2358, 2078, 13088, 6392, 2017, 2024, 2035, 2551, 2061, 2524, 1042, 2080]
```

3.4 Setting the Bert Classification Model

Bert Large Uncased version BERT is used for this task for better results.

Then the optimizer is selected and fine-tuning of model is performed.

The model summary is shown in Figure 8.

Figure 8. Model Summary

```
==== Embedding Layer ====

bert.embeddings.word_embeddings.weight                  (30522, 1024)
bert.embeddings.position_embeddings.weight                (512, 1024)
bert.embeddings.token_type_embeddings.weight                (2, 1024)
bert.embeddings.LayerNorm.weight                              (1024,)
bert.embeddings.LayerNorm.bias                                (1024,)

==== First Transformer ====

bert.encoder.layer.0.attention.self.query.weight         (1024, 1024)
bert.encoder.layer.0.attention.self.query.bias                (1024,)
bert.encoder.layer.0.attention.self.key.weight           (1024, 1024)
bert.encoder.layer.0.attention.self.key.bias                  (1024,)
bert.encoder.layer.0.attention.self.value.weight         (1024, 1024)
bert.encoder.layer.0.attention.self.value.bias                (1024,)
bert.encoder.layer.0.attention.output.dense.weight       (1024, 1024)
bert.encoder.layer.0.attention.output.dense.bias              (1024,)
bert.encoder.layer.0.attention.output.LayerNorm.weight        (1024,)
bert.encoder.layer.0.attention.output.LayerNorm.bias          (1024,)
bert.encoder.layer.0.intermediate.dense.weight           (4096, 1024)
bert.encoder.layer.0.intermediate.dense.bias                  (4096,)
bert.encoder.layer.0.output.dense.weight                 (1024, 4096)
bert.encoder.layer.0.output.dense.bias                        (1024,)
bert.encoder.layer.0.output.LayerNorm.weight                  (1024,)
bert.encoder.layer.0.output.LayerNorm.bias                    (1024,)

==== Output Layer ====

bert.pooler.dense.weight                                 (1024, 1024)
bert.pooler.dense.bias                                        (1024,)
classifier.weight                                           (2, 1024)
classifier.bias                                                  (2,)
```

3.5 Training and Evaluating

First helper functions are organized to calculate some metrics over the process. Then process is as follows:

3.5.1 Training:

1. Data inputs and labels loading,

2. GPU is used for data loading as it gives better acceleration,
3. Forward pass is performed that means feeding of input data through the network.
4. Then backward pass is performed that is back-propagation,
5. Then network updates the parameters,
6. Variables used in the process are tracked for monitoring progress.

3.5.2 Evaluation:

1. Data inputs and labels loading,
2. Using GPU for data loading,
3. Performing forward pass,
4. Variables used in the process are tracked for monitoring progress and validation data loss is computed.

4. RESULTS

Datasets are extracted from the social media platform, i.e Twitter. So, the extracted datasets are imbalanced because of inconsistent social media format. Therefore, the focus has been more on data preparation and pre-processing. This helps us in improving overall accuracy as well as performance of our model. Mental health detection model is evaluated on the basis of following parameters:-

1. Accuracy
2. F1 Score Macro
3. F1 Score Micro
4. Hamming Loss

As shown in Table 2.

Table 2. Result Summary Table

	Boredom Data	**Stress Data**
Accuracy	0.9561577752553916	0.9534375
f1 Score Macro	0.956138694989265	0.9534328432843284
f1 Score Micro	0.9561577752553916	0.9534375
Hamming Loss	0.0438422247446084	0.0465625

4.1 Result on Boredom Data.

Figure 9, summarizes the training related results on the Boredom dataset. The training results are for 3 epochs, for each epoch training loss, validation loss, validation accuracy, validation F1 score are calculated.

Figure 10, shows Training and validation loss vs epoch, where Training loss decreases over time.

Figure 9. Result on Boredom Dataset

epoch	Training Loss	Valid. Loss	Valid. Accur.	Val_F1	Training Time	Validation Time
1	0.33	0.21	0.93	0.92	0:04:53	0:00:24
2	0.16	0.20	0.94	0.93	0:04:53	0:00:24
3	0.12	0.21	0.94	0.93	0:04:53	0:00:24

Figure 10. Loss Curve

Figure 11, above is a confusion matrix in the form of a heat map, showing results based on actual and predicted labels.

Figure 12, shows Test accuracy along with other metrics of trained models on Boredom dataset.

4.2 Result on Stress Data

Figure 13, above summarizes the training related results on the Stress dataset. The training results are for 3 epochs, for each epoch training loss, validation loss, validation accuracy, validation F1 score are calculated.

Figure 14, shows Training and validation loss vs epoch, where Training loss decreases over time.

Figure 15, above is a confusion matrix in the form of a heat map, showing results based on actual and predicted labels.

Figure 16, shows Test accuracy along with other metrics of trained model on Stress dataset.

Figure 11. Confusion Matrix

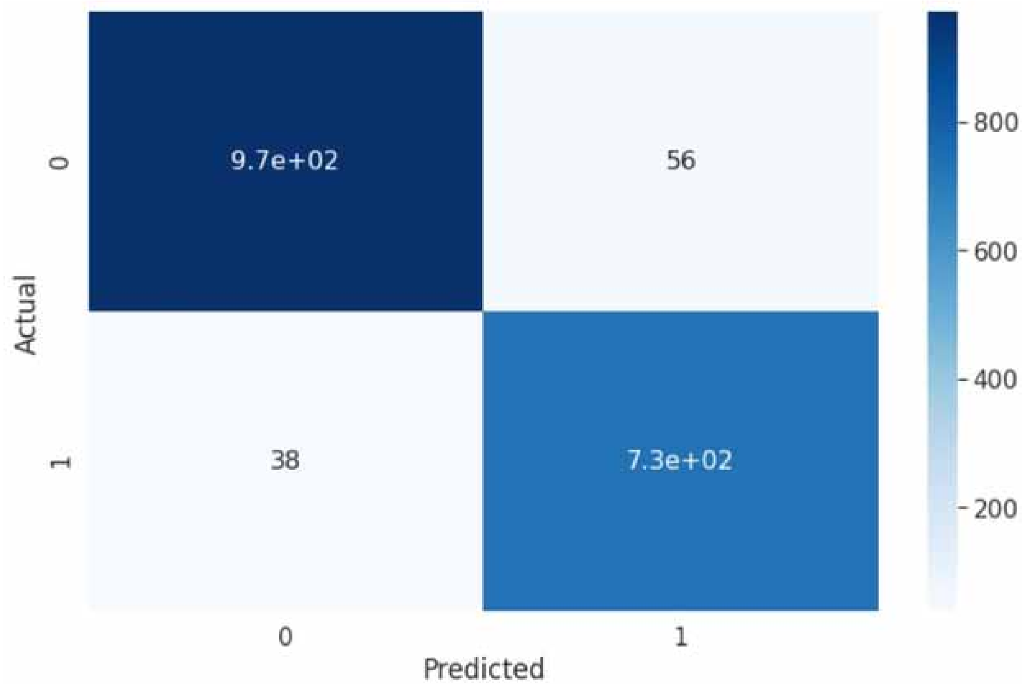


Figure 12. Classification Report

```
Accuracy : 0.9477196885428254
f1 score macro : 0.9467873155004786
f1 scoore micro : 0.9477196885428254
Hamming loss : 0.05228031145717464
Classification Report:
              precision    recall  f1-score   support

           0       0.96      0.95      0.95      1027
           1       0.93      0.95      0.94       771

    accuracy                           0.95      1798
   macro avg       0.95      0.95      0.95      1798
weighted avg       0.95      0.95      0.95      1798

Confusion Matrix:
 [[971  56]
 [ 38 733]]
```

Figure 13. Result on Stress Dataset

epoch	Training Loss	Valid. Loss	Valid. Accur.	Val_F1	Training Time	Validation Time
1	0.27	0.15	0.94	0.94	0:07:04	0:00:36
2	0.11	0.14	0.95	0.95	0:07:19	0:00:36
3	0.08	0.15	0.95	0.95	0:07:19	0:00:36

Figure 14. Loss Curve

5. CONCLUSION AND FUTURE WORK

Emotion Detection especially for Mental Health is one of the most important fields of research in Emotional Intelligence. In this chapter, it has been tried to target people from social media, especially from twitter. Considering the emotional state of people which is affected by COVID-19, the emotional states is collected in the form of stress and boredom data categories. From this data, text classification performed using transformer BERT, the results obtained were promising to classify emotional states of people.

As the COVID-19 pandemic has become more severe and the chance that this pandemic could grow stronger, there might be a drastic change in the emotional state of people and possibly it could become more negatively biased. This model will work properly in that case also but the dataset might change drastically so further improvement might be required related to dataset handling.

Figure 15. Confusion Matrix

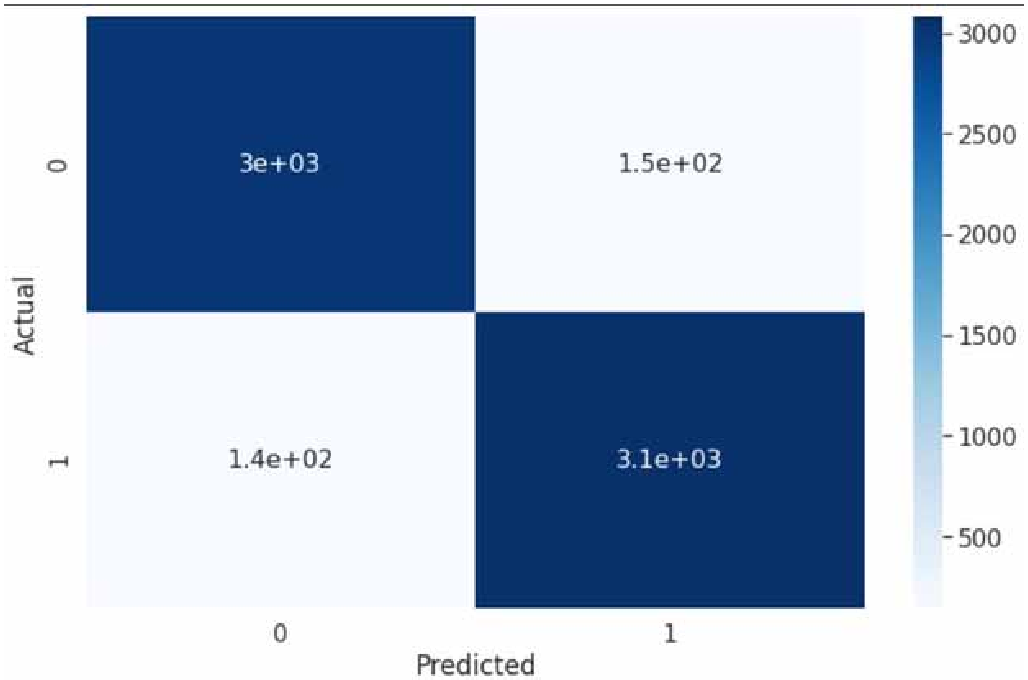


Figure 16. Classification Report

```
Accuracy : 0.9534375
f1 score macro : 0.9534328432843284
f1 scoore micro : 0.9534375
Hamming loss : 0.0465625
Classification Report:
              precision    recall  f1-score   support

           0       0.95      0.95      0.95      3173
           1       0.95      0.96      0.95      3227

    accuracy                           0.95      6400
   macro avg       0.95      0.95      0.95      6400
weighted avg       0.95      0.95      0.95      6400

Confusion Matrix:
 [[3019  154]
 [ 144 3083]]
```

As this model is used for binary classification tasks, there is a chance for improving it further for multiclass text classification also. This might give a better insight over the emotional state of people which has been affected by COVID-19.

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Chapter 7
Cancer Precision Drug Discovery Using Big Data and Artificial Intelligence Technologies

Pratima Bichandarkoil Jayaram
Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

Nalini Namasivayam
Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

ABSTRACT

Improved cancer treatments are widely cited as a significant unmet medical need. Recent technological developments and the increasing availability of biological "big data" provide an unprecedented opportunity to systematically classify the primary genes and pathways involved in tumorigenesis. Artificial intelligence (AI) has shown great promise in many healthcare fields, including science and chemical discovery. The AI will explore and learn more using vast volumes of aggregated data, converting this data into "usable" information. The aim is to use current computational biology and machine learning systems to predict molecular behaviour and the probability of receiving a helpful medication, thus saving time and money on unnecessary tests. Clinical trials, electronic medical records, high-resolution medical images, and genomic profiles can all be used to help with drug growth. The discoveries made with these emerging technologies have the potential to lead to innovative therapeutic approaches.

1. INTRODUCTION

Cancer is a significant and growing global health burden, accounting for over 12 million newly diagnosed cases each year and more than 15% global deaths. The development of new, improved cancer therapies is frequently mentioned as an unmet medical need (Varmus & Kumar, 2013). Cytotoxic agents have traditionally dominated cancer therapies. These therapies, which cause DNA damage that exceeds a

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cancer cell's ability to repair itself, have been a mainstay of cancer chemotherapy for more than 30 years (Pearl et al., 2015). Although these agents effectively treat testicular and breast cancers and childhood leukaemias, they are relatively ineffective in treating many cancers, including lung, brain, pancreatic and esophageal tumors, even when used in combination (Mukherjee, 2011; Varmus, 2006). Recently, the emphasis on drug discovery has shifted to identifying genomic and other molecular abnormalities in cancer subtypes to develop targeted therapies with the potential for greater efficacy and therapeutic selectivity (Yap & Workman, 2012). Early success stories of single-agent targeted therapies appeared to be very promising. Trastuzumab (Garnock-Jones et al., 2010) and imatinib (Stagno et al., 2016) are two critical examples used to treat breast cancer and chronic myeloid leukemia, respectively. Trastuzumab is a monoclonal antibody targeting cells overexpressing the human epidermal growth factor receptor HER2/ERBB2, whereas imatinib, a small molecule, inhibits constitutively activated Abl kinase caused by the BCR-ABL translocation. While some of these targeted therapies have been particularly effective, it appears that they are somewhat unusual, as some of the newer targeted therapies have only provided brief remissions before resistance develops (Al-Lazikani et al., 2012; Garraway & Jänne, 2012).

On the other hand, recent advancements in technologies have provided an unprecedented opportunity to comprehensively identify the alterations, genes, and pathways involved in tumorigenesis, raising the prospect of extending targeted therapies (Garraway & Lander, 2013; Stratton, 2011). Many innovative approaches and technologies have been implemented in drug discovery over the last 25 years. Next-generation sequencing and large-scale RNAi interference and, more recently, CRISPR technology have proven helpful for mechanistic biological exploration and drug target identification, particularly in oncology. The size and diversity of chemical libraries have grown. Also, the high-throughput screening has increased the availability of chemical matter acting on drug targets, while the structure and fragment-based design has improved hit-to-lead and optimisation of small molecules. Recombinant DNA technology has revolutionised the design of therapeutic antibodies, and around the same time, the drug discovery ecosystem has become more dynamic. Academic drug development and chemical biology are expanding in scope, as it is open innovation, and various forms of collaborations involving academia and the pharmaceutical and biotechnology sectors are now widespread (Varmus & Kumar, 2013). These modifications increase creativity and help to spread the risks of drug development. Mechanism-driven drug development is now the standard, owing to unparalleled knowledge of disease's molecular basis. Oncology has had the most groundbreaking first-in-class drug approvals (Pearl et al., 2015). The discovery of pathogenic molecular mechanisms supports this, most recently through the genome sequencing of tens of thousands of cancer patients, ushering in the era of precision medicine in oncology (Varmus, 2006). As a result, many genetically targeted medications can now be provided to cancer patients based on their risk level. These targeted drugs frequently target a specific addiction or vulnerability in the tumor identified using a predictive molecular biomarker included in the drug label (Mukherjee, 2011; Yap & Workman, 2012). The new generation is also making a significant impact on immuno-oncology drugs.

Meanwhile, the Big Data revolution has an increasing impact across multiple domains, affecting many aspects of our daily lives and numerous areas of research (Stagno et al., 2016). This is due to the increased availability and lower costs of technologies for generating, storing, and analysing large and diverse data sets. Some aspects of multidisciplinary drug discovery, particularly medicinal chemistry, have long embraced computational methods and the collection and analysis of Big Data to aid decision-making (Garraway & Jänne, 2012). The mining of raw biological data on a large scale for target hypotheses is now commonplace. Despite advancement, the drug discovery community is still a long way from understanding the full potential of Big Data analytics and Artificial Intelligence (AI). In this article, we will look at the role of Big Data and AI in modern cancer drug development. We investigate how incorporating Big Data from various information domains will aid in better decision-making throughout the drug discovery process. We address how AI and Machine Learning (ML) transform how we discover new drugs, highlighting areas where increased use of Big Data analytics will greatly support drug discovery.

2. TYPES AND SUBTYPES OF CANCER

Historically, there are 200 cancer types (and subtypes) identified and distinguished by the shape and position of the tumor and its progression of development. Using molecular profile similarity, heterogeneous tumor populations can now be grouped into clinically and biologically relevant subtypes (Ciriello et al., 2013). Cancer causes complex changes in the genome as it progresses. Examples are somatic mutations, copy number variations (CNVs), irregular gene expression, and harmful epigenetic patterns. As a result, each particular patient's cancer would be distinct. However, since the mechanisms affected in various cancer forms and subtypes of tumors are identical, the same therapeutic techniques will often be used for groups of patients. Furthermore, the genetic and phenotypic modifications that occur during tumorigenesis modify the collection of genes that cells become dependent. These improvements create vulnerabilities, which are often converted into practical therapeutic approaches.

2.1 Identifying Cancer Drivers

In most cancers, most genetic changes acquired as the disease signs of progress are inconsequential in driving the cancer phenotype; however, a few of the changes in a small set of genes are crucial to the development or sustainability of the disease. The genes that harbor these critical alterations are called 'driver genes and many studies powered by major international consortia have been undertaken to identify them.

3. TARGET TRACTABILITY

Large-scale experiments have discovered many genes whose protein products need to be evaluated for their potential as drug targets or their "druggability" (Rubio-Perez et al., 2015). A protein's druggability refers to its ability to bind small drug-like molecules with high affinity, primarily determined by its three-dimensional (3D) structure. The idea of the 'druggable genome,' first proposed in 2002, described genes in the human genome that code for proteins that could be modulated by small drug-like proteins (Hopkins & Groom, 2002). In a recent update, 1578 FDA-approved drugs operated on 893 human drug targets (Santos et al., 2016). The original study calculated the 'druggability' of all human proteins by measuring their sequence identity to known therapeutic targets and found that over 10% of the human proteome could be drugged. This number of druggable proteins has recently grown as a result of newer methods. Methods for predicting druggability on proteins whose family members have previously been untargeted have been developed using machine learning-based techniques to analyse the protein's 3D structure. Using these methods, several studies have established possible cancer drug targets from previously untargeted families (Patel et al., 2013; Pearl et al., 2015).

4. MACHINE LEARNING AND AI APPROACHES IN DRUG DISCOVERY

4.1 Definition of AI

The world of artificial intelligence is ancient. In the 1950s, the word "artificial intelligence" was coined (Zheng et al., 2016). AI is a computer algorithm that can 'learn' patterns from input data and then apply that learning to make novel predictions from new data in its broadest context. This term encompasses machine learning (ML) and deep learning (DL) (Mo et al., 2013). Statistics can be used to make forecasts based on data patterns in reality (such as a correlation between two parameters). Simpler algorithms that enable us to learn about tens or hundreds of parameters beyond simple statistical correlations are often referred to as machine learning (ML). Despite this size, the ML's parameters are entirely transparent to the human researcher, but the precise way these parameters combine to make the prediction is no longer apparent. However, the researcher's knowledge to access and distill is increasingly concealed inside large, sparse datasets. For example, such data includes all chemical compounds, atomic interactions, and synthetic reaction pathways in medicinal chemistry. Complex deep learning algorithms shine in these large-scale Big Data environments. DL, unlike ML, can discover key trends concealed in a multidimensional data space by layering abstractions of disparate data (Mo et al., 2013). The use of convolutional neural networks (CNNs) in image processing and recurrent neural networks (RNNs) in text and speech (Mo et al., 2013) are examples of how DL methods have allowed breakthroughs in several disciplines. However, they face high computational costs and the inability to handle "messy" and sparse biological data. These methods are included in AI, particularly when the algorithms change and adjust to new data.

4.2 Advancing Artificial Intelligence From Machine Learning to Deep Learning

The concept of AI was born in the 1950s and was used in drug discovery after the first study of QSAR was presented in the 1960s. In the early stage of drug discovery (e.g., before the 1990s), the common computational approaches used for model developments were linear regressions. In these early studies, the chemical descriptors used for modeling were also limited to chemical structural features, such as atomic type and fragmental descriptors. The advancement of AI in drug discovery was first facilitated by developing novel chemical descriptors such as topological descriptors and molecular fingerprints, which greatly increased the size/categories of descriptors calculated from training sets. Instead of using all available descriptors, descriptor selection was integrated into the modeling procedure, e.g., the genetic algorithm and simulated annealing. Instead of using linear regression, new machine learning approaches, which were developed based on nonlinear modeling algorithms such as k-nearest neighbors, support vector machines, and random forest, were used frequently in modeling studies from the 1990s to the 2000s. In the same period, model validation was emphasised and treated as a must-have modeling component. Instead of only showing self-correlations, the developed models using these new machine learning approaches were validated using cross-validations, external validations, and experimental validations. In addition, the applicability domain became standard practice for model development. In the early 2000s, QSAR modeling, together with relevant studies (e.g., docking), became a well-developed workflow based on the progress of AI discussed above. These milestones of AI in drug discovery are emphasised in other reviews. In addition to the development of AI, the computational power of hardware and the available data for modeling were also significantly improved to facilitate this progress . The early-stage computational modeling of small training sets by simple algorithms (e.g., linear regressions) did not require significant computational power. The advancement of computational power and the availability of biological data for drugs enabled novel modeling techniques such as large-scale networks to address challenges in drug discovery. The first application of the neural network, which was designed as a computational tool in the 1980s, in drug discovery was reported in 1989. Since then, various neural network approaches have been applied to drug discovery. The first popular approach was the artificial neural network (ANN), which focuses on the variable selection procedure. This approach is a machine learning algorithm inspired by biological neural networks such as the human brain. With several variables as the input (e.g., chemical descriptors), ANN approaches form hundreds of artificial neurons connected with relationships (quantified as weights) in the form of a network. A single neuron might have some effectiveness in predicting output, but the actual predictions are made by the network consisting of hundreds or even thousands of neurons. Since they learn from the input data, ANNs represent an excellent machine learning approach for constructing nonlinear relationships among the variables and the target biological activities. The advanced computational models using various machine learning approaches, such as ANNs, required powerful computers and benefited directly from the hardware developments in the 1990s. The concept of deep learning was originally presented together with ANNs in the 1980s. However, neural networks did not show significant advantages over other machine learning approaches when data used for model development are limited. From the 1990s to 2000s, computer hardware was still not adequate for training neural networks with many hidden layers and when the data sets for model development were large. In the 2010s, hardware development reached the milestone of using GPUs and cloud computing, which directly benefited neural network–modeling studies. Advanced as one of the major interests of AI by various information technology companies, deep neural networks (DNNs), sometimes referred to as deep neural nets, with many hidden layers, were developed to address challenging questions such as speech recognition. In the Google DeepMind project of 2015, an AI program based on a DNN with 13 hidden layers first mastered the game of Go, which has long been viewed as the most challenging of the classic games for AI. The milestone paper on deep learning was published almost the same time, and the big data concept was proposed the next year. Deep learning was immediately applied to the life sciences and demonstrated its ability to identify complex biological systems patterns. The first project in which deep learning approaches showed significantly better performance than other machine learning approaches for drug discovery was a QSAR machine learning challenge supported by Merck. Another similar effort organised by the National Center for Advancing Translational Sciences of the National Institutes of Health (NIH) was to model around 12,000 chemicals, including many drugs, for 12 different toxic effects. In this competition, DeepTox, a computational toxicity model based on DNNs, outperformed other models based on machine learning approaches. Besides the modeling challenges mentioned above, there have been various deep learning studies for drug discovery in the past three years. For example, Wen et al. reported a deep learning model developed to predict drug interactions and biological targets based on 15,524 drug-target pairs obtained from the DrugBank database. Another similar deep learning study was performed using transcriptome data obtained from the Library of Integrated Network-Based Cellular Signatures program. Furthermore, multitask learning based on DNNs is a modeling approach that allows multiple related tasks to be modeled simultaneously. Modeling several biologically related endpoints (i.e., bioactivities sharing similar mechanisms) for drug discovery purposes through multitasking learning has shown superior performance to traditional QSAR models by reducing overfitting, solving issues of partial data, and identifying variables from related tasks. The high performance of these DNN models demonstrates the advantages of using deep learning approaches to model large data sets and select meaningful features. However, recent reports also showed mixed results from comparing deep learning and machine learning modeling. Since deep learning is a brand-new concept being applied to computer-aided drug discovery, there are no universal criteria for selecting relevant modeling parameters and constructing the modeling workflow.

4.3 Target Selection and Validation

Therapeutic goals must meet two requirements: 1) their modulation must have the potential to affect the intended condition, and 2) they must be tractable in terms of drug discovery. For more than a decade, predictive modeling has aided target 'druggability' assessment. The canSAR knowledge base employs various machine learning techniques to evaluate target tractability based on protein 3D structure, chemical properties of bioactive compounds, and cellular network structure (Rubio-Perez et al., 2015; Workman & Al-Lazikani, 2013). The use of these integrated capabilities has enabled the mapping of druggable opportunities on the core disease-causing molecular networks found through systematic profiling of cancer patients for the first time. Furthermore, these methods have allowed for the realistic, evidence-based prioritisation of drug targets on a broad scale for potential drug development campaigns. Where appropriate, both chemical and genetic/biological methods should be used parallel to promote the experimental validation of selected targets (Thatcher et al., 2005). Chemical probes can also be used as pathfinder molecules for new small-molecule drug discovery programs, proving that the target can be modulated pharmacologically. However, choosing the wrong chemical methods for target validation can lead to incorrect conclusions and contribute to the biomedical literature's lack of robustness (Shepherd et al., 2005; Thatcher et al., 2005). In 2015, the Chemical Probes Portal (Shepherd et al., 2005) was created as a resource for chemical probe recommendations based on expert peer reviews. However, one drawback is that it is challenging to cover all of the liganded targets in detail through expert reviews, and it is also challenging to keep the recommendations up to date. Probe Miner is a new Big Data-driven resource that critically and quantitatively evaluates chemical probes for a given goal using all available data. It takes advantage of canSAR's multidisciplinary Big Data and currently has assessments for over 350,000 substances as potential chemical probes for over 2,300 human targets (Stinchcombe & Socinski, 2008). The use of both The Chemical Probes Portal and Probe Miner is recommended and complementary.

4.4 Drug Design

The vastness and complexity of the medicinal chemistry space inevitably lend itself to the use of predictive technology in the design and optimisation of ligands, ultimately contributing to the development of novel drugs. Medicinal chemists began using AI methods to design and prioritise compounds early on, such as the production of quantitative structure-activity relationships (QSAR) – a supervised learning tool commonly used since the 1960s to predict bioactivity and other properties (Garraway & Jänne, 2012). Following initial forays into the use of AI in this area, data availability is growing. The field is now maturing, with an increasing number of academic and industrial laboratories using this technology for drug design, as reviewed in reference (Garraway & Jänne, 2012). AI can refine feedback loops in the iterative classical design–make–test cycle in particular. The number of design–make–test cycles can be minimized, and a new drug can be found more quickly and with fewer overall resources when used in conjunction with the expertise and imagination of the medicinal chemist. AI's utility has been demonstrated in designing bio-aminergic GPCR ligands against complex poly-pharmacological profiles (Lindeman et al., 2013) and in the automated de novo design of 1B adrenoceptor antagonists (Tokheim et al., 2016). Furthermore, recent successes in applying AI to synthesis planning (Baeissa et al., 2016), a field that has traditionally not significantly benefited from ML approaches (Garraway & Jänne, 2012), show great promise for further benefiting small-molecule drug design. In biotherapeutics, for example, deep learning algorithms are being trained on patient data to predict neoantigens to inform immuno-therapeutic progress better (Baeissa et al., 2017). Furthermore, computational design and prediction of antibody epitopes assist in designing novel antibodies (Luo et al., 2009), demonstrating how Big Data and AI are also assisting in designing biotherapeutics.

4.4 ADMET Modeling

The use of Big Data approaches in ADMET modeling is still in its early stages. Following the realization in the late 1990s that poor ADMET was a significant cause of expensive late-stage clinical failures, increased emphasis was placed on fixing ADMET early in drug development (Gao et al., 2013). The subsequent development of higher throughput ADMET in vitro assays provided the requisite data to apply modeling approaches. However, the data remained limited and largely confidential. Recently, promising applications of AI methods to ADMET prediction have emerged. Consider the recent application of transfer and multitask learning in predicting pharmacokinetic parameters (Subramanian et al., 2005) or the application of DL to ADMET prediction (Huang et al., 2007). Furthermore, public-private collaborations, such as the eTOX consortium, have been established to recover legacy toxicological data from large pharmaceutical companies and build better predictive models (Reimand et al., 2007). Despite promising advances, we are currently limited in our ability to mine ADMET data and create predictive ADMET models due to a lack of adequate well-curated Big Data in the public domain.

4.5 Other Areas of Computational Modeling Utilising Artificial Intelligence for Drug Discovery

4.5.1 Trational Nanomaterials Design

Modern nanotechnology highly impacts drug discovery by offering biocompatible nanomaterials (e.g., nanomedicines with desirable therapeutic activities and low side effects) to the drug research and development process, especially as versatile yet reliable carriers for the delivery of drugs to treat systemic diseases such as cancers. Using AI in nano-modeling for drug discovery was based on molecular dynamic (MD) simulations. For example, several studies using MD simulations detected the insertion of nanoparticles in the plasma membranes of the recipient cells and an overall change in the cell membrane structure. Later, the same approach was used to estimate the affinity of carbon nanotubes to organic molecules. In another study, a set of nanoparticles was tested *in vitro* in four cell lines, and the potential membrane perturbation effects of these nanoparticles were studied. The reaction behaviors of individual nanoparticles were also investigated under certain conditions using MDs (e.g., interactions with or passing through membranes), along with the effects of the size, density, position, distribution, length, and type of surface ligands on the biological properties of the nanomaterials. The advantage of MD simulations is that they can precisely simulate molecular structures. However, the clear disadvantages are that modeling procedures are computationally expensive and cannot provide rapid predictions for extensive databases due to the current limitations of computational resources. Another computational approach is to apply traditional QSAR modeling methods to nanomaterials. For example, the QSAR technique was used to create predictive models for nanoparticles with similar or different metal cores. Recently, membrane-nanoparticle interactions were modeled based on the atomisation energy of the metal oxide, the period of the nanoparticle metal, and the primary size of the nanoparticle.

The current application of AI approaches in nano modeling has been limited to designing new nanomaterials due to a lack of suitable chemical descriptors. Although descriptors calculated from only the surface ligands help predict the bioactivities/properties of nanomaterials, the effects of the nanomaterial's size/shape, density, position, distribution, length, and type are described above surface ligands were not considered in these studies. Some other nano modeling studies have incorporated descriptors derived from experimental properties (e.g., nanoparticle size) or even biological data (e.g., proteomics data). Due to the diversity and complexity of nanomaterial structures, Puzyn et al. argued that no universal nano-QSAR model could accurately predict the biological properties of variable nanomaterials. Briefly, the properties and bioactivities of nanomaterials were primarily determined by their surface chemistry. To simulate the nano surface chemistry correctly, the functional groups' surface ligand orientations and accessibility needed to be considered in the calculations. For example, in the early modeling of nano hydrophobicity, the contributions of heavy atoms and functional groups to nanologP values were correlated with their accessibility by solvent molecules. In a recent study, an advanced method of integrating the solvent-accessible surface into calculations can be viewed as a universal nanologP calculator. A similar modeling strategy has been applied to model nano-cellular uptake capacities and other nano bioactivities. The resulting models were used to synthesise several new nanoparticles with desired nano bioactivities.

4.5.2 Convolutional Neural Networks and Image Modeling

The CNN is a unique network modeling approach inspired by neuroscience to imitate images within the visual cortex, where individual neurons respond to stimuli only in the receptive fields. Different neurons can partially overlap with each other to cover the entire receptive field. The CNN architecture is constructed so that hidden layers are particularly adept at screening multidimensional input such as the red, green, and blue saturation values obtained from thousands of pixels for an image. In the training process, the CNN approach uses kernels and grids of a predefined dimension to scan the image and recognise certain critical features such as lines and contours for a human face. The concept of CNNs was proposed in the 1980s for image recognition purposes but did not draw great attention until the 2010s. This approach has become well known, as it has dominated all image recognition challenges since 2012, and it is now the base of image/speech recognition, video analysis, language understanding, and other relevant applications. As one of the most popular deep learning approaches, CNNs have been used for image modeling in clinical diagnoses such as cancer, Alzheimer's disease, and heart disease. In traditional drug discovery, CNNs were also applied to analyse image data obtained from experimental drug testing, such as HTS results. Due to its unique advantages in image recognition, CNNs were also used to recognise 3-D experimental and virtual images to predict ligand-protein interactions. In some studies, CNNs were coupled with other computational approaches to realise specific goals. For example, CNN's were used as a new approach to recognise molecular features from molecular drug graphs. In this study, drug molecules were treated as 2-D graphs with atom features. The CNN was used to transform the molecular input graphs into new molecular features for training purposes. In another study, an advanced CNN approach called survival convolutional neural network was used to predict the cancer outcomes of patients based on histological images and genomic biomarker data. Furthermore, CNN's could function as a text-mining technique to extract drug-drug interaction data from the biomedical literature.

4.5.3 Personalised Medicine

A drug commonly interacts with multiple targets, including both on- and off-targets, and drug efficacy and side effects are greatly affected by this. Genetic, epigenetic, and environmental factors determine an individual biological system (e.g., a patient) by a drug molecule. To identify this hidden hierarchical information, personalised medicine was designed to respond to the individual characteristics of each patient. Personalised medicine strongly relies on a scientific understanding of how an individual patient's unique characteristics, such as molecular and genetic profiles, make this patient vulnerable to disease and sensitive to treatment. Driven by biomarker studies starting in the late 1990s, hundreds of genes have been identified for their contributions to human illness, and genetic variability in patients has also been used to distinguish individual responses to dozens of treatments. With the vast amount of data generated by these studies, such as the Human Genome Project, computational modeling has become one of the essential tools for personalised medicine. Drug-target predictions, metabolic network modeling, and population genetics pattern identifications are several recent advancements in this field that rely on computational modeling. Under the NIH Precision Medicine Initiative, many data generations and sharing initiatives and computational modeling efforts have arisen to support the expansion of precision medicine. For example, the Genomic Data Commons program of the National Cancer Institute aims to provide a data repository that enables data sharing across genomic cancer studies in support of precision medicine. So far, 33,549 case studies have been submitted and shared via this portal (https://gdc.cancer.gov/). Although it is not the focus of this review, genome sequencing analysis has been a widely applied approach involving AI techniques, and there are many reviews available on this popular bioinformatics topic.

5. BIG DATA IN BIOLOGY

5.1 Big Data in Drug Discovery Target Identification and Validation

The role of drug discovery is to develop effective and safe treatments for ailments where there is a significant unmet medical need. It follows that the role of biology in drug discovery has been to understand the underlying causes of these ailments, predict and validate potential biological targets for their treatment, develop techniques to identify treatment modalities that interact with biological targets, predict how these treatments will interact with the body when given to the patient and design the most effective clinical trials to determine if these collective predictions are correct. This section describes how biological Big Data is evolving and the successes and challenges in harnessing the data to impact target identification/ validation in particular. The revolution in molecular and cellular biology, beginning in the early 1970s with the ability to manipulate genes, culminating in whole-genome sequencing in the new millennium, has resulted in an explosion of biological data and techniques that have significantly impacted drug discovery been performed. Today, manipulation of genes/proteins in cells and whole organisms is considered standard practice in drug discovery efforts to identify, validate and develop novel treatments for diseases. The obvious starting point in the majority of drug discovery projects has traditionally been single protein targets. This approach has delivered effective drugs with the genomics revolution continuing to supply new techniques and more significant, more detailed datasets that enrich our understanding of potential drug targets and their role in disease.

5.2 Genomics and Genetics

The human genome project was heralded as a breakthrough for understanding and improving human health, and it is beginning to deliver that promise in disease areas that are more amenable to genomic analysis techniques, such as cancers and rare diseases. Whole human genomes, exomes, and accessible tissue-/cell-specific transcriptomes can now be sequenced with relative rapidity and low cost, leading to the generation of vast amounts of data. This, in principle, should allow the unprecedented characterisation of the genetic basis of diseases, leading to the identification of better drug targets. Despite this technical tour de force, the interpretation and validation of much of the biological data remain a significant issue. From a simplistic perspective, how can we align existing data if we do not fully understand its context and the experiment performed? This issue is exemplified by the continued lack of understanding of the function of non-coding regions, which make up most of the human genome, despite having completed the human genome sequence in 2003 (Cancer Target Discovery and Development Network, 2016). In some instances, genomics provides human genetic evidence to identify potential drug targets or provide the basis of precision medicine strategies to select individuals that will respond to a given treatment or in which treatment might be contraindicated. These approaches are paying some dividends in oncology, in particular, where several marketed therapeutics based on precision medicine strategies have become available. This allows the identification of patients most likely to respond due to the genetic properties of their cancers, e.g., imatinib for chronic myeloid leukemia containing a BCR-ABL kinase fusion (Xu et al., 2017) or BRAF inhibitors for melanoma with BRAF mutations (Cai et al., 2019). Cancer is particularly amenable to genomics-aided drug discovery and development because of the accessibility and availability of diseased tissue. This is not always the case. Other disease areas may require bridging genetic observations from genome-wide association studies (GWAS) or from genetic analysis of diseases in which the causal genes can be clearly defined, e.g., the approval of the PCSK9 antibody-based approach for dyslipidemia in 2015 was first underpinned by a genome mapping study identifying PCSK9 as a causal gene for autosomal dominant hypercholesterolemia (Wenzel et al., 2019). Genomics-based studies are also shedding light on other disease areas that might be considered to have a more complex polygenic or environmental basis, highlighted by the rapid increase in the number of disease-associated genetic loci being identified over the past few years (Li et al., 2018; Russo et al., 2018). These studies have yet to be translated into therapeutic benefits, which remains the critical hurdle in driving the understanding of complex diseases (Zhou et al., 2019). Gene expression analysis has evolved with the development of the RNA-seq technique (Minko et al., 2013) generates large whole transcriptome datasets, permitting the analysis of genes encoding potential drug targets, in concert with many others in diseased tissues. While the transcriptome is only half the story, with the translatome now emerging as a relevant field of study, the potential power of this technique is being exploited. Efforts are underway to sequence the transcriptome of every cell type in the human body. Our understanding of the complexity of gene regulatory networks that underpin these transcriptomes is rudimentary at best and represents snapshots of dynamic systems in space and time. The central dogma that DNA makes RNA makes protein, which, in conjunction with the environment, ultimately determines normal and disease phenotypes will evolve. Understanding biological networks at a cellular, multicellular and whole organism level is required so that normal physiology and its perturbation in disease can be understood and harnessed to deliver effective disease treatments. Understanding and using the transcriptome in concert with the translatome is the Holy Grail; most drug discovery targets are translated protein targets, so in some diseases, the dysregulation that ultimately delivers the disease phenotype may sit between transcription and translation.

5.3 Successful Target Validation Requires Decision-Making Experiments

In the early stages of drug discovery hypothesis generation, the relevance of data from multiple domains (biology, chemistry, safety, translational medicine, genetics, multispecies variation) has to be considered and set into the context of the potential new idea. To do this systematically, data from multiple public and proprietary sources have to be integrated (Hofmarcher et al., 2019) and analysed to build confidence in, and add evidence to, any given new drug discovery idea. This is a significant challenge given the complexities in managing entity namespace and ontologies (Stepniewska-Dziubinska et al., 2018) and a general lack of interoperable data standards (Altae-Tran et al., 2017; Ragoza et al., 2017). Indeed, the complexity of this undertaking and its relevance to drug discovery has been the primary driver in cross-pharma precompetitive activities (Mobadersany et al., 2018; Zhao et al., 2016). Understanding the context of the experiment that delivered the result on which you now base your hypothesis is a challenge that, until the AI revolution, could only be achieved through extensive reading of the scientific literature. Linking information from multiple data sources will build confidence in a hypothesis. However, until using AI, it was not easy to use these data sources together to generate hypotheses of a high enough quality to deliver a positive result in a proof-of-concept study. For any drug discovery hypothesis, the route to validation and clinical testing can essentially be reduced to a series of questions. The application of Big Data to these questions follows the approach exemplified by the Open PHACTS IMI project, where large amounts of data are integrated to systematically resolve critical questions in early drug discovery (Xie et al., 2014). In the setting of an entire drug discovery project, these questions are based on: understanding the role of the target in the disease in question, understanding the risks that modulation of that target could bring as the program advances through to clinical testing, and risks relating to the chemical matter. These questions include but are not limited to: does the target appear in a disease-relevant pathway, and how strong is the evidence linking a pathway to the target involved in a disease or a potential safety signal? Is there supporting evidence for the hypothesis from pharmacology or genetic evidence in animal models, and how strong is the evidence that this will translate to a human? Is there human genetic evidence supporting the hypothesis, and is there evidence of causation or ability to stratify patients? What is the current therapy or standard of care in this disease, and what does the competitive landscape look like? What chemical tools are available to test this hypothesis, and what is known about their risk profile? As mentioned previously, big data-powered analyses are now being utilised to answer many of these questions, as mentioned previously (Liu et al., 2009). The issues highlighted with data availability and quality also have to be kept in mind. Given the patchy nature of publicly available data and the challenges of collecting samples in some disease areas, not all of these questions are answerable for all disease areas. Also, the curse of dimensionality previously mentioned, the bias in data, and gaps of fundamental understanding in many diseases mean that pragmatism has to be deployed (Hamburg & Collins, 2010). The general lack of success in some disease areas like Alzheimer's disease (Collins et al., 2003; Sydow et al., 2019) underlines the lack of understanding of causal disease and normal biology remains a significant challenge. However, this is also an opportunity that Big Data approaches can contribute to resolving (Chang et al., 2010). The wide availability of open and fully contextualised datasets remains crucial in developing and applying Big Data approaches to early drug discovery idea generation. To build on the issues exemplified in the FAIR (Schrider & Kern, 2018) approach: data should be Findable, Accessible, Interoperable, and Reproducible. Too often, valuable data resources fail in one or more of the FAIR principles. Funding constraints often lead to critical data resources becoming inaccessible over time, meaning valuable data can be lost to the community (Collins & Varmus, 2015). While ELIXIR

(Grossman et al., 2016) and other coordination initiatives (Marti-Renom et al., 2000) aim to tackle this, the availability of fully provenanced data that can be traced back to the originator's experiments is vital for Big Data approaches. The sustainability of data resources is a vital issue the community needs to address in the long term. Data interoperability has been touched on elsewhere but remains a significant obstacle in developing Big Data workflows for drug discovery hypothesis generation. The ability to mix data from different technologies, experiments and disease areas without losing context and metadata is critical yet often unachievable. Finally, reproducibility has its unique complication in Big Data. This goes beyond the widely understood issues in other domains (Bharti et al., 2019) and pertains to software reproducibility—publishing the code base, full details of datasets and data methods, and peer scrutiny of code—as part of the publication process (Russell & Norvig, 2003).

The early stages of drug discovery aim to establish a viable hypothesis, build confidence in that hypothesis with any available data, and then determine an experimental decision-making route forward—ultimately to the clinic. Translation from the experimental setting to the human patient is critical at all stages, but minor data are often available (Hansch & Fujita, 1964). While drug repurposing opportunities for drugs with known safety and tolerance might be testable directly in the clinic, these opportunities are rare (Martin, 2010; Mnih et al., 2015). Depending on the disease area, a preclinical model will often be required, and the relevance of this model to the ultimate disease setting might be cryptic or inconclusive for decision making (Zefirov & Palyulin, 2002). The critical question to be kept in mind in leveraging Big Data approaches at this stage is—has Big Data enabled a real test of the drug discovery hypothesis, which could translate to human disease? With an emphasis on open innovation, there are signs that this is a solvable problem, but the genuine engagement of the scientific community as a whole is required to deliver impact beyond the currently isolated examples of promising progress (Labute, 2000). Critically, it will be those communities of researchers who engage best with Big Data specialists who can generate real progress in understanding disease biology.

5.4 Challenges of Big Data

Although big data offers many opportunities in drug development, it also poses technological and conceptual challenges. Technical challenges, such as storage space, are significant; it is expected that between 100 million and 2 billion human genomes will have been sequenced by 2025. This amount of data can necessitate up to 40 EB of storage (Stephens et al., 2015) and will necessitate substantial investment to handle (Lynch, 2008; Trelles et al., 2011). The philosophical issues about how we gather, analyse, and treat the resulting insights from this data are critical issues that must be addressed to ensure the validity of any work with big data. These factors are discussed further below.

In addition to typical issues about data quality (Weng & Kahn, 2016), 'big data' presents specific problems because, unlike traditional science data, it is not representationally sampled and is widely collected without a prior hypothesis. Data collection without a clear objective from the start can result in unexplained systemic biases (Fallik, 2014) or problems later on as data collection is modified to use modern, improved schematics, resulting in disparate datasets (Lazer et al., 2014). At a deeper level, if we depend solely on insight from data that lacks meaning or underlying processes that are poorly explained, our findings can be confounded in undetectable ways. Some practitioners are worried that vast amounts of data with a bit of background will supplant domain expertise and scientific rigor, posing the risk that the research process in drug discovery will shift from a scientific to an engineering discipline (Callebaut, 2012). The mathematical model is essential for analysing any large dataset, and any data obtained is only as valuable as the model that represents it. The context in data (such as clinical annotation) can be challenging to understand at scale and much more difficult to keep when data is reduced to fit into a model (Boyd & Crawford, 2012). Another consideration when selecting a suitable model is the ease with which the process of your study can be interpreted. Each phase of an experiment can be well understood in conventional experimental processes, and findings can be easily interpreted to help both validate conclusions and hopefully better understand the underlying mechanisms of the observed process. This is not always the case in mathematical models; for example, a neural network embodies no decision model or even a problem domain; it is essentially a black box that predicts future events based on unauditable processes (Clarke, 2015) and should be used with caution, even as a supplement to experimental validation. Even if no errors occur during the processing or simulation stages, 'extensive data analysis is prone to various statistical issues, including high false error rates (Ioannidis, 2005) and overfitting (Boyd & Crawford, 2012). Sound statistical practices, such as ensuring high-quality data, integrating sound domain knowledge, and developing an overall strategy for modeling and validating issues, are more critical than ever in extensive data analysis (Hoerl et al., 2014). The significance of statistical rigor is illustrated in well-publicised cases such as Potti et al. (Potti et al., 2011), where uncorrected sources of variance and inadequate statistical procedures resulted in the cancellation of clinic trials and a complete retraction.

Many claims that big data can only be used to supplement experimental confirmation. There is currently much debate within the Cancer Target Discovery and Development Network about the degree of experimental evidence needed to supplement insights derived from extensive data analysis (Cancer Target Discovery and Development Network, 2016). Although big data offers many opportunities in drug development, it also poses technological and conceptual challenges. Technical challenges, such as storage space, are significant; it is expected that between 100 million and 2 billion human genomes will have been sequenced by 2025. This amount of data can necessitate up to 40 EB of storage (Stephens et al., 2015) and will necessitate substantial investment to handle (Lynch, 2008; Trelles et al., 2011). The philosophical issues about how we gather, analyse, and treat the resulting insights from this data are critical issues that must be addressed to ensure the validity of any work with big data. These factors are discussed further below.

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process. This is not always the case in mathematical models; for example, a neural network embodies no decision model or even a problem domain; it is essentially a black box that predicts future events based on unauditable processes (Clarke, 2015) and should be used with caution, even as a supplement to experimental validation. Even if no errors occur during the processing or simulation stages, 'extensive data analysis is prone to various statistical issues, including high false error rates (Ioannidis, 2005) and overfitting (Boyd & Crawford, 2012). Sound statistical practices, such as ensuring high-quality data, integrating sound domain knowledge, and developing an overall strategy for modeling and validating issues, are more critical than ever in extensive data analysis (Hoerl et al., 2014). The significance of statistical rigor is illustrated in well-publicised cases such as Potti et al. (Potti et al., 2011), where uncorrected sources of variance and inadequate statistical procedures resulted in the cancellation of clinic trials and a complete retraction. Many claims that big data can only be used to supplement experimental confirmation. There is currently much debate within the Cancer Target Discovery and Development Network about the degree of experimental evidence needed to supplement insights derived from extensive data analysis (Cancer Target Discovery and Development Network, 2016).

6. CONCLUSION

As technology progresses, we can now examine increasingly large datasets, and international efforts to curate and collate this data to provide an unprecedented opportunity for today's research communities. However, there is still room for change. Before these methods and tools can be matured entirely, issues such as compilation, quality control, standardisation, access, and statistical rigor must be addressed. Cancer chemotherapy is currently experiencing a paradigm shift, moving away from conventional, all-purpose treatments including potentially harmful cytotoxic agents and toward a far more selective strategy that includes the use of targeted and even personalised therapies. This advancement is due, in large part, to the availability of biological "big data" through a variety of platforms and resources built to turn the data into actionable insight. The need for better cancer treatments has resulted in a plethora of cancer research that incorporates massive amounts of data from various platforms. These studies have helped us understand the mechanisms underlying cancers and the resulting vulnerabilities that can potentially be exploited as drug targets. Data interpretation is a significant hurdle in implementing routine clinical sequencing by next-generation sequencing for diagnosis and cancer management. Extensive data management and interpretation require large servers and skilled bioinformaticians. For diagnosis, the generated datasets include a benign, likely benign, variant of unknown significance, likely pathogenic, and pathogenic variants. Categorising all variants into classes and recognising their clinical significance is imperative.

In addition to diagnosis, data obtained can be helpful for cancer management (Trelles et al., 2011). Precision medicine has benefited from targeted sequencing, the current standard for clinical purposes where selected candidate genes are highly prevalent for the given cancer subtype. Examples of such genes include BRCA1 and BRCA2 in breast cancer (Weng & Kahn, 2016), p53 and PTEN in prostate cancer (Fallik, 2014), KRAS in pancreatic cancer (Lazer et al., 2014), BRAF in colorectal cancer (Callebaut, 2012; Clarke, 2015), and ERBB2 in lung cancer (Hoerl et al., 2014; Ioannidis, 2005). Although targeted sequencing has higher sensitivity, coverage, and lower costs, it does not identify large genomic rearrangements and detects potential pathogenic mutations in genes not covered in the panel (Trelles et al., 2011). Whole-genome sequencing or whole-exome sequencing can overcome this issue.For instance, this method has proven successful in unraveling cervical cancer pathogenesis and identifying novel therapeutic targets (Lynch, 2008). However, the disadvantage of whole-genome and exome sequencing is associated with the high cost and sizeable computational burden with complicated data analysis (Cancer Target Discovery and Development Network, 2016).

In the next decade, further enhancement of the NGS platforms may see a decline in costs without the quality trade-off. Implementing AI in the healthcare sector still has many barriers, irrespective of its benefits. With automated computation, there is a surge in big data and costs. AI systems can be expensive due to their dependence on specialised computational requirements for fast data processing. These systems also require different quality processes (Xu et al., 2017). Although AI systems offer accurate data and image analysis, the generated data is only valid when clinically relevant and interpreted correctly. To implement AI-based systems for routine clinical practice, the intended users require training and understanding of the system (Cai et al., 2019). Rigby (2019) highlighted the ethical challenge with AI in healthcare. With the surge in big data, it is imperative to alleviate the ethical issue related to the use of patient data in unwarranted and unconsented circumstances. Moreover, ethical policies and guidelines are required to protect patient safety and privacy (Wenzel et al., 2019). AI in healthcare and precision oncology would significantly benefit from overcoming these challenges and limitations with advances in AI technology.

Further research has provided methods for us to predict the suitability of these drug targets, potentially saving some of the considerable time and expense associated with drug development failure. While 'big' data can only be used to supplement experimental validation, it remains an integral part of modern drug research as we map out cancer environments and better identify various cancer subtypes to provide a more reliable, resilient, and targeted range of cancer therapies.

7. FUTURE PERSPECTIVES

As with previous chemotherapies, predicting and overcoming resistance is a significant obstacle for targeted cancer therapies. Some of the more recent targeted therapies have only given short-term remissions until resistance develops. This is due to the pre-existence of resistant sub-clones or the tumor's continued development under the selective pressure of a drug regime (Al-Lazikani et al., 2012; Garraway & Jänne, 2012). To prevent the development of resistance, using a personalised approach to treat all tumor patients may necessitate combination therapies with one or more drugs.

Clinical studies will also benefit from the use of 'big data. Testing novel compounds against characterised cell-line collections can aid in preclinical stratification in the identification of sensitive cancers. The data generated by these studies can be used to guide clinical trial design and help in the creation of customised therapeutic regimens.

The continued growth in the amount and availability of 'big data' provides many opportunities in the field of cancer drug development, offering exciting ways to inform decisions at each stage of the discovery pipeline, from drug target recognition and subsequent molecule selection to stratifying patients, allowing for better-targeted trials and lower attrition rates. Researchers, scientists, and practitioners would collaborate with patients and healthcare professionals to provide more personalised cancer treatment using large-scale integrated data.

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Chapter 8
Robot Therapy:
A New Horizon in Mental Healthcare

Uthirakumar Devaraj
Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

Balamurugan Elumalai
epartment of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, India

ABSTRACT

This chapter discusses the current and potential use of robot technology in mental healthcare. Robots use the transition using effectors, which may shift the robot itself (locomotion) or move objects in the background (manipulation), making judgments based on sensor input. Robotics has long been defined as the science that examines the intelligent links between perception and action, but in recent years, this definition has shifted outward, with a greater emphasis on challenges connected to connecting with real people in the virtual environment. This transformation has been referred to in the literature as human-centered robotics, and a developing area in the last decade focusing on problems in this arena is known as human-robot interaction (HRI). Robotics technology is still in its early phases in mental healthcare, but it represents a potentially powerful tool in the professional's toolkit. Socially assistive robotics (SAR) is an up-and-coming field that has spawned a slew of fascinating mental health applications.

INTRODUCTION

Individuals and society bear the tremendous weight of mental illness (e.g., World Health Organization [WHO], 2010). 25% of Indians have a diagnosable psychiatric disease in a given year, with 5% of the population exhibiting symptoms before 18. (Kessler & Wang, 2008; Kessler et al., 2009; Kessler & Wang, 2008). Mental illnesses are also linked to high financial costs, such as medical care, lost wages, and criminal justice (Jason & Ferrari, 2010). Most people who require mental health care will never receive it (Kessler et al., 2005). Although 33% of people with psychiatric diagnoses receive mental health therapy, just a small percentage receive evidence-based care. This lack of therapy is not due to effective treatments; rather, many psychological techniques for mental health issues have been created and widely

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evaluated (National Registry of Evidence-based Programs & Practices, 2012). Over 320 evidence-based remedies for mental health illnesses have been identified by the government (U.S. Department of Health & Services, 2014). One of the most difficult aspects of mental health care is ensuring that those who require counselling can receive it. Mental healthcare is attempting to better satisfy unmet needs in the sector through a variety of tactics, including a greater emphasis on spreading effective interventions, novel treatment models, and the use of technology to extend the reach of existing solutions (Internet-based treatments; Carlbring & Andersson, 2006; Cummings, Wen, & Druss, 2013). The way people acquire mental healthcare treatments has changed dramatically as a result of recent innovations. For instance, internet-based therapies are becoming more widespread for various psychiatric disorders (depression, bulimia nervosa, social phobia; Andersson et al., 2005, 2006; Ljotsson et al., 2007). Patients typically participate in online treatment programs on their own time, with varying levels of therapist help (telephone check-ins to monitor progress; Spek et al., 2007). Knaevelsrud & Maercker, 2007; L'Abate & Kaiser, 2012; Spek et al., 2007) show that internet-based interventions increase functioning, have low drop-out rates, and be safe well-tolerated.

Technology developments in treatment include web-based programs. Socially assistive robotics (SAR) is an intriguing and newly emerging technology in mental healthcare treatment choices. Robots that assist human users through social contact are called SAR (Feil-Seifer & Matari, 2011). This robotic device can instruct and provide feedback to patients, assist with treatment compliance, and track progress. Previously, socially assistive robots were used in mental healthcare settings for children with autism spectrum disorder and older people with dementia (Moyle et al., 2013; Vanderborght et al., 2012). However, these robots can also be used to address a wide range of clinical issues, including persons with mood and anxiety problems, children with disruptive behaviour issues, and those who do not meet diagnostic criteria but have mental health issues (high levels of stress). SAR work is not widely known among mental health specialists, such as researchers and practitioners, who could significantly influence the subsequent mental healthcare applications of SAR. Even though SAR is still in its infancy, its value in addressing unmet requirements is expanding. In remote areas, robots can fill vacant niches and assist human providers in their ongoing efforts to deliver services (helping as helpful tools within treatment sessions with a provider).

Furthermore, robots can play therapeutic roles (for example, naive peers) that even doctors could utilize in treatment. In this context, robots can enhance traditional delivery methods or assist patients by providing in-home resources and services. Thus, if we want to benefit our field's most critical clinical needs, we need to start collaborating with mental health doctors right away.

This chapter focuses on recent SAR advances and mental health applications. Also, the chapter looks at how these robots have already been used in mental health treatment, focusing on how they have served various tasks (i.e., companion, therapeutic play partner, coach). Following that, the critical research lines required to merge SAR with the ever-expanding mental health field have also been discussed.

1. Compassionate Robots that Assist Others

1.1 Definition and Examples

It is critical to begin by describing the group of robots into which social assistive robots fall to understand where we are going. It includes robotics, which is a unique field at the intersection of assistive robotics, which assists human users through interactions with robots (such as mobility assistants and educational robots), and socially interactive or intelligent robotics, which assists people in interacting socially with robots (such as robots that help people learn new things) (like robotic toys and games). MITManus, which assists stroke victims by physically guiding them through physical tasks, is an example of a traditional helpful robot (Prange, Jannink, Groothuis-Oudshoorn, Hermens, & IJzerman, 2006). The robot interacts with the user physically (but not socially) by moving the user's body around on the screen. Socially intelligent robots can interact with people socially but cannot aid people expressly. Leonardo, for example, is a socially intelligent robot with an expressive face and body that can visually monitor a human user's expression, physically respond to touch, and participate in social learning (MIT Personal Robots Group, 2014). On the other hand, Leonardo is not designed to help people and is not a socially assistive robot.

SAR includes a social component to aid a human user (e.g., coaching, education, and motivation). Although precise design specifics will be explored later, it is essential to remember that robots can take numerous forms in SAR work, ranging from tailored, specialist laboratory-made robots to commercially available toys that are modified and customized to produce more specialized systems. The drawback of both of these systems is that they are expensive and time-consuming to build. SAR requires robots to comprehend their surroundings, converse with humans, and regulate their social cues (Okamura, Matariç, & Christensen, 2010). Creating robots that can perform complicated and intricate social interactions is undoubtedly challenging (Tapus, Matarić, & Scassellati, 2007). Many robots discussed in this article work either partially or totally under human control. This resembles the human and robot roles of puppeteer and puppet, respectively (Lu & Smart, 2011). This research will intend to produce self-operating SAR systems that can be employed without any form of human supervision. SAR, a transdisciplinary area, integrates robotics, engineering, medicine, communication, and psychology and has numerous actual and future applications. This does guide visitors through museums and assist elderly patients in eating their meals (Ghosh & Kuzuoka, 2013; McColl & Nejat, 2013). SAR has already been applied in multiple therapeutic contexts in healthcare, including stroke rehabilitation, recovery for cardiac patients, weight reduction and exercise programs, and patient education (Kidd & Breazeal, 2005; Henkemans et al., 2013; Kang et al., 2005). Elderly patients' activity can be helped using a SAR system (Fasola & Matarić, 2013). Bandit, a physically present robot, was employed in the investigation (i.e., a virtually present robot). During two weeks, each group member completed four 20-minute workouts. The robot replicated many activities for the participants, provided feedback on the participants' exercise performance, encouraged and complimented the individuals. Participants in both groups demonstrated equivalent levels of task performance and compliance with the directions provided by the virtual and real robots. The observed results of the study may be attributed to the small sample size (N = 33) and low power to identify differences between groups. Engagement with a physically present robot was much more pleasurable and helpful than interaction with a screen portrayal of the robot. Physically current robots received higher marks in terms of helpfulness and attractiveness. These findings imply that a robotic instructor can assist older persons through activities and that a robot may be preferred to screen-based or computer-based activities.

Weight loss encouragement is also available using robotic technology. Each group was assigned a weight-loss assist: a robotic weight-loss assist (named Autom), the same desktop software as in the robot, or a paper-and-pencil record (part of the standard weight-loss treatment; Kidd & Breazeal, 2008). Autom was built as a coach to help participants lose weight, and they only engage with the coach each day. Autom may engage in small talk and provide diverse dialogues and interactions based on numerous parameters (e.g., time of day, time since last interaction). It is compatible with research hypotheses considering the brief period of the program. Participants in the weight-loss program who worked with

Autom lasted significantly longer (mean = 50.6 days — more than a week beyond the program's formal conclusion) than participants in the computer program (36.2 days) or participants in the paper log conditions (26.7 days). It was revealed that participants who worked with Autom had a significantly greater therapeutic link than those who worked with either the computer or the paper log conditions (which were not different from each other).

According to this research on Autom and the findings of the previous workout program, robots may be integrated into treatment regimes in ways that are acceptable to users, and robots may provide benefits (e.g., increased enjoyment, higher compliance) over computer-based programs. As both of these SAR cases demonstrate, SAR systems have been used in various situations, with favourable outcomes on each occasion. Perhaps most importantly, human users were receptive to receiving aid from SAR systems and interacting with them for their intended purposes. In mental healthcare interventions, SAR systems of a similar nature could assist in monitoring treatment participation, offering encouragement and support, and leading users through clinically relevant activities and tasks.

1.2. Recognizing Human Responses to Socially Helpful Robotics

As a collective, socially helpful robots have been depicted as a homogeneous and uniform entity up to this point. At first, it is crucial to highlight that the robots themselves are incredibly diverse and can perform various mental health research and development roles. Indeed, socially assistive robots, like all robots, are a very diverse group that can take forms of many different physical guises, including animal-like, machine-like, and human-like appearances (Fong, Nourbakhsh, & Dautenhahn, 2003). The physical shape of the robot is significant to consider in search and rescue operations because it facilitates the human urge to engage with and ascribe social characteristics to even the most basic robotic forms (Okamura et al., 2010). Various SAR types have been used in existing mental health care applications, and more are being developed. SAR applications have used various animal and animal-inspired patterns, including dogs, cats, seals, and dinosaurs. Also employed were different humanoid shapes, which ranged from incredibly lifelike to more machine-like in appearance. For example, a spherical robot that can wander around has engaged newborns in interactive tasks (Michaud & Caron, 2002; Michaud et al., 2005). Although these robots fall into broad categories of robotic shapes, there is a great degree of variance in the physical look of these machines.

One advantage of these robots is that many specific physical features and functions (e.g., facial design, voice pitch, speech style) can be controlled to increase sociability and likeability in the robot, thereby facilitating positive and productive interactions between humans and robots. The proportions of a robot's face might cause users to react differently, with some judging some robots as more social due to this characteristic (Powers & Kiesler, 2006); similarly, how a robot communicates with humans influences the user's interaction with the robot. When a robot addresses a human by name, that human is more likely to regard the robot as nicer and behave in a more socially engaged manner (e.g., pay closer attention and speak more to the robot; Kim, Kwak, & Kim, 2012). People are also more likely to respond favourably to robots that appear more lively and exhibit emotional responses (e.g., suitable facial expressions, positive speech content) throughout an engagement (Leite, Pereira, Martinho, & Paiva, 2008). Further factors that may help humans and robots interact more effectively are the user's personality characteristics and the "fit" between the user's personality and the robot's style. It has been shown that a match between user personality and robot "personality" (the substance of feedback and the manner of input) is associated with increased time spent with the robot (Tapus & Matari, 2008). These examples demonstrate that SAR application in mental healthcare brings up exciting possibilities for robotic devices designed to carry out specific duties and functions in mental health. Because of their versatility, robots can be used to treat a wide variety of therapeutic populations, clinical situations, and therapeutic aims simultaneously (Okamura et al., 2010). It is crucial to note that people generally respond favourably to robots of a range of design shapes, aside from issues about customizing them. To say that all users (for example, individuals from different cultures and varying levels of expertise) react to robots in the same manner. Variability does exist, as evidenced by how people perceive and respond to robots, which has been demonstrated (Wang, Rau, Evers, Robinson, & Hinds, 2010).

On the other hand, individuals of all ages are generally amenable to interacting with robots in general. Robots elicit a positive response from children and teenagers, who are delighted to engage in interactive play activities with them (Bernstein & Crowley, 2008). Older people and the elderly frequently say that they are eager to accept robot assistance in various tasks, such as housework and medication reminders (Smarr et al., 2012). It appears that gaining more experience and engaging with robots results in even more positive reactions.

Users who interact with a robot regularly appear to become more comfortable with the robot and adapt their behaviour with the robot in response (e.g., increased physical closeness to the robot) to reflect their increasing comfort level, even over relatively short periods (e.g., weeks) (Koay, Syrdal, Walters, and Dautenhahn, 2007). Other factors that may help humans and robots interact more effectively are the user's personality characteristics and the "fit" between the user's personality and the robot's style. It has been shown that a match between user personality and robot "personality" (e.g., the substance of feedback and the manner of input) is associated with increased time spent with the robot (Tapus & Matari, 2008). The application of SAR in mental healthcare brings up exciting possibilities for robotic devices designed to carry out specific duties and functions in mental health. Because of their versatility, robots can be used to treat a wide variety of therapeutic populations, clinical situations, and therapeutic aims simultaneously (Okamura et al., 2010). It is crucial to note that people generally respond favourably to robots of a range of design shapes, aside from issues about customizing them.

2. Robotics to Aid and Assist in Mental Health

Despite being a nascent subject, SAR has fascinating uses in mental healthcare. As is common in new fields, research on SAR applications in mental health is characterized by modest sample numbers (e.g., N usually 50, which is modest by RCT standards) and simplistic methodological techniques (e.g., lack of proper comparison conditions). Despite these evident limitations, SAR research has already been undertaken for many mental health difficulties (e.g., dementia, depression, autism spectrum disorder) and a broad population of patients (e.g., young children, the elderly). Socially supportive robots, in particular, have already performed several clinically relevant functions. This section will look at some of the SAR systems' roles in clinical research and other clinically relevant activities, such as companion, therapeutic play partner, and coach or instructor. While not exhaustive, these roles provide a valuable overview for understanding the scope of research and how it might be applied further.

2.1. Companionship

One of the more widely used SAR functions in mental healthcare has been robots acting as companions. SAR systems perform similarly to a trained therapy animal (e.g., a therapy dog) in most of this work.

Although a study of the use of animals in mental healthcare treatment is beyond the scope of this article, a growing body of literature supports the therapeutic use of animal interactions (Nimer & Lundahl, 2007). Unfortunately, there are practical challenges with introducing live animals into therapeutic settings (e.g., therapy offices, hospitals, and long-term care institutions), such as animal welfare, patient allergies, and the risk of disease or infection (Shibata, 2012). Socially helpful robots are considered a means to reap some of the clinical benefits of animal-assisted therapy while avoiding the difficulties of working with actual animals. Although many pet-like robots are on the market today, most of the research has concentrated on Paro, a robot built to appear like a baby harp seal, and Aibo, a miniature robotic dog (Broekens, Heerink, & Rosendal, 2009). Many of the research evaluating socially helpful robots in the role of a companion has focused on older patients, many of whom had dementia-related cognitive impairment (Shibata & Wada, 2010) or were at high risk for depression (Banks, Willoughby, & Banks, 2008). The benefits of using SAR systems as a companion system have been observed to be favourable. Pilot and case study participants often report favourable experiences and appear interested during interactions with the robots (Libin & Cohen-Mansfield, 2004; Marti, Bacigalupo, Giusti, Mennecozzi, & Shibata, 2006). Multiple studies have found higher mood and decreased self-reported feelings of depression after introducing a socially supportive robot into an elderly long-term care facility (Wada, Shibata, Saito, Sakamoto, & Tanie, 2005).

Following the introduction of the robots, patients have been observed to spend more time in public areas and with other patients and staff members (Wada & Shibata, 2006). Furthermore, after interacting with a socially supportive robot, physiological stress levels (as measured by salivary and urine hormones) were shown to be lower (Kanamori et al., 2003; Wada & Shibata, 2007). This growing body of evidence from case studies and pilot studies suggests that SAR may have various psychological advantages in senior people (e.g., increased mood, stress reduction), and more rigorous research is needed. Even more encouraging, published RCTs support the findings of smaller-scale investigations. In a recent randomized controlled trial with elderly adults living in a nursing home or hospital, participants who interacted with the robotic seal Paro regularly reported a significant reduction in self-reported loneliness, whereas their peers assigned to recreational activities reported no change in these feelings (Robinson, MacDonald, Kerse, & Broadbent, 2013).

Paro appeared to inspire more excellent contact among the study participants. More residents participated in the discussion about Paro, and there was more public dialogue than in the debate about the dog (Robinson et al., 2013). Another recent RCT utilizing Paro showed that interacting with the robot provided further mental health advantages to people with dementia (Moyle et al., 2013). Following their contacts with Paro, participants reported a higher quality of life and more joy. The results were so promising that the same study team is now working on a larger-scale RCT with Paro (Burton, 2013).

Positive results are not restricted to Paro. Residents at three different long-term care facilities were randomly assigned to one of three treatment groups in another small trial that included the robotic dog Aibo: weekly interactions with Aibo, weekly interactions with a trained therapy dog, or no interactions with a robotic dog or therapy dog (Banks et al., 2008). Those in the robot and therapy dog conditions showed significant reductions in self-reported loneliness at the end of the program compared to residents in the control conditions. The residents in the two active intervention conditions were no different from each other in terms of self-reported loneliness and attachment to the dogs (living or robotic), indicating that interactions with the robotic dog were associated with changes similar to those observed after interactions with a trained therapy animal (Wada, Shibata, Saito, & Tanie, 2004).

These kinds of studies point to two crucial conclusions. To begin, socially assistive robots can be integrated into clinical settings (e.g., hospitals, long-term care facilities) for usage with clinical populations. Second, the use of these robots appears to be related to better therapeutic outcomes. During a five-week program with the robotic seal Paro, staff members self-reported that staff stress levels were reduced due to the robot's introduction. These findings are thought to be the outcome of beneficial changes in the patients. Given these encouraging findings, applications to clinical populations of people experiencing higher degrees of mood disruption and stress are indicated due to the potential psychological benefits for patients and caregivers.

2.2. Play Companion for Therapeutic Purposes

Another line of research on SAR applications to mental healthcare has focused on robots as play partners that assist children in practising or developing clinically relevant skills, most commonly in children with autism spectrum disorder (ASD; Diehl, Schmitt, Villano, & Crowell, 2012; Scassellati, Admoni, & Matari, 2012). Socially assistive robots are employed in conjunction with human providers (e.g., therapists, research assistants) in much of this work to boost engagement and provide additional possibilities for social interaction and skill growth within an exchange (Atherton & Goodrich, 2011). Children respond positively to these socially supportive robots, perceived as a new and entertaining supplement to treatment (Scassellati, 2007). However, the therapeutic promise of SAR in ASD goes beyond primary novelty effects. Socially assistive robots can perform a variety of therapeutically relevant roles, including engaging children in tasks, modelling good social signs (e.g., making eye contact), facilitating joint attention activities, and serving as partners for essential social skill practice (e.g., taking turns in play; Scassellati, 2007; Scassellati et al., 2012). Given the extensive range of functions these robots may do, it is not surprising that a wide range of robots has been employed in the existing literature. Unlike previous research on SAR as a therapeutic companion (which concentrated on a small number of robotic systems), this area of research encompasses robots ranging from lifelike humanoid robots to effortless caricatured designs. The activities featured in this area are typically designed to be enjoyable and engaging, and they are frequently framed in terms of games. As a result, the SAR systems employed in the study are commonly used as a therapeutic toy or a therapeutic play companion. (Kozima, Michalowski, & Nakagawa, 2009; Kozima, Nakagawa, & Yasuda, 2007).

Children were observed during interactions with a Keepon, a miniature interactive robot, in a series of case studies involving young children with developmental abnormalities (including children diagnosed explicitly with ASD) (Kozima et al., 2007). Keepon is quite simple in terms of design; it resembles two tennis balls, one on top of the other, and its "head" has two eyes but no other facial features. Keep stands about 10 inches tall, including its pedestal. Keepon may indicate attentiveness and emotional states (by orienting its face and eyes toward different objects) (by bouncing up and down in pleasure or excitement). Young children (toddlers and preschoolers) demonstrated enhanced social engagement with Keepon across several months of interactions. A young child with ASD, for example, used the robot as a centre of joint attention. When the robot moved, the child looked and smiled at his or her parent and therapist.

Furthermore, the robot "imitated" the youngster's actions, prompting the toddler to exchange a social smile with a caregiver. These elementary social gestures can be difficult to elicit in young children with ASD, and the potential utility of basic robots like Keepon warrants further clinical research. More rigorously controlled laboratory-based research supports the concept that socially assistive robots can be valuable tools for engaging youngsters with ASD. Many autistic children suffer from social communication, particularly beginning and maintaining conversations. Children with autism spectrum disorders participated in three separate tasks in a recent lab-based study (Kim, Paul, Shic, & Scassellati, 2012; Kim et al., 2013). The target child and a study confederate were seated at the same table in the paradigm. The child participated in three activities that involved building or working with blocks. At the same time, they have seated: a robot partner condition (in which the child and the robot completed the task together), an adult partner condition (in which the child and another non-confederate adult conducted the study together), and a computerized block activity. The adult-robot interactions were designed to elicit many social behaviors from the youngsters, such as taking turns with the interaction partner and identifying the emotion and preferences of the interaction partner. Pleo, a robot built to look like a baby dinosaur and capable of moving (e.g., walking, jumping) and displaying socially expressive vocalizations and behavior (e.g., wagging its tail), was employed as the robot partner. Children spoke more during the robot engagement than during either the human partner engagement or the computer job.

Among the problems to explore when employing SAR in therapeutic play contexts are how or why these robots may be beneficial clinical aids for children with ASD. Researchers in this field have proposed that robots could act as embedded reinforcers of social behavior (Kim et al., 2013). That is, the robots themselves can be used to both elicit and reward social behavior in children. Considering the interaction with the robot as rewarding unto itself, one can imagine how socially assistive robots could be integrated into clinically relevant tasks for children in fun and engaging ways while also meaningfully targeting appropriate problem behaviors.

2.3. Trainer/Instructor

A coach or instructor is a third role that socially supportive robots have played in mental health research. Socially assistive robots, like Autom, the weight loss coach, and Bandit, the fitness instructor, can provide direct guidance and supervision to patients or clients engaged inappropriate therapy activities (Fasola & Matari, 2013; Kidd & Breazeal, 2008). In light of the examples of Autom and Bandit, terminology like coach or instructor may be overly basic regarding the role that SAR systems can play in mental healthcare. These robots can describe the model activities, monitor patient performance, provide remedial feedback, and provide encouragement and support. Nonetheless, a coach or instructor aids in conveying the spirit of a robot assisting humans through tasks. To illustrate, in a pilot study, a sample of older persons with dementia interacted with a social robot in an attention and memory exercise (Tapus, Tapus, & Matari, 2009).

Instead of a lower body, the robot is supported on a moveable platform resembling a cart on wheels. The activity was structured as a “Name that Tune” game, in which participants were given a set of four tunes, each with its button. Songs from the group were played at random, and participants were instructed to press the appropriate button as rapidly as possible. The robot instructor described the task to the participants for six months and guided them through the activity once a week.

Furthermore, as players displayed increased skill in the movement over time, the robot was programmed to improve the game’s difficulty (e.g., avoid delivering advice). The robot provided positive encouragement to the participants during the encounters. This pilot study shows that the robot maintained the participants’ attention during this therapeutic activity effectively.

The robot also changed its behavior to the skill level of the participants, indicating clinical adaptability that could be useful in other therapeutic applications. Of course, this form of coaching or guidance could be employed in a wide range of therapeutic activities, both inside and outside of treatment sessions.

Socially assistive robots can lead patients through tasks that a human provider has selected as clinically relevant and meaningful to their treatment program during a treatment session, similar to how the robot led participants through the music task. The robots, however, can be employed outside of treatment sessions. As a result, the robots can be used to engage and encourage patients to engage in treatment-related activities outside of the therapy session, effectively extending a therapist's reach into a patient's home. In addition, by using an organized and positive coaching style, these robots can support patients in evaluating their compliance with other treatment areas (e.g., medication adherence). This SAR function could be beneficial to a variety of clinical populations other than those with cognitive impairment.

2.4. General Remarks

Socially supportive robots have served in roles other than those mentioned above. One intriguing method these robots can utilize in mental healthcare is to integrate them into existing interventions. As a result, the robots can be integrated into existing and effective therapy programs, ideally in ways that lessen the time demands imposed on human care providers. There is little published evidence for robots serving as a novel delivery platform for medicine. Modest pilot research for children with ASD, on the other hand, gives valuable information. Probo, an animal-like robot with an elephant-like trunk and an emotionally reactive face, was employed in the study (Goris, Saldien, Vanderborght, & Lefeber, 2011; Goris, Saldien, Vanderniepen, & Lefeber, 2009). Probo is around 30 inches tall and is covered in a bright green fabric. Probo was incorporated into Social Stories, an existing autism treatment program for youngsters. Short scenarios are produced or tailored for children with ASD to better understand specific, problematic social situations, and they are often provided by a human therapist (Gray, 2010). Probo was utilized to give social stories in a recent modification of the program, and in a series of single-case tests, Probo and a human therapist were contrasted in their therapy delivery (Vanderborght et al., 2012).

Both therapy platforms were well received by the children (human and socially assistive robot). Surprisingly, following the robotic intervention, child performance on the behaviours mainly addressed in the social stories increased substantially more. As this example with Probo shows, SAR research in mental illness is still in its early stages. Small studies (e.g., case studies, pilot research), with limited samples and in limited settings (e.g., laboratories, long-term care facilities), and frequently lacking proper methodological controls and comparison circumstances, characterize this work. Even studies with a randomized and controlled design often have small sample sizes, raising the potential for some failures to detect significant differences due to insufficient power (Banks et al., 2008). Perhaps more crucially from a clinical standpoint, no research has shown long-term clinically relevant alterations due to interactions with SAR systems. Given the restrictions outlined above, we see present applications of robots to therapeutic areas as proof of concept or principle. SAR undoubtedly warrants mental health researcher's attention to capitalize on the code that robots can play a role in assisting individuals with psychological issues or sources of disability.

3. Clinical Research Priorities and SAR applications

The rising use of SAR in mental healthcare interventions provides a timely opportunity to address critical gaps in service delivery to people in need. Several essential research priorities exist to satisfy this requirement. These priorities are not exhaustive; instead, they serve as a starting point for systematic empirical research on robotics therapies for mental health disorders.

3.1. Extending Clinical Applications of Robots

One of the priority study areas is deploying robots to a greater range of mental health domains to assess the advantages in clinical and community populations. First, more attention should be paid to a larger range of clinical dysfunction areas than is now available. As previously discussed, much of the research in SAR interventions have focused on older persons (e.g., dementia treatment; Bemelmans, Gelderblom, Jonker, & De Witte, 2012) and children (e.g., in the treatment of ASD; Scassellati et al., 2012). Regarding extending robotics to clinical dysfunction, one place to start would be dysfunctions with a high prevalence or the highest unmet demand. Although extending SAR across the complete range of clinical dysfunction (e.g., psychiatric diagnosis) and subclinical disorders (i.e., below diagnostic threshold) are possible alternatives for the next stages in research, we will focus on one illness to illustrate the research lines that might be pursued. Consider major depressive disorder, which has the greatest lifetime prevalence of any psychiatric condition in the United States (Kessler et al., 1994; Kessler et al., 2005) and is linked with enormous cost to the diagnosed individual (e.g., personal suffering) and society (e.g., work absenteeism; Kessler, 2012). The burden of depressive disorders (e.g., years of good health lost due to incapacity) was placed third among mental and physical diseases in 2004. (World Federation for Mental Health, 2011). Depression is expected to be the leading cause of disability by 2030, surpassing cardiovascular illness, traffic accidents, chronic lung disease, and HIV/AIDS (WHO, 2008). Creating SAR therapies for depression can help many people while also addressing a critical public health need. First, SAR can be used to sustain adherence to treatment protocols (e.g., medication compliance, psychotherapy homework) and engagement outside of a human therapist session. Having a robot physically there to provide reminders and encouragement is related to higher treatment protocol adherence than other self-monitoring measures (e.g., computer programs, paper-and-pencil tracking; Kidd & Breazeal, 2008). Second (and related), socially assistive robots may be useful in increasing participation in self-help therapy programs. Several programs for treating depression have been designed and assessed (Bennett-Levy, Richards, Farrand, Christensen, & Griffiths, 2010; Harwood & L'Abate, 2010). Given that the presence of a physically embodied robot is associated with improved task compliance and more positive perceptions of interactions (Bainbridge, Hart, Kim, & Scassellati, 2011), self-help programs may benefit greatly from the addition of a robot that can guide patients through therapeutic programs. In this approach, robots could aid in the transition of self-help treatments to an interactive therapy experience. Finally, socially helpful robots can be used to facilitate social contact and participation. Social support in casual chats or practice may be a beneficial complement to treatment in treating depression. Psychotherapy was formerly referred to as the "purchase of friendship" (Schofield, 1986). Robotic "friends" may be first insulting, but as an assist, complement, and additional source of social connection. Robots provide certain distinct advantages. Unlike traditional friends and therapists, robots are available for social contact around the clock, including times (e.g., very late at night, very early in the morning). Extending robotics to a variety of healthcare applications is a research priority. We used depression to illustrate some of the lines of work that might be pursued, but, of course, depression is not a necessary first step. The employment of robots in connection to clinical concerns is a first step and a research focus. Collaborations between therapy researchers and those active in robots will be required. Many working with SAR already focus on human-robot interactions and how humans respond in clinically relevant situations. It is hardly a stretch to think about how robotics could benefit more clinical and subclinical populations. One of the priority study areas is deploying robots to a greater range of mental health domains to assess the advantages in clinical and community populations. First, more attention should be paid to a larger range of clinical dysfunction areas than is now available. As previously discussed, much of the research in SAR interventions have focused on older persons (e.g., dementia treatment; Bemelmans, Gelderblom, Jonker, & De Witte, 2012) and children (e.g., in the treatment of ASD; Scassellati et al., 2012). Regarding extending robotics to clinical dysfunction, one place to start would be dysfunctions with a high prevalence or the highest unmet demand. 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Given that the presence of a physically embodied robot is associated with improved task compliance and more positive perceptions of interactions (Bainbridge, Hart, Kim, & Scassellati, 2011), self-help programs may benefit significantly from the addition of a robot that can guide patients through therapeutic programs. In this approach, robots could aid in the transition of self-help treatments to an interactive therapy experience. Finally, socially helpful robots can be used to facilitate social contact and participation. Social support in casual chats or practice may be a beneficial complement to treatment in treating depression. Psychotherapy was formerly referred to as the "purchase of friendship" (Schofield, 1986). Robotic "friends" may be first insulting, but as an assist, complement, and additional source of social connection. Robots provide certain distinct advantages. Unlike traditional friends and therapists, robots are available for social contact around the clock, including times (e.g., very late at night, very early in the morning). Extending robotics to a variety of healthcare applications is a research priority.

3.2. Creating a Solid Evidence Base for SAR in Mental Health Care

Robots can be clinically significant additions to treatment and affect mental health outcomes (e.g., symptoms, social behaviour). Robotics may be possible for many patient populations (e.g., youngsters and the elderly) and clinical difficulties (e.g., social skill deficits in ASD, cognitive impairment in dementia). The evidence for the use of robots in treatment is compelling enough to warrant a focused effort. The road to establishing a treatment as evidence-based is long and takes many years and many distinct trials and replications.

Furthermore, as the analysis of the various ways robots have been employed in mental healthcare indicated, SAR treatments are not a single therapy program. Instead, they are a new treatment that includes a wide range of unique kinds and exemplars of robots. As a result, the process of developing an evidence foundation of support will unfold over time as data accumulates for various sorts of robots with varying "abilities," as applied to multiple challenges and clinical dysfunctions. There are numerous approaches to creating an evidence foundation for robotic therapies; three of them may be good places to start. First, single-case experimental ideas could be a great place to start. Creating therapeutic robots will require an iterative procedure to guarantee that clinical goals, treatment techniques, and mechanical behaviour all function in concert. Because there are no off-the-shelf robotic therapists to choose from, the initial task is developing the robot to behave in the manner desired by the clinical researcher to achieve specific therapeutic aims. Trying this on a limited scale with regulated designs may be the least resistant in establishing programmed robotic research. There are already case studies demonstrating the application of robotics to mental health issues.

Case studies are frequently used to assess the viability of employing a novel robot to solve a specific clinical problem (e.g., ASD; Kozima et al., 2007; Robins, Dautenhahn, & Dickerson, 2009). Adding an evaluative component to single-case assessment and evaluation would clarify the influence and function of robots in therapeutic improvement. Second, researchers should think about incorporating robotics into existing evidence-based interventions. Rather than creating a conceptually original treatment program, robots might be integrated to assist at crucial moments in existing programs, increasing the intervention's effectiveness. We said that homework and practice tasks cover a wide variety of psychosocial treatments, as well as a wide variety of dysfunctions for which the therapy is employed (Kazantzis & L'Abate, 2007; L'Abate, 2011). Even if robots only serve to increase in-person practice and homework, it would be a significant contribution. Robots could augment present therapy activities and add new ones that technology (e.g., monitoring, real-time feedback) already provides (e.g., apps). Finally, RCTs that explicitly address the shortcomings inherent in exploratory research will be required in the end. Given the current focus on ASD and dementia (and related disorders), these diseases seem to be natural candidates for the first large-scale intervention research. Large-scale RCTs may be further down the road in SAR research since there are fundamental difficulties to resolve the shape of the robot, the specific programmed actions, and how these interact with therapeutic aims. Nonetheless, as previously indicated in mood disorders and loneliness in senior populations, exceptional research has explored interactions with robots in randomized designs (Banks et al., 2008; Robinson et al., 2013).

3.3. Forming Solid Alliances with Roboticists

Developing and refining SAR systems needs people from the mental health sector to interact and collaborate with computer scientists, engineers, and roboticists responsible for developing and refining SAR systems. It is necessary for mental health practitioners and academics to get more familiar with some critical components of robotics research, including the following points, to produce the work required in this area: • The motives and rewards for robotics research are frequently additional mental healthcare research. In contrast to psychology, which prioritizes peer-reviewed journal publications, computer science considers conference papers the preferable method of communicating new ideas and research. Long-term research studies are challenging to conduct since robotics researchers often focus on short-term initiatives. In general, the area encourages novel designs and new robot capabilities while ignoring the validity of these capabilities and evaluating systems in RCTs. This, of course, makes it difficult to form a viable collaboration. A concerted effort must be made to ensure that both groups see the benefits of the partnership. • Significant technology advances are required before the field can have broadly applicable SAR systems. Most systems today have minimal autonomy or are deliberately designed to reduce the perceptual or cognitive skills required by the robot. This means that modest changes to the robot's operation may be trivial or impossible with today's technology. • It is critical for psychologists and mental health professionals to recognize what robots can and collaborate closely with robotics experts who can provide critical feedback on what tasks robots can reasonably do, shaping the design and execution of intervention studies. • Corporate claims about robots may not align with academic research work. While many academic groups are working on SAR, there is also a rising number of robotics companies marketing toward SAR applications. These systems may appear identical to those used in research (and in some cases are the same hardware), but they provide pretty specific software functionality.

4. Particular Difficulties and Problems

Multiple problems can be easily identified when discussing the expansion of SAR in mental healthcare. The employment of robotics in this domain is sufficiently novel to create many legitimate concerns among all parties concerned (e.g., mental health professionals, patients, a family member of clients). We will now look at some of the most pressing issues and how they may affect the delivery and consumption of interventions.

4.1. Technological Factors

One potential source of concern is that the technological expertise required for mental healthcare consumers (e.g., patients, therapists) to use robots effectively may be beyond the existing skillsets of some users. For example, one challenge for some therapists who utilize robots in treatment may be the expertise of computer systems required to interact with robots continuously (Giullian et al., 2010). The focus of treatment will most likely shift for several weeks or months. A robot will need to be programmed for many vital tasks; it would be desirable for therapists to accomplish this programming themselves for practical purposes. When a robot is used in the treatment of ASD, for example, the specific foci that a therapist addresses in a given session are likely to change over time for an individual patient (e.g., because a patient makes progress and masters skills, or because a patient enters a new environment that poses unique challenges) and across different patients (e.g., because of various presenting problems, because of varying levels of functioning). While it may appear to be a scary prospect (at least for some of us), new programming platforms for socially assistive robots (designed with the non-expert user in mind) are now being developed and assessed to create user-friendly robots (Atherton & Goodrich, 2011; Gorostiza & Salichs, 2011).

Moreover, users (e.g., therapists, patients) do not need to comprehend the technology behind how and why the robot works to use it (Lin, Abney, & Bekey, 2011). Indeed, many of us know little (if anything) about computer programming but can use computers, smartphones, and tablets with ease. The technological hurdles of deploying robots in evaluation, diagnosis, or therapy will likely be overcome over time. However, all existing SAR systems are experimental; they are not yet off-the-shelf therapy systems purchased and instantly employed for mental health applications.

Robotics in manufacturing and medicine (for example, da Vinci® robot-assisted surgery) were introduced progressively for specialized applications before expanding more generally and routinely

(Christensen, Grossman, & Hwang, 2009; Rogers, 2003). The typical method for introducing innovations is limited use, broadening as the innovations become more convenient and accessible. We are at a very early stage in terms of using robotics in mental healthcare.

4.2. Ethical and Clinical Implications

Robotic interventions raise a variety of distinct ethical concerns or topics. Even if the robot's capabilities are fully disclosed, deception is possible. Users may think a robot is a machine. Users (e.g., youngsters and elders) may be deceived into believing a robot has skills (emotional awareness) that it does not. A robot-client relationship is unethical (Sharkey & Sharkey, 2010, 2012). For robots to be seen as sentient beings who interact with the world, makers must make them appear lifelike. However, there is more. Robots are gradually adopting realistic social behaviours and traits, allowing for attributions far beyond what they can do. For example, children who interact with a robotic dog tend to perceive it as a social companion with mental states and act accordingly (e.g., offering it a toy ball; Melson et al., 2009). Transparency only addresses possible deceit; attributions of alleged traits and qualities remain an issue. Other concerns about robots may exist, but they are not always ethical. Robots could be seen as a replacement for human social interaction, similar to how video games for children and adults replace family activities. Remember that social behavior is vital in rehabilitation. One would want to deploy robots that increase social engagement. Such as replacing human and animal social bonds (Calo, Hunt-Bull, Lewis, & Metzler, 2011). Conversely, robots encourage more meaningful social interactions. People that interact with robots report less loneliness and happier moods (Banks et al., 2008; Kramer, Friedmann, & Bernstein, 2009). Robots will be used in conjunction with human mental health experts. They cannot replace humans, but they can help. (Feil-Seifer & Matari, 2010) SAR-based therapies have the potential to evolve into self-help models of care that do not require the supervision of a qualified mental health professional (Harwood & L'Abate, 2010).

Relationship issues can raise concerns when providing mental health care. Regularly interacting with robots may lead to emotional attachment to the machines (Kalvi Foundation, 2012). This problem of wanting mechanical alternatives for socializing with humans and animals has already been brought to light. The second issue is whether to stop using a robot and start using a new or improved one (as we regularly see with technology). Clarity about these technology challenges prevents customers from being astonished if breakdowns occur (Kalvi Foundation, 2012). This could help users better grasp the limitations of employing SAR and aid them in not over-estimating a user's capabilities. The risk of breakdown cannot be prevented, but there is inevitably no point worrying about this. to basic domestic robots (e.g., Roomba; Forlizzi, 2007). While the hazards of more socially engaged robots being employed to help individuals manage mental health issues are not fully known, they indeed demand a more significant investigation.

4.3. Other Concerns

Any mental health intervention that has a mechanical component comes with an associated cost. While the robots presented differ in form and function, they also vary widely in price. Many of the robots utilized in extended therapy studies have a considerable expense. This comprises the purchase price of the robot and other costs, such as programming, maintenance, and repairs. The difficulty in figuring out the remaining cost is dependent on numerous factors, including how skilled the user is with the robot, the robot's technological specs, and how the robot will be utilized clinically. Indeed, mental disease and mental healthcare costs must be considered when weighing the seriousness of those concerns. First, individuals with mental health difficulties bear a significant financial burden because of the high expense of mental disease. Assume, for example, mental illnesses, such as substance use disorders, cost about $500 billion every year (Jason & Ferrari, 2010). The second drawback of our field's treatment approach is that it is expensive and time-consuming to train and supervise those experts who work with clients. These contextual considerations aside, researchers are already addressing clinician issues connected to robot programming and directly addressing therapist needs by building cost-effective robots (Boccanfuso & O'Kane, 2011). Technology-based costs, such as robot development, also go down as volume increases. One robot development and construction are pretty costly. Nevertheless, creating 1000 units dramatically reduced the cost, and making 1,000,000 units is exceptionally cost-effective. According to FeilSeifer, Skinner, and Matarić (2007), one additional query for users concerns the safety of a robot.

To sum it up, we prefer not to be dismissive when discussing safety. Even if prejudices about robots alter a robot's perceived safety, perceptions of robot safety still pose hurdles. Finally, mental health professionals may be concerned about how robots can affect human caregivers' jobs. The thought of robots as a threat to job security is certainly understandable.

Nonetheless, in actuality, robots have many functions, from acting as helpers (e.g., assisting surgical operations like robot-assisted treatments where the precision of robotic equipment aids a human surgical team) to independently operating (e.g., space exploration vehicles on multi-year missions). Robots have mostly displaced human workers in these more independent roles because they can either accomplish specific tasks in more predictable ways or because the duties themselves constitute a significant danger or threat to human workers (International Federation of Robotics, 2012). SAR in our presentation focuses on many mental health uses. First, robots can serve in a favorable position, where the robot works alongside a human therapist rather than competing with the human therapist.

SUMMARY AND CONCLUSION

Solving a situation of this magnitude requires many approaches that build on the great achievements of traditional psychosocial treatment and delivery. SAR is a field bursting with new ideas that push the frontiers of what robots can do and how they may benefit humans. Robots are already being used in mental healthcare, with encouraging outcomes. For our current treatment dilemma, we recommend more robots in mental healthcare. SAR can be used in several ways in therapy. The primary treatment method involves a robot and a human therapist. However, a robot's potential applications go far beyond therapist assistance. With these gadgets, people who could not get therapy elsewhere can get it at home (e.g., those living in rural settings, individuals housebound because of physical impairments). In the future, robots may fulfil therapeutic functions traditionally performed by human mental health professionals. However, we do not advise replacing or removing human therapists with robots.

Immediate access to mental health professionals is required to satisfy societies vast unmet treatment needs. Instead, we recommend using robots to help mental health professionals reach more people and better treat them. We realize that SAR cannot solve this problem on its own, nor should it. There are, nevertheless, valid questions concerning ethics, safety and costs (e.g., physical design, user perceptions). We understand that robotics can help those who do not receive care or whose care may be improved by daily support, delivering an intervention, encouraging adherence to another type of intervention, or giving some form of engagement.

Abbreviations

AR- Augmented Reality
VR- Virtual reality
R&D- Research and development
ASD- Autism spectrum disorder
SAR- Self assistive robots

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Chapter 9
Cardiac Fitness Status Among Male Paddy Cultivators:
A Study in the Context of Emerging Increase in Ambient Temperature

Ayan Chatterjee
https://orcid.org/0000-0002-1791-0532
Guru Nanak Institutions, Telangana, India

Shankarashis Mukherjee
West Bengal State University, India

ABSTRACT

Physical work capacity of the human resources is affected due to adverse thermal working conditions. Keeping this in view, the present study has been undertaken to assess cardiac fitness status in terms of indices of physiological strain among male food crop cultivators. Physical and physiological parameters of the study participants was measured. Indices of thermal working environmental conditions were calculated. Indices of physiological strain of the study participants were also calculated. Result of the present study indicated that environmental condition adjudged by select popular heat indices is above the suggested threshold value making the task strenuous. Additionally, human resources are suffering from varying degrees of physiological strain.

INTRODUCTION

Agriculture plays a substantial part in the lives of people all over the world including India. Earlier studies reported that, upsurge in ambient temperature is not limited to agricultural output; it has a major impact on work performance, especially in agriculture (Chatterjee *et al.*, 2020a, 2020b, 2020c). Moreover, different tasks performed by agricultural workers require extensive physical energy (Chatterjee *et al.*, 2021). Food crop like paddy is important in India both from standpoint of food security and providing livelihood to millions of countrymen. It being an open-air occupation and to a great extent not mechanized fully in many parts, it poses

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a challenge to the human resources involved in it; the gravity of the situation is on rise with climate change becoming more of a reality, than possibility in future. Human resources who are exposed to excessive heat in course of their livelihood earning, especially in low- and middle-income tropical countries, are at highest risk in respect of their health and wellbeing (Kjellstrom *et al*., 2016; Lundgren *et al*., 2013). India being a tropical country is no exception to it. The impact of rise in ambient temperature is not confined to agricultural output; it has an impact on the work performance of human being associated with occupational activities (Parson, 2014) in informal sector especially those carried out in the open under the sky particularly agriculture (Venugopal *et al*., 2016). On the other hand, it has been reported in earlier studies that, climate change having a significant impact on the public health and a vast number of human resources earn their livelihood being associated the agriculture particularly the cultivation of food crop under the open air without the use of the state of art technology. Keeping this in view the present study has been undertaken to assess cardiac fitness status in terms of indices of physiological strain among male food crop cultivators during manual transplanting task.

MATERIALS AND METHODS

Initially selection of the study area was carried out. After getting permission from institutional human ethical clearance committee the study was carried out among the male paddy cultivators permanently residing in an around of Village Krishnaganj, Goghat II administrative Block Arambagh Subdivision and Hooghly district, West Bengal. The paddy cultivators having a minimum work experience of five years and no known history of illness (self-reported) and regularly performing their occupational responsibility at least for a period of six to six and half hours in the paddy field included in the present study. Before going into data collection necessary consent obtained from the study participants. Data were collected during 'Aman' type of paddy cultivation period (i.e., June to middle of July) and during 'Boro' type of paddy cultivation period (i.e., December to middle of January). These data were presented in two working spells i.e., morning [6.00-9.00 am] was referred to as spell 1 [S1], and around noon [9.30-10.00 am to about 1pm] referred to as spell 2 [S2]. It may be mentioned that the data of individual who are available for study during 'Aman' and 'Boro' type of paddy cultivation time were only considered for the analyses. Data were collected from 51 adult male food crop cultivators (age range of 21 - 30 years) while they were taking part manual transplanting task (random transplanting method) during 'Aman' and 'Boro' type of paddy cultivation. These data were represented as the data from manual transplanting group (MTG - A) and (MTG - B). Initially the name, age (year), ethnic background, working experience (year), and working time ($hr.day^{-1}$) of the study participants was recorded to each individual in a pre-designed schedule. Information for the assessment of socio-economic status of the participants was recorded by using Kuppuswamy's socioeconomic scale [SES] (Ravikumar *et al*., 2013). Stature in cm and body weight in kg was measured using an anthropometric measurement set and a weighing scale, respectively. Body Mass Index (BMI) ($kg.m^{-2}$) was calculated. Pre-work heart rate ($HR_{Pre\text{-}work}$) of the study participants was recorded and/or by using the Polar heart rate monitor and stopwatch before the individuals started their work and expressed in $beats.min^{-1}$. Pre work Systolic and diastolic blood pressure ($SBP_{Pre - work}$ and $DBP_{Pre - work}$) also recorded during the morning hours before the individuals started their working and/or by using an automated blood pressure monitor in sitting condition and expressed in mm Hg. Indices of physiological strain - peak heart rate (HR_{peak}), expressed in $beats.min^{-1}$ (Astrand and Rodhal, 1986), net cardiac cost (NCC) was obtained (Chamoux *et al*., 1985) and was expressed in $beats.min^{-1}$. Peak estimated energy expenditure (EEE) was obtained (Ramanathan *et al*., 1967) and was expressed in $kcal.min^{-1}$. The 'heaviness' of work was calculated in terms of - HR_{peak} ($beats.min^{-1}$), NCC ($beats.min^{-1}$), and EEE ($kcal.min^{-1}$). In case of basic environmental parameter - Dry bulb (T_{DB}) and Wet bulb (T_{WB}) temperature were measured with the of Hygrometer. The dry bulb temperature was recorded thereafter during the working hours in the agricultural field (ACGIH, 2008; Heidari *et al*., 2015). Wet Bulb Globe Temperature (WBGT) index was found out. Corrected Effective Temperature (CET) was determined (Brake and Bates, 2002). Modified discomfort index (MDI) was determined (Epstein and Moran, 2006). The percentage of human resources dissatisfied because of thermal environment was ascertained for two working spells during the manual transplanting task (Fanger, 1970). The collected data were tabulated, analyzed and were tested for significance with analysis of variance (ANOVA), as appropriate. P value lower than 0.05 ($P<0.05$) was considered significant.

RESULTS

Basic profile including age (year), ethnicity, SES, working experience (year), and average working time ($hr.day^{-1}$) of the participants are presented in Table 1.

Table 1. Basic profile of the food crop cultivators'

Variables	Values
Age (year)	25.3 ± 1.19
Ethnicity	Bengalee
SES	Lower middle
Working experience (year)	6.7± 0.85
Working time^ ($hr.day^{-1}$)	6.1 ± 0.31

Data were presented in AM ± SD

Physical and physiological variables of the study participants are presented in Table 2.

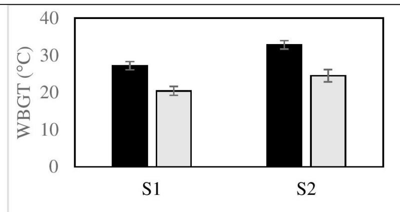
Table 2. Physical and physiological parameters of the food crop cultivators'

Variables	Values
Stature (cm)	158.5 ±3.11
BW (kg)	53.2 ± 4.29
BMI	20.1 ± 2.15
$HR_{Pre-work}$ ($beats.min^{-1}$)	70 ± 5.19
$SBP_{Pre-work}$ (mm Hg)	118 ± 7.01
$DBP_{Pre-work}$ (mm Hg)	76 ± 4.67

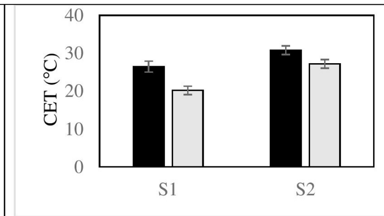
Data were presented in AM ± SD

In the present study the thermal environmental condition was monitored by three heat stress indices for two different working spells were separately found out for the working environment for MTG- A and MTG-B respectively (figure 1).

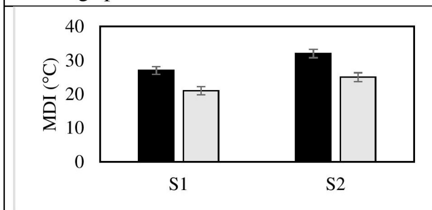
Figure 1. Indicators of thermal environmental status along the working spells



Comparison of WBGT (^{0}C) Values along working spells



Comparison of CET (^{0}C) Values along working spells



Comparison of MDI (^{0}C) Values along working spells

■ MTG - A

□ MTG – B

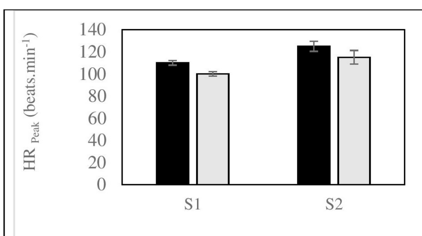
S1 and S2- Working spells

Table 3. Percentage of paddy cultivators working in conditions exceeding WBGT $_{MAX}$, and MET $_{MAX}$ values

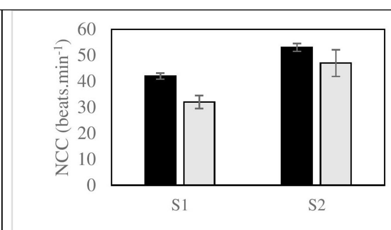
No of Individuals	**MTG - A**		**MTG - B**	
	Working Spells		**Working Spells**	
	S1	**S2**	**S1**	**S2**
51	40	100	nil	30

Data presented as individuals (%)

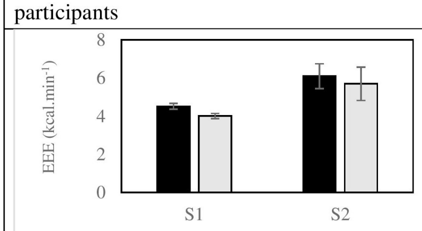
Figure 2. Indices of physiological strain along working spells



HR $_{peak}$ (beats. min^{-1}) status of the study participants



NCC (beats. min^{-1}) status of the study participants



c) EEE (kcal. min^{-1}) profile of the study participants

■ MTG - A

□ MTG - B

S1 and S2- Working spells

Percentage of food crop cultivators working in conditions exceeding WBGT $_{MAX}$, and MET $_{MAX}$ values are presented in table 3.

Indices of physiological strain in terms of HR $_{peak}$, NCC, and EEE for both the groups along the working spells are presented in figure 2.

DISCUSSIONS

In terms of BMI, study participants were in 'normal weight' category as per the classification given by WHO (WHO, 2000). The result regarding the BMI values is agreement with the findings of earlier studies (Chatterjee *et al.,* 2020e, 2015a, 2015d, 2014).

For MTG - A

In Case pf WBGT Index

In terms of the working environmental condition of MTG-A individuals as adjudged by WBGT, in the first spell, there is no restriction on both 'light' and 'moderate' types of work; 'heavy' and 'very heavy' type of task; whereas during the second spell of the working hours no work is ideally allowable (ACGIH, 2008).

In Case of CET Index

And in terms of CET the work environmental condition of MTG - A individuals during the first spell, there is no restriction, at all, recommended against carrying out of the work and in second spell only 'light' category of work should ideally be carried out (WHO, 1969).

In Case of MDI

In terms of MDI the work environment of MTG-A individuals during the first and second spells is adjudged as 'severe' the human resources who are possibly compelled because situational compulsion to carry out the work are at some degree of risk of suffering from heat induced issues (Epstein and Moran, 2006; Sohar *et al*., 1962).

For MTG- B

Whereas the working environments for MTG-B individuals in terms of WBGT, CET and MDI were more suitable and there is no restriction recommended for carrying out the task (Miller *et al*, 2007; Epstein and Moran, 2006; Sohar *et al*., 1962).

The percentage of human resources during manual transplanting task who worked in conditions exceeding permitted WBGT max and met max values calculated. It has been presented in table 3. It could be observed that in second spells in MTG - A, all the human resources work exceeding the limits, because of the extreme condition of the thermal environment prevailing in the parboiling task during 'Aman' type of paddy cultivation.

Manual transplanting task were assessed for grading the ‘heaviness’ of the particular work in terms of indices of physiological strain. The nature of the work of the MTG-A and MTG -B individuals has been found to be of ‘heavy’ and ‘moderate’ types respectively during the first and second spells, [Fig.2 (a)]. In terms of another indicator of physiological strain, NCC (beats.min^{-1}), [(Fig. 2 (b)], in case of MTG-A individuals, during the first spell average NCC values categorize the work as ‘rather heavy’ and during the second spell as ‘heavy’ degree. In case of the MTG-B, during the first and second spells, the work has been categorized as ‘moderate’ and ‘moderate’ respectively. Another indicator of physiological strain is EEE. For the MTG-A, during the first and the second spells, average EEE values indicate the work to be ‘heavy’ and ‘heavy’. For the MTG-B individuals the average EEE values indicate the work to be ‘moderate’ throughout the working spell, [(Fig. 2 (c)]. The findings of the present study in terms of the indices of physiological strain, as described, are in consonant rhyme with earlier reports from studies carried out on human resources primarily engaged in transplanting of paddy seedlings task from our groups (Chatterjee *et al*, 2016). The variation in the values of the indicators the physiological strain along the spells may be attributed to the combined effect of the thermal environment and the workload on the subject since the heart rate manifests the integrated impact on the body, responds quickly to changes in work demand and indicates it virtually in no time; the findings are in agreement with earlier reports (Chatterjee *et al.,* 2015b, 2015c). From the result of the present study, it may be mentioned that the MTG-A individuals particularly suffer from various degrees of physiological strain in different working spells, and it has been reported in earlier study (Kjellstrom *et al*., 2016) that in such situations, continuation of work at the same pace may be quite challenging with obvious repercussion on work performance.

CONCLUSION

From the present study, it may be concluded that human resources engaged in manual transplanting task belonging to MTG-A involved in ‘Aman’ type of paddy cultivation suffer more relatively from physiological strain, compared to the MTG-B individuals involved in ‘Boro’ type of cultivation.

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Chapter 10
Self-Maintained Health Surveillance Artificial Intelligence Assistant

Helly Yogeshkumar Raval
Ganpat University, India

Satyen M. Parikh
Ganpat University, India

Hiral R. Patel
Ganpat University, India

ABSTRACT

Artificial intelligence assistant is a program and software that can interact with the user in natural language or with voice or in picture format. After the pandemic situation, people are highly worried about their health. People are not usually aware of all medications or symptoms of diseases. Undernutrition can lower immunity, increase the risk of illness, affect physical and mental growth, and decrease productivity. Issues of this kind may be resolved by providing suitable advice on healthy living with medical chatbots. Chatbots may be used to calorie count, check the quantity of water a person has taken, monitor the schedule of sleep, and maintain training records. They might offer various healthy meal recipes, remind individuals of taking medication, or advise a doctor. Finally, chatbots are able to provide inspiring and motivating phrases to increase self-esteem and attitude.

INTRODUCTION

In this developing world, AI has been playing a significant role in recent times. When we consider about the chat with software that is Conversational Assistant which has become the personal guide of the majority of the people. Chatbots such as Google Assistance help to complete our basic tasks such as scheduling a meeting, setting up an alarm, booking an appointment, ordering things, etc. After 2020

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there has been a major change in everyone's life due to the pandemic situation. It has affected the various sector in some or the other way such as people not getting hikes, losing their jobs, small-scale organizations getting shut down permanently, etc. People are stressed, suffer from mental health issues. So, people are now aware of their mental and physical health and seek a proper assistant who can guide them with relevant information. Therefore, in this situation, the AI assistant will give quick support, to stay safe and take necessary precautions whenever required (Nourchene Ouerhani, A. M.,2019). It will also take care of daily routine tasks like meditation, timely food habits, exercise as per the ayurvedic guide. People have forgotten the traditional cure method Ayurveda in this changing world. Ayurvedic expertise, which came from India over five thousand years ago, is widely known as the Mother in all Meditation. The primary objective over here is to train assistance in such a way that it can take care of one's health by providing suggestions, notifications, or tips for Physical and Mental health, give an opinion on food habits, meditation, reminding for doing exercise, and many more to boost the immune system and accept the tradition of Ayurveda Highly beneficial to heal and enhance the immune system. For the special case where someone is battling a disease, there are basic questions configured during the initial setup that can be changed accordingly and managed by the AI assistant. The secondary objective is to update the user with information regarding the COVID-19 guidelines, awareness of taking vaccines to people of specific age groups, vaccination booking, and rules of social distance, mask up and stay home unless there is an emergency. Therefore, all in one AI Assistant will be available handy all day and guide users for any query related to COVID-19, vaccination, symptoms, treatment, and many more.

Hence, to fulfil the requirement which the people seek for a healthy lifestyle and stay safe, many mentioned using the AI Assistant with the IoT wearable integration will give the best results as it is already being used by many successful companies. To configure the AI Assistant, it will require a few steps with a one-time configuration to integrate with the device. To use and check the process will be quite simple. So, the main mission is to give required assistance 24x7 to the user which will help from starting the day to sleep (Satyen Parikh, 2020). It will track all the activities from day to day and will give users notification if there is any lack of activity or any problem found. It will assist in maintaining the health of the user and maintain the immune system and stay safe. It will guide users for exercise, yoga, meditation, and if anyone requires some knowledge or tips that also it will assist. If anyone requires tips related to Ayurvedic treatment it will assist the user with that.

BACKGROUND

Chatbots in Medical Sector

A chatbot is an application built with a machine learning algorithm to encourage and interact with the user for providing them real-time support by integrating natural language processing (NLP).

In retail, news, social media, the bank, customer service, chatbots also have acquired popularity. Many individuals talk to chatbots without even knowing a day on their cell phones. Chatbots helps in improving the way people live, from getting up to sports news to browsing bank applications, to playing Facebook Message conversation-based activities.

Health insurers, suppliers, and healthcare professionals, including nursing doctors, also started using these intelligence solutions to streamline patient care and save needless expenditures. Whenever a patient talks to a physician who seems human but is an intelligent chat machine behind, a health chat is making progress in healthcare services.

Impact of a Chatbot Using Artificial Intelligence

Patients enjoy talking with medical professionals, and chatbots sound more humane with artificial intelligence. In reality, some chatbots with efficient self-learning models can hold thorough, almost human-style discussions effectively.

AI-driven medical chatbots lead to substantial healthcare paradigm shifts. More than 96% of patients that utilize the AI chatbots recently considered an AI developing company. The wide usage, indicating the improved customer involvement in helping patients to navigate healthcare services.

Machine Learning applications have started to change patient care as people know it. Although chatbots will still enhance health care in their early phases, they will result in considerable savings in medical expenses and improves patient care results shortly.

Use of Chatbot in Healthcare

Hybrid chatbots provide massive benefits in healthcare, and the people who are involved take advantage. Finally, medical chatbots minimize the strain of health workers by lowering hospital visits, eliminating needless care and procedural approach, and moderate admissions and readmissions in hospitals to enhance treatment compliance and awareness of their symptoms. This has several advantages for patients that are more amount of money is being wasted on useless treatments and tests at a hospital or clinic, ease of access, healthcare assistant is just a click away.

Chatbots save healthcare costs with analysts forecasting that healthcare chatbots cost reductions are expected to reach $3.6 billion worldwide by 2022. The chatbots reduce hospital long waits, appointment hours, unwanted medications, and hospital reactions by integrating patients and help them explain their illnesses and remedies without seeing a doctor. Chatbots reduce individual hospital processing times.

In addition, medical chatbots are used by government and health clinics to evaluate and monitor individuals even before they enter the consultation room. The bots raise important issues regarding the symptoms of the patient, with automated answers that provide the physician with appropriate history. These patient experiences are then provided to the doctor via a message interface, who tries to find out which patients must first be visited and which patients must be consulted shortly. Chatbots cannot substitute the knowledge of a doctor and take over patient care, but the combination of both in developed countries increases the effectiveness of patient care, simplifies, and quickly monitors treatment without sacrificing quality.

Use Cases: Healthcare Chatbots

To create a chatbot that attracts users and delivers solutions, chatbot developers must first evaluate which kind of chatbots would most successfully achieve these aims. As a result, two elements that the chatbot developer must consider are the user's purpose and the best aid that the user requires, then the researcher may create the proper chatbot to answer them.

In healthcare, there are three major applications for chatbot technology: informational, communicative, and predictive. The conversational style, level of communication, and sort of solutions provided by these chatbots differ.

- **Informational Bot**
    - Informational chatbots offer users applicable content, generally in pop-ups, alerts, and news headlines. Informational bots, in general, deliver autonomous content and user help. When you search for virus-like symptoms on the Web, for example, a chatbot may appear with advice on virus treatment and current occurrences in the region.
    - Chatbots are also used by health media sites and mental health services to assist them to find a more thorough understanding of a phenomenon. For example, a chatbot may emerge and ask Do you need help with alcoholism when you read about alcoholism or withdrawal? Contact one of our specialists on mental health.
- **Communicative Bot**
    - Conversational chatbots are designed to be interactive tools that respond to the user's intentions. A conversational chatbot, on the other hand, has varying levels of understanding not all of them provide the same depth of interaction.
    - In the first stage intelligence chatbot, for example, simply delivers pre-built replies to clearly defined queries, with no desire to understand it through any modifications.
    - The answers are pre-programmed. If Kevin continues to ask questions, the chatbot cannot create responses at this level of knowledge. In the second stage intelligence chatbot, on the other hand, is capable of doing so.
    - Conversational chatbots with greater intellectual capacities may better grasp the context and give more than pre-programmed responses. This is because the chatbots examine a discussion as a group instead of analyzing phrases in context.
    - The more intelligent a chatbot, the more personalized the replies. Conversations begin to mimic human interaction at this point.
    - Natural language processing (NLP), natural language understanding (NLU), and Artificial Intelligence technologies that allow robots to perceive human speech and intention are used in conversational chatbots.
- **Predictive Bot**
    - Design-oriented chatbots are conversational, but not just designed to provide responses or guidance, they are also developed to deliver therapies.
    - A Woebot is one example of a Predictive chatbot. Woebot is a chatbot created by Stanford University academics to help people with mental illnesses by utilizing cognitive behavioural therapy (CBT) approaches. Individuals suffering from depression, anxiety disorders, or mood disorders can communicate with this chatbot, which then assists people in treating themselves by altering their behaviour and cognitive patterns.
    - For example, Peter suffers from social phobia and converses with Woebot.
    - Initially, the chatbot assists Peter lighten the strain of his observed misstep and makes it known to him that it isn't out of the ordinary, which might restore his trust.
    - Chatbot developers should use several chatbots to get their audience involved and valuable. It is essential to know viewers and which chatbots perform best according to a specific environment.

- ◦ The chatbot which seeks to provide health assistance should take the rules that govern it very closely into consideration. There are certain rules for asking questions to chat assistants that should be followed.

Table 1. The best chatbots that are commonly used in healthcare:

Sr. No	Name	Type	Working	Advantage
1	HEALTHILY	Doctor Appointment chatbot	Users may input their symptoms and obtain the most diagnosis from an AI-enabled chatbot. MB offers valuable health hints and information on the symptoms and on the proven evidentiary-based solutions that have been trained using machine learning models for exact or near-accurate diagnosis.	Book Appointment, Share Information of local health service provider, Guide about the nearby clinic. Available in multiple chat applications.
2	ADA HEALTH	Health Assessment	To evaluate individual health more closely and to suggest appropriate remedies, Ada chatbot asks the user common information and replies on data sets from hundreds of other comparable inputs and situations.	Medical problems, therapies, treatments and communicate them with local providers of health care.
3	BABYLON HEALTH	Consultant Chatbot	The health chatbot allows users to report their problems and the software uses thousands of mildew conditions against a dataset. Then the various diagnoses are shown and the users could take measures to tackle the problem.	Consulting the virtual doctor, a chatbot, and an actual doctor. Expert consultation. This ai chatbot has integrated speech recognition and natural language processing to evaluate speech and text and generate appropriate results.
4	FORKSY	Nutrition Advice Chatbot	This chatbot follows diet and automatically gives you dietary decision with the response; it also informs useful advice about every meal you eat - along with its quantities of calorie intake and health advantages and concerns.	Forksy is a digital dietitian that enables you to manage dietary behaviors by making diet and calorie intake suggestions.
5	SAFEDRUGBOT	Health Assistant	Physicians do have a personal assistants chatbot to provide them with the information they need - Safedrugbot. It is a chatbot for doctors who conduct physician queries on an enormous database of medicines. This health discussion also provides medicines with updated drug prescription information and general health recommendations for women who are nursing.	This chatbot provides information about medicine dose, adverse medication effects, and the correct treatment choice for numerous conditions for healthcare practitioners.

AI Assistant to Fight Against COVID-19

With the increasing illness spreading, there is an increase in disinformation and various false narratives that might perhaps lead to a steady increase in the pandemic graph. Digital technologies that distribute reputable health records to individuals throughout the world have therefore become important. And health chatbots are excellently filling the void.

The World Health Organization (WHO) has just developed an interactive chatbot to offer correct information about COVID-19 in several languages utilizing a messaging app. Users need to log in to the chatbot the users get notified instantly by the World Health Organization (WHO) about the newest facts and information about the condition. The chatbot also enables people to evaluate their coronavirus awareness utilizing active assessment. This dialogue boot can assist people to comprehend the nature and the progress of the disease by use of enquiries.

The Indian Government has also established an interactive WhatsApp chatbot, the MyGov Corona helpdesk, which gives people in India reliable facts and information on the crisis. In addition, chatbots enable selected content. Details may be adapted to the needs of the user function that cannot be done in internet searches utilizing search engines for COVID-19 data. In addition, the information provided by the chatbot includes locations for the viewer so that they may access only valuable information.

Chatbot to Identify COVID-19

The health experts cannot access and monitor everybody who has indications of an illness; thus, utilizing AI bots might speed and efficiency in the diagnostic test. Large amounts of data have been used for conversational chatbots, including symptoms, method of transmission, natural pathology, predicting variables, and coronavirus medication. Bots can then obtain information from this source to produce automatic answers to inquiries from individuals.

A good example is a chatbot that detects the intent of a user's symptoms, using machine learning skills, then recognizes users who are likely to become infected and gives guidance for healthcare experts or extends these results. This is a straightforward approach to reach those who are possibly sick and to limit virus transmission. The goal is to maintain training chatbots on improvements and research findings linked to COVID-19. With new condition trends discovered by scientists, these data need to be incorporated into the ML train dataset so that a bot can accurately evaluate the symptom of the users at any time.

Google Cloud has established a Virtual Agent Program called the Rapid Response Chatbot to offer customers information and respond to their queries on the symptoms of coronavirus. Google has broadened this possibility to allow technology firms to create AI chatbots using their free software platform. A company that took advantage of the chance, created a virtual agent model for healthcare facilities and systems and was established to follow people having warning signs of the illness. This template enables health practitioners to build voices, or chatbots, which will evaluate users with a range of standard inquiries include their age, journey background, recent interactions, smoking history, and present symptoms.

Chatbot to Cure COVID-19

Following restrictions of stay home in a certain nation and the suspension of elections and appointments, users and healthcare providers can only meet virtually.

AI-driven chatbots can also become part of healthcare preparations for meeting the requirements of sufferers during the shutdown, from those with a coronavirus symptom fear to those with other symptoms. Many healthcare providers have used telehealth, relieve worries and prescribe with their sufferers. Social isolation and loss of a job have also affected psychological well-being. People can connect with an expert virtual mental wellbeing to receive a certain relief using psychiatrist chatbots. These chatbots are training on vast data and contain the ability to analyze natural languages to grasp individuals' problems.

LITERATURE REVIEW

Chatbot systems are now becoming competitive with the increase of smartphone, IoT and Messaging platforms, voice, and language processing. However, when dealing with some areas and their special requirements, implementing an all-size strategy cannot achieve much. To maximize the potential for the chatbot to meet the objective specified, it is necessary to design patterns for certain domains. Thus, the attention to context, content, user interactions, and the adaptation of design strategies to meet the pattern can enhance the process. (D. Lockton et al., 2010)

Bonobot (Park. S et al., 2019) was created as a research prototype to present the sequence in a chat. (Kumar M.N, 2016) suggests a chatbot with the following system: Input collecting and data pre-processing, medical terminology identification, mapping necessary documentation, and providing response and answers. Demands for improved mental health services have risen and the shortage of resources has made it considerably more difficult to satisfy these requirements. New solutions are thus required to make up for the lack of resources and to encourage self-care for individuals. (Jones SP et al., 2014)

The distance can limit the access of people in rural places in both high-income and low-income nations to standard mental health care. Technological advances in treatment, such as mobile applications, may solve most of these obstacles and engage hard-to-reach people to reach (Schueller SM et al., 2014). A 15,000-app study by the World Health Organization found that 29% focused on diagnosing or supporting mental health. (Anthes E, 2016)

Table 2. Different Author's view on Healthcare Chatbot

Sr. No	Paper Title	Author(s)	Publication Year/ University/ Email	Description
1	Medical Chatbot Techniques: A Review	- Andrew Reyner Wibowo Tjiptomongsoguno, - Audrey Chen, - Hubert Michael Sanyoto, - Edy Irwansyah, - Bayu Kanigoro	2020, School of Computer Science, Bina Nusantara University, Jakarta, Indonesia eirwansyah@binus.edu, bkanigoro@binus.edu	The paper aims to identify and enhance chatbots that can assist individuals to receive the same care as the physician. Usually, the NLP string format is transformed into a tokenized format. Instead of string format, the tokenize format may be simply processed by the application. After input data is tokenized, the symptoms of the class and the illness present in the training phase may be treated with machine learning. So, according to the author the NLP and Machine Learning are hence the best algorithm for chatbot development. (Andrew Reyner Wibowo Tjiptomongsoguno, 2020)
2	Can a Chatbot Determine My Diet?: Addressing Challenges of Chatbot Application for Meal Recommendation	Ahmed Fadhil	2020 University of Trento Trento, Italy fadhil@fbk.eu	Chatbots have a great potential to reach a diverse range of users in the field of health promotion. The intention of the chatbot system in connection with the healthy food suggestion was presented in this study. The present problems connected with the chat system were explored and the challenges were addressed from technological, theoretical, behavioral, and social dimensions. A pipeline is presented to help developers build and deploy these systems as recommendations. This ensures that the system meets the pipeline objectives. (Ahmed Fadhil, 2020)

continues on following page

Table 2. Continued

Sr. No	Paper Title	Author(s)	Publication Year/ University/ Email	Description
3	Addressing Challenges in Promoting Healthy Lifestyles: The AI-Chatbot Approach	- Ahmed Fadhil, - Silvia Gabrielli	2017 Fondazione Bruno Kessler, Centro Ricerche GPI Via Sommarive, 18 - Trento, Italy {fadhil | sgabrielli}@fbk.eu	This study focuses on the unique method of AI chatbots that offers simpler and easier compliance with medical support measures. Conversational assistance has the advantage of being used in a wide range of applications on smartphones and computers. It will focus on exploiting the capability of smart chat systems to intervene in telemedicine's to influence behavior to promote healthy lifestyles. Authors have offered an AI-chatbot automation solution that supports the instruction of nutrients that can assist to overcome existing constraints of the comparable mHealth solutions that have been given in health and wellness. (Ahmed Fadhil, 2017)
4	A review of AI Technologies for Wearable Devices	Jin chun yu	2019 Mechanical Design Manufacture and Automation, Honors College, Northwestern Polytechnical University, 710072	In this work, authors review the research of wearable technology using Artificial Intelligence using the characteristics of wearable device varieties of the data gathered and models collected. In addition to increasing effectiveness in comparison to conventional approaches, authors see artificial intelligence technology developing a number of new applications. (Jin Chun Yu, 2019)
5	Effectiveness and Safety of Using Chatbots to Improve Mental Health: Systematic Review and Meta-Analysis	- Alaa Ali Abd-Alrazaq, - Asma Rababeh, - Mohannad Alajlani, - Bridgette M Bewick, - Mowafa Househ	2020 College of Science and Engineering, Hamad Bin Khalifa University, Doha, Qatar Jordan Health Aid Society International, Amman, Jordan Institute of Digital Healthcare, University of Warwick, Warwick, United Kingdom 4Leeds Institute of Health Sciences, School of Medicine, University of Leeds, Leeds, United Kingdom mhouseh@hbku.edu.qa	This research aims at evaluating the effectiveness and safety of the use of chatbots by collecting and combining the data of prior studies to enhance psychological health. Chatbots can promote mental wellness. But the information of this review was not enough to conclude it definitely since the clinical impact was not shown, because of a paucity of research evaluating each result, because the risk of bias in these trials was high and because several findings were contradictory. Finding strong findings on the efficacy and safety of chatbots must be investigated. (Alaa Ali Abd-Alrazaq, 2020)

MAIN FOCUS OF THE CHAPTER

Issues, Controversies, Problems

Many lives have been affected by the COVID19 outbreak. Many of us face difficult, stressful circumstances that can create intense emotions for people of all ages. Efforts on human health like social distance are important if COVID-19 is to be less widespread, yet it can make us feel alone and raise fear and tension. Learning to manage anxiety in a healthy way can make people stronger.

The following are caused by Pandemic Situation:

- People are afraid of going out to the hospital/ clinic when suffering from fever, cough, cold due to this pandemic situation.
- Emotions of anxiety, anger, unhappiness, stress, ignorance or impatience.
- Hunger, energy, preferences, and interest modifications.
- Focus and decision-making complexity.
- Insomnia or bad dreams difficulties.
- Actions, like head pain, discomfort in body, abdomen, and skin problems.
- Enhancement of chronic conditions.
- Deterioration of the circumstances of mental wellbeing.
- Enhanced use of cigarettes, drinks, and other drugs.
- Tension, anxiety, sorrow, and concern during the COVID-19 outbreak are unambiguous.
- Some unauthenticated myths regarding the vaccine have spread.
- The people who are less educated are unaware about the importance of vaccines.
- After taking vaccines people are not following the guidelines.

SOLUTIONS AND RECOMMENDATIONS

Here are methods people should follow to overcome the above situations/ problems/ issues (World Health Organization):

- So, to resolve the fear of going out there, an AI Assistant will help at a certain level to solve this issue and is available 24x7 at any time.
- AI Assistant will suggest home remedies and Ayurvedic treatment which is easily available at home.
- Guide users to boost their immune system by using in-house treatment.
- If there are minor symptoms of COVID-19 so it can be easily curable using AI Assistant.
- Home Quarantine guide and the basic treatment can be done using the AI Assistant.
- Start taking pauses, including media platforms from viewing, reading, and hearing news articles. It is wonderful to be educated, yet it is continually disturbing to hear about the outbreak. Take only a few times a day and cut off telephones, television, and computer display for a while.
- Pay attention to the body.
- Make deep breaths, relax, or the external symbol to meditation.
- Try eating nutritious, balanced food.
- Physical activity.
- Have plenty of sleep.
- Extensive use of alcohol, cigarettes, and substances should be avoided.
- Follow with usual preventative action, as advised by the healthcare professional (such as vaccines, screenings).
- Whenever it's turn, get vaccinated with the COVID-19 vaccine.
- Relax with time. Start doing other things you like.
- Communicate to others.
- Discuss thoughts and feelings to individuals who are outside the icon you respect. Connect to the community groups or religious organizations.

- If measures for social distance are in place, attempt to connect online, via social media, or by telephone or email.
- Awareness regarding the Vaccination should be spread and this AI Assistant will play a major role.
- Assistant help to guide after taking the vaccination that minimum of 7 days isolation should be followed as immunity is decreased for days after taking the vaccine.
- Between the two doses the vaccine experts have set the gap of certain days that should be followed as per the government guidelines.
- All the information regarding the vaccination, centers, registration as per the government will be available by the AI Assistant.

FUTURE RESEARCH DIRECTIONS

In this section, the authors have described the Proposed Approach, Proposed Method, Proposed Model, Limitations of the existing proposed system, and Future Insights.

Proposed Approach

The initial step for creating and training the model will be collecting information and fetching the data related to the Ayurvedic methods for strengthening the immune system. The next approach to train the model for the Assistant is to fetch relevant and accurate information and guidelines for staying safe, maintain social distance, wear a mask and wash hands frequently. After that, it will fetch all the information from the relevant source to Boost Immune System like Meditation, Yoga, Exercise, Healthy Food Habits, and many more related to it. Once this information will be gathered like Ayurvedic treatment to boost an immune system, a guide to creating ayurvedic brew, the guideline to stay safe, Meditation, Yoga, Exercise, Healthy Food Habits, and many more related to it.

All the related data will be cleaned and converted to the appropriate format as the AI model required and data will be fed to the model for training purposes. The model will be trained by using an appropriate AI Algorithm and will apply the one with the best and accurate results. The model will be evaluated by using an evaluation technique and the results will be generated. According to the results, one can select the model with the best and accurate results and an efficient model will be selected.

Once the AI model is trained it will be integrated with the IoT device by using sensors to collect data. The AI model will also require the input data of the user, so to get the user's information it will be using an IoT device to monitor the basic health-related information like step count, heart rate, and many more to get the data. Thus, using sensors and the wearable device will automatically fetch the user's data which will be triggered at a specific time. Therefore, it will fetch the data at some time interval and give appropriate tips/notifications in the user's device where the AI Assistant is being configured.

In the current state to track physical activity sensors are used, like smartwatches, accelerometers, heart rate sensors, and humidity sensors were used to detect the physical conditions and were also used to develop a smartwatch application. Because of the success of smart IoT devices, one can collect a variety of data to enable a variety of creative applications. Higher data management capabilities are designed to handle complicated and large data. This massive but complex data was processed by artificial intelligence technologies in recent years.

Table 3. Useful smartphone applications for Healthcare

Sr. No	Application Name	Description	Features	Device/Ratings
1.	Generis	Diabetes is a prevalent condition. Everybody knows those who are struggling with this condition and the painful challenges that come with running out of diabetic pills or diagnostic equipment. One healthcare mobile app for patients that should be downloaded or suggested is Generis: DNA & Nutrition, a public benefit system for those suffering from Diabetes. Generis: DNA & Nutrition links its users to neighbouring app users who may be able to provide needed supplies or even assist with a blood sample or treatment. In its forum, Healthcare also provides useful tips and assistance.	Seek medical advice. Receive healthcare suggestions. Programs are tailored to achieve the goals of the user. A quiz is prepared to know about the lifestyle that includes food intake and sleep habits.	iOS / 4.5
2.	PEPID	A mobile app that allows customers to quickly connect with their chemists about various medical articles, write prescriptions, and handle refills. PEPID is a smartphone app that does all of these things. They hoped to improve access to health information by assisting chemists in digitalization. PEPID creates smartphone apps for clinics, as well as data storage and technology services. These applications can help chemists engage with customers while also making the medication filling process easier for everyone.	Procedure and usability have been streamlined. Search engines and auto-correction. Notes are made and history is saved. Login Recurring. Calculators for diagnostic purposes.	iOS / 4.7 Android / 4.3
3.	UpToDate	This innovative healthcare software for patients combines the greatest features of nearly all important mobile applications on the market. It has strong location-based technologies and the first-ever 3D foetal animation movies. The app's user experience is basic and beautiful. Insightful films, professional advice groups, personal picture albums, baby goods purchasing, and a weekly pregnancy monitor are among the other features. Though it's complimentary, Totally Pregnant is littered with connections to online in-app purchases of programmes such as Overgrowth and maternity yoga.	Account Recurring Searching is simple, and auto-completion is available. Keeps the past information and favorites. Mobile-optimized healthcare calculators	iOS / 4.0 Android / 4.5
4.	Doctor on Demand	Doctor on Demand specialists for an online conversation is ready mobile healthcare app, which serves everyone about healthcare app. It provides doctors who can treat semi medical issues, including cold symptoms, backaches, indigestion, and paediatric disorders and many more. The app gives you access to physicians who can provide you with a medication, even for transportation issues, and solve all healthcare inquiries. A psychotherapist and lactation advice are also available as services.	24X7 availability of doctor. Set up an appointment whenever it is convenient for you. Medical insurance is encouraged. There is no service charge. Social assistance is provided.	iOS / 4.9 Android /4.8

Wearables in wellness usually store, track, and communicate with user's health data. It informs the person about different health criteria at the right time. Neural networks use evolutionary algorithms based on deep learning to learn and perform a certain function by recurrent and self-corrected function.

While several methods for processing sensor data in wearable devices have been proposed, will concentrate on three of them that is believed the most successful are: Ensemble Learning a Machine learning increases computer system's efficiency by learning from data, allowing them the potential to think like humans, resulting in artificial intelligence, Convolutional Neural Network is a convolutional neural network in a neural network having at least one convolutional layer. Long Short-Term Memory (LSTM) is a type of recurring neural network which addresses the problems of gradient explosion and gradient disappearance better than the conventional repeated neural network. (Jin Chun Yu, 2019) These are the algorithms that will be used to train the model.

Wearables when integrated with AI models can not only log data, but also recommend what the user should eat, how much sleep they should get, and how they should train to better their health, among other things. Wearables now come in several different forms, with innovations such as the incorporation of intelligent speech assistants. These wearables include specialized sensors that monitor, evaluate, and enhance user's exercise or sport-specific actions while having real user insights.

PROPOSED METHOD

Natural Language Processing

Natural language processing (NLP) is a machine's understanding of human language. It began in 1950 with a paper called Machine and Intelligence published by Alan Turing.

According to Wikipedia, the field of linguistics, computer science and artificial intelligence, which is natural language processing (NLP), is the interactions between computers and human language, especially the programming of computers for processing and analyzing large numbers of natural language information. The information of messages and the complexity of their language may therefore be understood by a machine. The system then extracts and describes and arranges correct facts and data from the content.

NLP is described as the "process of generating meaningful phrases and sentences in natural language." Natural Language Processing makes it impracticable for Natural Language Understanding (NLU) and Natural Language Generation (NLG). The data input is mapped into natural language by NLU. NLG performs data extraction and storage, emotion analysis, and other tasks.

- **NLP Approach**
    - Named Entity Recognition
    - Classification
    - Sentiment Analysis
    - Topic Modelling
    - Text Summarization
    - Aspect Mining

Ensemble Learning and Machine Learning:

Machine learning increases computer systems' efficiency by learning from data, allowing them the potential to think like humans, resulting in artificial intelligence. The study of algorithms creating data models on a computer called learning algorithms that is Machine Learning. Information is always in the type of data in computer systems; hence machine learning is an algorithmic study that generates models from computer data.

Provision of empirical facts to a learning algorithm and modelling using those data, and judgments in new situations automatically. Ensemble learning is achieved by creating and integrating several machine learning algorithms, rather than by using a single machine learning algorithm. Ensemble learning, when used in this method, can often produce greater outcomes than a single model. (Jin Chun Yu, 2019)

Convolutional Neural Network (CNN)

At least one convolutional layer in a neural network is known as a convolutional neural network. It usually consists of three layers: convolution, pooling, and fully connected. The convolution and pooling layers differ from other neural networks. The input data and convolution kernel are connected at a convolution layer and the output is obtained with a scalar deviation.

The neural network can determine the exact position of pixel shifts using the convolution operation. The purpose of pooling is to lessen the sensitivity to the location of the convolution layer. In kind of a defined format window of the input data, the pooling layer produces a result for each component, similar to the convolution layer.

The pooling layer immediately calculates the maximum or average value of the items in the red window, in contrast to the convolution layer calculating the common relation between the input and convolution kernel. Maximum pooling and average pooling are terms used to describe the assumptions. (Jin Chun Yu, 2019)

Architecture

- **Input**
  - It is the input parameter where the user can input a specific object.
- **Feature Map**
  - When the algorithm is applied to the input data it will result from a feature map.
- **Subsampling**
  - It will compress data size by using specific functions.
- **Convolution**
  - It is a statistical function to combine different kinds of data.
- **Connected**
  - It is the conclusion of the architecture by combining the above layers.
- **Output**
  - Generate the appropriate result.

Long Short-Term Memory (LSTM)

Long short-term memory (LSTM) is comparatively a recurrent neural network, that better addresses the difficulties of gradient explosion, gradient extinction, as well as the extent dependency of the normal recurrent neural network. The LSTM introduces the input gate, the output gate, and the forget gate architecture. When the data is inserted in the memory cell, the input gate must be observed.

The input data will pass through while the input gate is 1, but it cannot pass through otherwise. Likewise, the output gate determines when a memory cell's value can be read easily. Therefore, the forget gate determines whether or not the value in the memory cell can be retained. The value recorded in the memory cell is recovered, whenever forgotten. (Jin Chun Yu, 2019)

Proposed Model

In this model, the author wants to propose a system that is available anytime handy and users don't have to worry about their daily health routine habits. Thus, here the things which are required are the user's mobile, AI assistant installed in it, and the smartwatch. Once the application is installed in the user's mobile and the smartwatch is connected the user can manage their whole day's activities.

The author aim is to create a personal assistant which performs the following activities includes: Setting up alarm/ reminder for waking up / taking medicine etc., Step's count, Heart Rate count, Calorie's count, Healthy food intake tips, remind you of drinking water, Ayurvedic tips to build the immune system, guide you in meditation/Yoga/Exercise, when going out remind you to wear the mask, Update with the latest information regarding COVID-19, Information regarding Vaccination and many more.

Here authors have included a Smartwatch and wristbands for surveillance of the user's activities, there are different kinds of sensors that track the activity and notify the user at the appropriate time.

LIMITATION

Any software or application which is built using Artificial Intelligence or any other technology may have certain limits. Hence, for the model which the author has proposed issues like for the special case user with any major disease where the doctor's guidance is required. The basic needs can be fulfilled but AI assistants cannot assist them completely. But chatbots can call on behalf of the user. It is mandatory to connect the device with the smart wearable band otherwise it will not fetch the data. The sensor with the wearable device is accurate at a certain level it cannot be 100 percent accurate and one cannot depend fully on the numbers by the wearable device. Researchers are working on wearable sensors to make them accurate. It is the technology which is emerging nowadays and many works are going on in this area.

FUTURE INSIGHTS

In this chapter the author has included wearable technology that is wearable watch/band, different methods can be useful to monitor user's activity and help to maintain user fit and health.

Here is the list of smart accessories which can be used further:

- **Smart Mobile**
  - Mobile phones are equipped with various sensors that collect details on user movement. People generally have their smartphones in their hands or pocket, which fulfil the data collecting criteria. The gathering of data could be utilized for many reasons like tracking mobility, accident identification, elder surveillance, and patient recovery treatment.
- **Smart Glasses**
  - Clever glasses may breach the privacy of others by filming and capturing video. Furthermore, as long as the objective is clear and the surveillance system is appropriate intelligent glasses are not a privacy danger, but rather a practical life helper and medical instrument. For instance, Google has planned to integrate built-in sensor contact lenses to measure user's blood sugar levels.
- **Smart Fabric**
  - Intelligent clothing collects user physical data using customized sensors and devices to track and collect user's training data and heat utilization. Smart child clothing is also available for young parents for physical observation of their children.
- **Smart Footwear**
  - Intelligent shoes primarily gather data from sports consumers to enhance their sports programs. Furthermore, additional motion sensor functions are provided for certain clever shoes like Nike's FuelBand SE, which encourages users to rise and move now and then.
- **Smart handsfree**
  - Smart earphones innovative application methodologies such as smart speech interpretation and computation that enable users to utilize speech recognition to operate their devices more efficiently. Devices may be integrated in the future together with the pulse rate, body temperature, and motion of the user.

CONCLUSION

In this chapter, the author wants to narrate the information that with the use of the Artificial Intelligence Assistant one can get the required information and get help at any time without going outside. By using AI Assistant, users can ask for any help related to health, exercise, yoga, meditation, ayurvedic treatment information, user's activity surveillance, a guide to boost the immune system, COVID-19 Guidelines, Relaxation activities, Vaccination information, and many more. This can be done using the integration of machine learning algorithms and IoT Sensors. The main motto of the author is to help the user in this pandemic situation and can get help using an all-in-one Artificial Intelligence Assistant. Proposed approaches have been discussed and that is how the flow of the user will work. How easily users can manage their daily tasks and any information that users require any health-related help can be solved easily. In this assistant smartwatch is used to monitor user's activity further with the use of advanced sensors in different devices efficiency can be increased. Although the initial chat buzz decreases, medical chatbots are still able to help the healthcare business. Investigations, patient involvement outside medical institutions, and mental wellbeing are three main factors that might be especially beneficial. Experts typically agree that the prospect of chatbots in the health sector looks brilliant in their medical chat market study.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence (AI): Artificial Intelligence is the perceptron that acts and thinks like the human way and has the ability to function when programmed.

Artificial Intelligence Assistant (AI Assistant): AI Assistant is a virtual assistant which is built using Natural Language Processing.

Chatbot: A chatbot is computer software for artificial intelligence that communicates via voice and video.

IoT (Internet of Things): It is a device that is integrated by a sensor used to transfer data from an application or software to the server.

LSTM (Long Short-Term Memory): A machine learning algorithm that worked recurrently and in a sequential manner and was used to predict future data.

NLP:**:** NLP is the submodule of language and Artificial Intelligence. NLP is a mediator which processes between the machine and natural language.

Pandemic: A situation when the disease is spread all over the world and it is complex to manage.

Sensor: It is a system which is used to identify activities or change or actions performed in the given environment.

Smart Wearable: A technology advancement that can be in the form of electronics accessories like a watch, tattoo, belt, cloth, and many more. It monitors the user's activity, records the data, and sends it to the linked device.

Chapter 11
Technology-Powered Education Post Pandemic:
Importance of Knowledge Management in Education

Anu Thomas
L.J. Institute of Engineering and Technology, India

Ramesh Tribhovan Bhai Prajapati
L.J. Institute of Engineering and Technology, India

Ashneet Kaur
Jagannath International Management School, Vasant Kunj New Delhi, India

ABSTRACT

In order to provide personalized learning and to track student performance, many learning platforms accelerated pre-pandemic. But the focus was for the fortunate students. The recent COVID-19 pandemic taught the education sector the importance of including technology in day-to-day learning activity. Knowledge management is beneficial to all institutes in order to retain experienced teachers and in order to strengthen new teachers with the various steps involved in the process. Managing intellectual assets in order to provide excellent education and to meet all related challenges would be the right step. This study focuses on growth and demand of knowledge management in the education sector. In this chapter, the authors include the matter, like to study the impact of each of the steps involved in knowledge management on the performance of student. In light of the objectives of this chapter, more exploration on studying the effectiveness of knowledge management on education and empirical evidence of the efficacy of KM on the performance of the student is carried out.

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INTRODUCTION

Pandemic acted as a catalyst to redesign the existing frameworks of education. Physical distancing during the pandemic, hit worst to the little learners worldwide. Learners were forced to study using remote learning options whereas the educators were forced to learn various remote learning platforms to facilitate the learning process. But the whole process of remote learning was an eye-opener to the education management sector. It showed the obstacles in technology based learning and even provided the courage to opt for several technology enabled learning to facilitate better education. Several barriers to remote learning include:

1. Student learning satisfaction.
2. Parent/guardian satisfaction over student's academic performance.
3. Teacher's adaptation to online learning mode.
4. Infrastructure constraints.
5. Deploying remote learning to every student.
6. Behaviour and adaptation during pandemic.

Knowledge Management is a process where various steps are involved with respect to handling the knowledge. These steps are:

a. Knowledge Acquisition
b. Knowledge Application
c. Knowledge Evaluation
d. Knowledge Sharing
e. Knowledge Access

It has gained immense demand and popularity in almost all sectors of business but the demand in the education sector is a new study. It is multi disciplinary approach and requires lot of study to understand its efficacy.

BACKGROUND

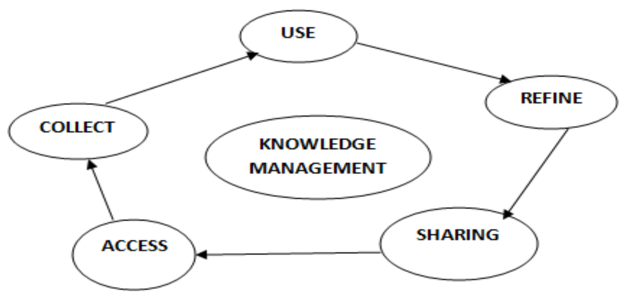
Knowledge Management

Knowledge Management is a process of handling knowledge. In this process of Knowledge management, the focus is on creating, sharing, using and managing the knowledge of an organization. It is a multidisciplinary approach and also an emerging field for research. The various steps in this process are:

1. **Collect:** In light of objectives of an organization, focus is on searching and collecting basic information from various sources.
2. **Use:** The information collected in the initial stages is exploited and attempt is made to use the content as per client's request.

3. **Refine:** In this stage, the organization focuses on enriching the existing content and information by adding more value to it and by adding additional information to enrich the yield.
4. **Sharing:** The most important purpose of knowledge management is to share the information with other members of the organization.
5. **Access and Store:** The focus of knowledge management is to enable easy access to knowledge within the organization. Though creating the KM system is the initial step, but individuals should also have an understanding in using that system.

Figure 1. Knowledge Management lifecycle



E-Learning

The growth of distance learning yielded to the rise of E-learning. The very face to face approach of learning has now been modernized to fully online mode of learning. One cannot deny the vital role of technology in the field of learning. Universities are now using live e-leaning and self paced e-leaning along with distance learning and traditional face to face learning. In order to utilize the advantages of e-learning, it is important to understand the recent trends and practices in order to promote effective e-learning.

In almost all institution of higher education, e-learning has taken its place. (Sharpe et al., 2006) especially for delivering open and distance education (Rosenberg, 2006, Snart, 2010). Mayes and De Freitas (2005) consider e-learning a tool for making effective assessment of learning outcomes and a cost-effective way to reach distance learning students. It is apparent that e-learning tools enhance the instructional ability of instructors and learning activities of learners which is an improvement to traditional classroom-based learning (Rosenberg, 2006, Snart, 2010).

Related Work

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   Year: 2010
   Research: Modeling the impact of Knowledge Management using technology.
   Findings: Provides organization as well as the learners' flexibility of time and place.
2. Author: Bain and Swan
   Year: 2011

Research: Technology enhanced feedback tools as a Knowledge Management mechanism for supporting professional growth and school reform.
Findings: To create Knowledge Management system to provide feedback for multiple stakeholders of institutes.

3. Author: Lee, Lu, Yang, and Hou
Year: 2010
Research: A process-based Knowledge Management system for schools: a case study in Taiwan.
Findings: A process management based KM to set up and share documents to achieve school performance goals
4. Author: Ainissyifa, H
Year: 2012
Research: The Influence of Human Resources toward Knowledge Management Implementation on Secondary Education Institution.
Findings: Studies impact of human resource on use of KM.
5. Author: Thambi and O'Toole
Year: 2012
Research: Applying Knowledge Management taxonomy to secondary schools.
Findings: Most of the categories of Michael earl's enterprise based KM taxonomy are related to schools.
6. Author: Cheng, Eric C. K.
Year: 2013
Research: Applying Knowledge Management for school strategic planning.
Findings: Identifies the critical success factor for successfully implementing KM in schools.
7. Author: Yohannes Kurniawan
Year: 2014
Research: The role of Knowledge Management system in school: perception of applications and benefits
Findings: Focuses on the issue of knowledge capture, sharing and utilization.
8. Author: Sanghamitra Brahma, Sumita Mishra
Year: 2015
Research: Understanding Researchable Issues in Knowledge Management: A Literature Review
Findings: Attempts to explain KM framework can be used in different B-schools to utilize its capabilities.
9. Author: Kai Wing Chu
Year: 2016
Research: Beginning a journey of Knowledge Management in a secondary school
Findings: Dual approach like information based and people interaction based approaches are effective.
10. Author: Eric C. K. Cheng
Year: 2017
Research: Knowledge Management strategies for capitalizing on school knowledge.
Findings: Contributes to management practices of school organization and focuses on customization strategies.
11. Author: Sugunah Supermane, Lokman Mohd Tahir
Year: 2018

Research: An overview of Knowledge Management practice among teachers.
Findings: Dimensions like knowledge storage and retrieval are dominant and dimension like knowledge distribution was least dominant.

12. Author: Eric C.K. Cheng
    Year: 2019
    Research: Knowledge Management strategies for sustaining Lesson Study.
    Findings: People based KM strategy predicts knowledge sharing and it based KM strategies predict teacher's knowledge sharing.
13. Author: Silvia Iacuzzi, Paolo Fedele & Andrea Garlatti
    Year: 2020
    Research: Beyond Coronavirus: The role for Knowledge Management in schools responses to crisis.
    Findings: Beyond Coronavirus: The role for Knowledge Management in schools responses to crisis.

METHODOLOGY

Problem Statement

During this pandemic, COVID-19, when all organization came to standstill due to physical distancing, even academic institutes suffered its consequences. This pandemic acted as catalyst for educational change. It represented an opportunity to think of options for better learning amidst social distancing. This chapter focuses on studying the effectiveness of knowledge management on E-learning. The aim of this chapter is to leverage the benefits of knowledge management.

Research Objective

This chapter focuses to study the efficacy of knowledge management on E-learning from empirical evidence of higher education institutes in Delhi, India.

Research Question

In light of the objectives of the research proposal, the study will focus on the question:

What is the effect of Knowledge Management (Use, Collect, Access, Sharing and Refine) on the effectiveness of using E-learning process in all higher education institutes in Delhi, India?

Research Hypothesis:

To understand and answer the research question, the following hypothesis will be tested:

There is a huge effect of Knowledge Management (Use, Collect, Access, Sharing and Refine) on effectiveness of E-learning.

Relevance of Study

The study will help all educational institutes to focus on Knowledge management. Its result will be a decision tool for all organizational administrators. While a lot of study relates the relationship of KM on performance n corporates, but minimal work has been done in academia

Sampling

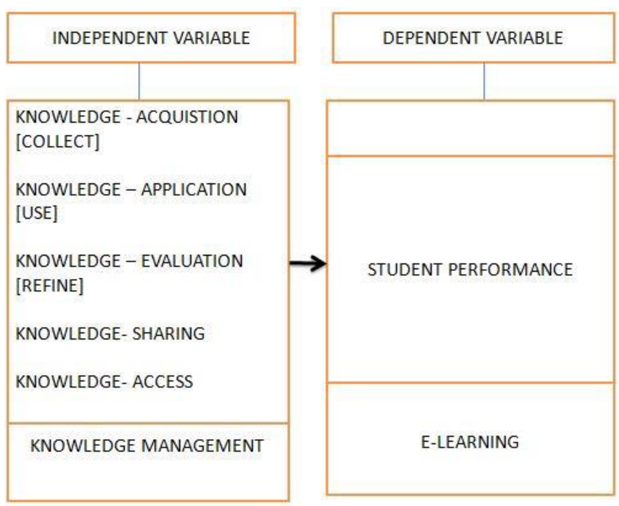
The population of study includes 112 respondents all from higher education institutes from Delhi, India. Simple random sampling was used among all educators of higher education institutes in Delhi, India.

Research Model

The study comprises of independent variable as Knowledge Management (KM), considering the sub variables as KNOWLEDGE COLLECTION (KC), KNOWLWDGE USE (KU), KNOWLEDGE EVALUATION (KE), and KNOWLEDGE SHARING (KS) AND KNWOLEDGE ACCESS (KA).

The study focuses on one dependent variable as STUDENT PERFORMANCE (SP) in these higher education institutes.

Figure 2. Research Model



Research is the systematic design, collection, analysis and reporting of data and finding a specific solution to a problem or situation. Most of the information is gathered through primary data collected through a self structured questionnaire. Secondary data has been collected from various journals, articles etc

Tools and Techniques

The online survey was In this study 5-point Likert scale where the respondents were asked to indicate the responses using 1 for strongly agree and 5 for strongly disagree for various independent variables used. Also regression tool is best suited to conduct this research project. Regression analysis is a powerful statistical method that allows you to examine the relationship between two or more variables of interest. While there are many types of regression analysis at their core they all examine the influence of one or more independent variables on a dependent variable.

Regression model involve the following variables:-

$$SP = \beta 0 + \beta 1KA + \beta 2\ KAP + \beta 3KE + \beta 4KS + \beta 5KAC + e$$

Where,

SP =Student performance
KA = Knowledge acquisition
KAP = Knowledge application
KE = Knowledge evaluation
KS = Knowledge sharing
KAC = Knowledge access

Hypothesis

- H_a1: Knowledge acquisition has a significant effect on performance of the higher education students.
- H_a2: Knowledge application has a significant effect on performance of the higher education students
- H_a3: Knowledge evaluation has a significant effect on performance of the higher education students
- H_a4: Knowledge sharing has a significant effect on performance of the higher education students.
- H_a5: Knowledge access has a significant effect on performance of the higher education students.

Objectives

- To study the changing scenario of education.
- To study the impact of Knowledge acquisition, Knowledge application, Knowledge evaluation, Knowledge sharing and Knowledge access on students performance of the higher education institutions.

Sampling Design, Size and Profile of Respondents

Random sampling technique has been used. The sample consisted of the 112 students who are studying in the higher education institutes in Delhi NCR. The students belonged to both under graduate and post graduate courses.

Statistical Analysis

Analysis of the data has been done using SPSS 2.0. Descriptive statistics was used to indicate the sample details and inferential statistics was applied to analyze the data.

4. ANALYSIS

a. Demographic Profile

Table 1. Demographic Profile

		Frequency	Percentage
Gender	Male	55	49%
	Female	57	51%
TOTAL		**112**	
Age	15-20	18	16%
	21-25	76	68%
	25 – 30	18	16%
TOTAL		**112**	
Education	Under graduate	49	44%
	Post graduate	63	56%
	PhD	0	0%
TOTAL		**112**	

The above table shows the demographic presentation of the sample taken. Out of 112 respondents 16% were from 15-20 age groups, 68% were from the 20-25 age groups, 16% were from the 26-30 age groups. Further, of the total respondents 44% were post graduates, 56% were from the graduate category and 0% were from the doctoral category as it is assumed that most PhD work is done by the researcher at his own pace, so we have taken only graduates and postgraduates students for the research. So majorly the undergraduate and post graduate students were taken.

Reliability Statistics

The questionnaire consisted of 5 constructs used as factors. Each factor consisted of five statements. This test is applied to check the reliability of the questionnaire developed using multiple Likert scale. Table 2 gives the summary of reliability, determined via Cronbach's Alpha coefficient (Nunally 1978). Reliability of 20 statements was computed via SPSS 20.0. The table below shows that all values are above 0.8, thus making the questionnaire reliable.

Table 2. Reliability of Instrument

CONSTRUCTS	CRONBACH ALPHA	NO. OF ITEMS
Knowledge acquisition	0.84	5
Knowledge application	0.89	5
Knowledge evaluation	0.83	5
Knowledge sharing	0.83	5
Knowledge access	0.80	5

Hypothesis Testing - Multiple Regression

As all the variables taken up in the study were normally distributed, parametric tests were used to measure the hypothesis. To identify which of the factors were the best predictors of performance of higher education multiple regression was computed.

The outcome dependent variable can be depicted by equation of multiple

$$SP= \beta 0 + \beta 1KA+ \beta 2\ KAP+ \beta 3KE+ \beta 4KS+ \beta 5KAC+e$$

Table 2 depicts the value of r, r square, adjusted r square, F and Durbin Watson. $r = .830$ shows the relationship between all the variables undertaken for the student. *R square* is 0.689 shows predictor variables (Knowledge acquisition, Knowledge application, Knowledge evaluation, Knowledge sharing and Knowledge access significantly explains 68.9% variability. Adjusted *R Square* reflects the variation is truly caused by the independent variable.

F Test is the null hypothesis that the model explains zero variance in the dependent variable. ANOVA model was significant. F ratio is significant, [$F = 46.43$; $p = 0.000$] which is <0.05 indicating it is highly significant. The Durbin Watson $d = 1.970$ which is between the two critical values of $1.5 < d\ 2.5$. There is no linear auto-correlation in our multiple linear regression data.

Table 3 shows the coefficient and b value in the multiple regression model equation, all the regression coefficient provide the significant effect on the outcome variable of intention to use.

Table 3. Regression model with F & Significance

MODEL SUMMARY							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.	Durbin-Watson
1	0.830	.689	.674	1.29710	46.43	0.000	1.970

Source: Authors Calculation

The regression equation depicted from the table 4 is as below:

Table 4. Coefficient of regression model

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.322	1.508		1.540	.127
	Knowledge acquisition	.212	.056	.233	3.819	.000
	Knowledge application	.323	.070	.311	4.642	.000
	Knowledge evaluation	.366	.053	.478	6.964	.000
	Knowledge sharing	.018	.057	.020	.318	.751
	Knowledge access	.036	.036	.053	.978	.330

a. Dependent Variable: Student Performance of Higher Education

Y (Performance of higher education) = 2.322 + 0.212(Knowledge acquisition) + O.323 (Knowledge application) + 0.366(Knowledge evaluation) + 0.018 (Knowledge sharing) + 0.036 (Knowledge access)

Empirical Findings and Discussion

The performance of the student is most affected by Knowledge evaluation and application of the knowledge.. Among all the predictor variables the most effective variable was Knowledge evaluation (β-.366) followed by Self Efficacy (β-.323), Knowledge access(β-.212), Knowledge access (β - .036) and Knowledge sharing(β - .018).

Table 2 depicts the value of r, r square, adjusted r square, F and Durbin Watson. *r = .830* shows the relationship between all the variables undertaken for the student. *R square* is 0.689 shows predictor variables (Knowledge acquisition, Knowledge application, Knowledge evaluation, Knowledge sharing and Knowledge access significantly explains 68.9% variability. *Adjusted R Square* reflects the variation is truly caused by the independent variable.

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Table 5.6 shows the coefficient and b value in the multiple regression model equation, all the regression coefficient provide the significant effect on the outcome variable of intention to use.

FUTURE RESEARCH DIRECTIONS

This chapter has shared some insights for Knowledge Management from Higher Education Institutes of Delhi, India. Within that perspective, the hypothesis and the outcome are well crafted. However, the sampling audience can be further diversified and huge data set will help to come to conclusion regarding the scope of KM in Education.

CONCLUSION

While there is understandable pushback against the online juggernaut, there is pure gold in each of the academy's schools to temper the immanent shift from brick-and-mortar to online educational settings. We need to first explore those insights within our academic camps. An actualized, distilled sense of what each school is about needs to be further crafted through comparative discussions with other schools.

The performance of the student is most affected by Knowledge acquisition and application of the knowledge. Among all the predictor variables the most effective variable was Knowledge acquisition (β-.366) followed by Knowledge application (β-.323), Knowledge evaluation(β-.212), Knowledge sharing(β - .036) and Knowledge access(β- .018).

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KEY TERMS AND DEFINITIONS

Knowledge Access: It is defined as the process of retrieving or disseminating of knowledge to users.

Knowledge Acquisition: It is defined as the process of extracting, structuring, and organizing knowledge from source. The different sources for Knowledge Acquisition are through a variety of learning activities with an organization.

Knowledge Application: It is defined as use and application of available knowledge to make decisions and perform tasks through direction and routines. Associating knowledge gained with existing background information helps to build greater meaning and increased engagement.

Knowledge Evaluation: Evaluation of knowledge involves systematically collecting information and analyzing it to see whether a program or a project is doing what it set out to do. Evaluation is a process that examines available knowledge credibility.

Knowledge Sharing: It is defined as an activity through which knowledge is exchanged among people, friends, peers, families, communities or within or between organizations.

Chapter 12
Prospects and Challenges of Using the Flipped Classroom in Computer Science Instruction During the Coronavirus Lockdown

Michael Onyema Edeh
Coal City University, Nigeria

Aabha Sharma
G.D. Goenka University, Gurgaon, India

Akindutire Opeyemi Roselyn
Ekiti State University, Nigeria

Ani Ukamaka Eucharia
Coal City University, Nigeria

ABSTRACT

The coronavirus pandemic brought about devastating challenges to every segment of human endeavours, particularly the education sector. This study examines the prospects and challenges of using flipped classroom in computer science instruction during the coronavirus lockdown. The conclusions here were based on available literature and practical experience of the researchers. Though the face-to-face class discussions were not possible due to COVID-19 restrictions, flipped model provided opportunities for computer science educators to upload lesson notes in digital platforms and then engage the students in remote class discussions. However, factors such as COVID-19 lockdown restrictions, time constraints, and lack of face-to-face class interactions hampered the successful implementation of flipped classroom in computer science instructions during the COVID-19 lockdown. The authors conclude that the use of flipped classroom strategy could potentially enhance technology application and learning outcomes in computer science instruction.

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1. INTRODUCTION

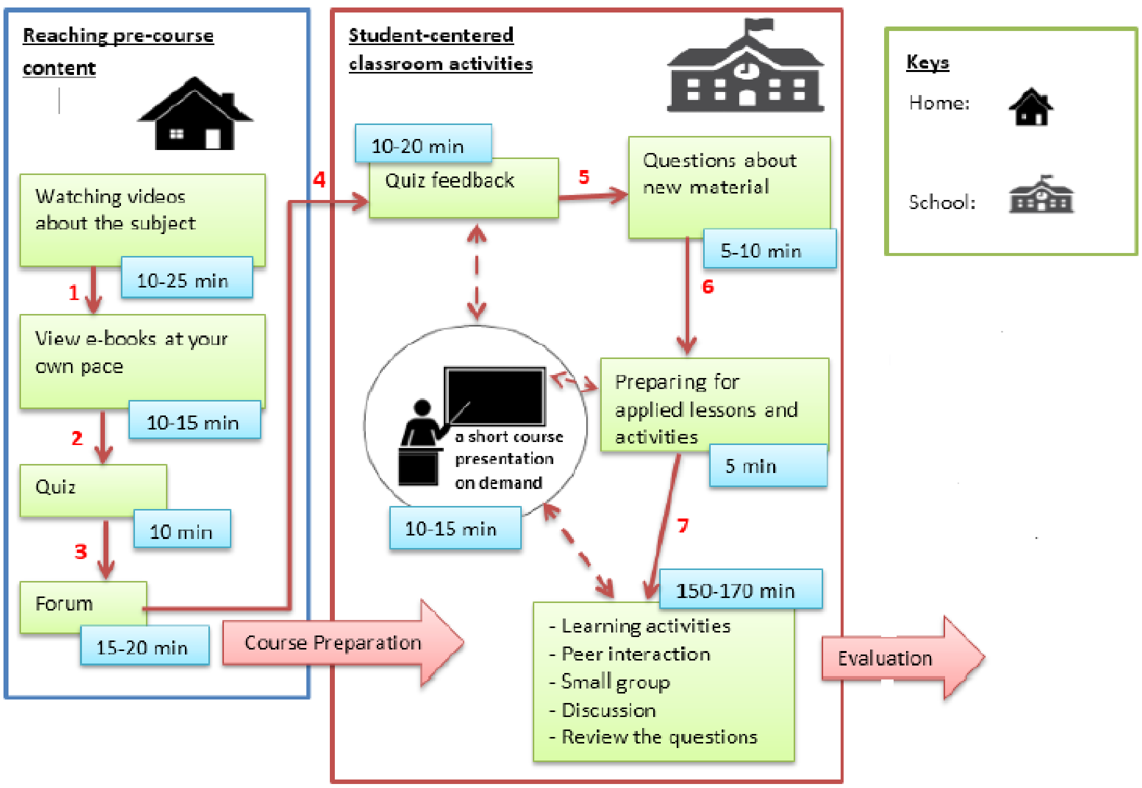
The changing nature of learners and the learning environment requires the use of interactive teaching and learning strategies that enhances problem-based education and student-centred education. The need for blended learning, students' creativity and participation brought about the concept of flipped classroom. Flipped classroom is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamics, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (The Flipped learning network, 2014). A flipped classroom is a type of blended learning where students study content at home before classes, and then discuss the materials at school during the physical classroom discussions. A study by Gilboy and Pazzaglia (2015) found that the majority of the 142 students who took part in a flipped classroom evaluation preferred the flipped method to the Traditional pedagogical strategies. According to Hamdan et al., (2013), flipped classroom create effective teaching environment at schools, and it is the best model for using technology in education. Flipped classroom afford both students and educators the opportunity to combine digital learning and face to face classroom discussions, thereby accommodating different crop of learners. Considering the benefits of flipped classroom, the present study examines its prospects and challenges in Computer Science instruction during the COVID-19 lockdown.

2. LITERATURE REVIEW

Flipped classroom affords students the opportunity to complete homework, discuss, explain, and extend the concepts they learned from the pre-recorded material during class time (JoRanna, 2014). Onyema et al, (2021) conducted an experimental study on the effect of Flipped classroom on the academic achievement of students in computer science. The study sampled 100 first year students using an achievement test. The results indicated that the experimental group who took the flipped treatment outperformed their counterparts in the control group who did not take the treatment. Shereen and Diala (2018) carried out a study on the effect of using flipped classroom technique on the learning outcome of fourth grade students in Jordan. They discovered that students who participated in the flipping exercise did better than others who did not. A study by Lesage et al (2019) examined the possibility of improving the performance of at-risk university Mathematics students using flipped classroom approach. The researchers tested two mathematics classes of university students (n=62) in the Faculty of Business and Information Technology. Their results showed that after employing the flipped classroom, 92% of the students (n=57) passed the course with an average grade of 76%. While an end-of-course survey also indicated that over 90% of students rated their overall experience with the course as very good or excellent, with a mean score of 4.5 on a five-point Likert scale. Similarly, another study by Tarik and Sevinc (2019) flipped classroom was compared with blended learning and face-to-face learning environments to identify the effect of these learning environments on students' achievements, academic engagement and satisfaction levels. Their results revealed that the students were generally satisfied with the flipped classroom and their scores were higher than those who were taught using conventional face-face learning approach. In contrast, a study by JoRanna (2014) examined the effect of the flipped classroom on academic achievement in high school mathematics. They found that flipped curriculum was not a significant factor in increasing student academic achievement or in increasing student critical thinking skills. Many studies (Davies et al, 2013; Herreid and Schiller, 2013), have also affirmed that flipped classroom approach can help students construct meaning in given topics and also participate more actively in the learning process.

As seen in figure 1 adopted from Tarik and Sevinc (2019), flipped classroom involves different stakeholders and requires both home and school activities. For these activities to be completed, the actors especially the students and the tutor have to play their parts and prepare for the physical classroom discussions. Teachers must make themselves available to offer explanations for contents uploaded, expected tasks and other questions that may arise during the flipping exercise.

Figure 1. Flipped Classroom Design (Tarik and Sevinc, 2019)



3. OVERVIEW OF CORONAVIRUS DISEASE 2019 (COVID-19)

The human Coronavirus Disease has become one of the worst global pandemics for decades, and it has caused the death of thousands of people, and disruptions in many human activities (Onyema et al., 2020). Though, there are now available COVID-19 vaccines like Jonson and Johnson vaccine, Pfizer and Astra-Zeneca vaccines, the number of cases have continued to rise with no sign of slowing down. As of April 21, 2021, the global number of Coronavirus deaths has exceeded 3 million, while the total number of cases has reached over 144 million (Worldometer, 2021). Coronavirus has adverse effects on education including, learning disruptions, and decreased access to education and research facilities (Onyema et al. 2020). The lockdown restrictions associated with Coronavirus increased the challenges of flipped learning implementation particularly in Computer Science instruction. Many aspects of Computer Science instruction are practical-based which means that it requires the use of physical Computer laboratories and practical demonstration of skills. However, the school closure due to COVID-19 have limited access to these facilities which often aid flipping activities. The implementation of Flipped classroom involves the use of both online and physical classroom for physical face to face discussions under the guidance of the teacher, but these have been hampered by COVID-19 lockdown thereby creating a gap in flipping activities. There are also economic issues resulting from COVID-19, which could negatively affect the abilities of educators and students to sustain online aspect of flipped learning activities.

4. COMPUTER SCIENCE INSTRUCTION

Computer Science is an important discipline that drives technological innovations. The application of Computer Science instructions and skills has brought about many breakthroughs in different spheres of life. No wonder, many educational institutions now offer some Computer Science courses such as “CSC 101-Introduction to Computer Science” as a General Study (GST) Course to be taken by all students irrespective of their various fields as part of the required courses in their programme. This is because the possession of computer literacy skills has become very relevant in accessing some employment opportunities in the labour market. Some of the trending topics in Computer Science instruction include: Machine learning, Cyber Security, Big data, Robotics, Augmented/Virtual Reality, Nanotechnology, Software Engineering, Internet of a Thing (IoT), Neuromorphic computing, Brain computing, Bioinformatics, Quantum and Distributed computing, Human Computer Interaction (HCI), Cloud Computing, Artificial Intelligence, Data Science/Analytics, Python programming, Technology law, and Human/Net-Centric Computing. Consequently, considering the importance of Computer Science, there is need for the educators to adopt flexible instructional approach like the flipped learning strategy to enhance productive Computer Science instruction.

5. PROSPECTS OF FLIPPED CLASSROOM IN COMPUTER SCIENCE INSTRUCTION

The quality of teaching technique employed by the teacher basically influence student’s interests and learning outcomes (Onyema & Deborah, 2019). The conventional teaching approach often places the teacher at the center of learning, while the students are rarely involved in the class. Students often act as listeners with little or no opportunity to contribute in the conventional class. However, the evolution of Flipped classroom model presents good alternative by ensuring that students participate more, create and contribute ideas during discussions. Consequently, the potential benefits of flipped classroom in Computer Science instruction can be summarized as follows:

5.1. Active/Problem-based learning: The use of flipped learning can potentially promote active involvement of students in Computer Science instruction. The students play more roles in flipped classroom than they do in the conventional Computer Science classrooms, thereby giving them more sense of belonging and control to think more deeply, and solve problems on their own (Onyema et al., 2019). With flipped learning, students can engage in problem-solving activities and collaborations to increase the quality of their presentations in the class and to proffer solutions to given tasks.

5.2. Demonstration of learners' expertise: Flipped learning offers opportunities for students to develop themselves and also demonstrate their expertise in the classroom, unlike the conventional approach where the teachers seems to be the only masters or dispensers of knowledge. Computer Science students can demonstrate their programming and other creative skills during class discussions and presentations.

5.3. Blended Learning: Flipped learning is synonymous to blended learning because it provides opportunities for teachers and students to teach-learn and interact using both physical classrooms and technological tools and platforms. Students who learn in flipped classroom could easily blend with changing learning environments, and educators can use the flipping to accommodate different kind of learners.

5.4. Personalized Learning: In flipped learning arrangement, learners take ownership and more responsibilities for their own learning. The provision of lesson notes and other supplementary materials such as videos enable students to study and learn on their own. This means that flipped learning can enhance independent or self-directed learning by students. Flipped classroom can potentially enhance the abilities of Computer Science students to take ownerships of their own learning (Onyema *et al.,* 2021).

5.5. Motivation in Learning: The provision of teaching materials ahead of discussion in a flipped classroom could potentially inspire Computer Science students to study the materials with excitement to contribute positively during the class discussions. Students could be motivated to develop more interests in a course through the use of flipped learning strategies, since they have the opportunity to create their own meanings out of the given materials and also present it before the class. Active presentations and discussions in flipped classroom could potentially promote students' attendance in a course or class.

5.6. Ubiquitous Learning: The flexibility in Flipped learning mode supports learning convenience at any time and place. Students can study the provided lesson materials on the go using their mobile devices (Onyema, 2019). They can also source for additional materials relating to the given topics own their own, unlike the traditional approach where the teacher may be in a hurry to complete the topic within the allocated time and space.

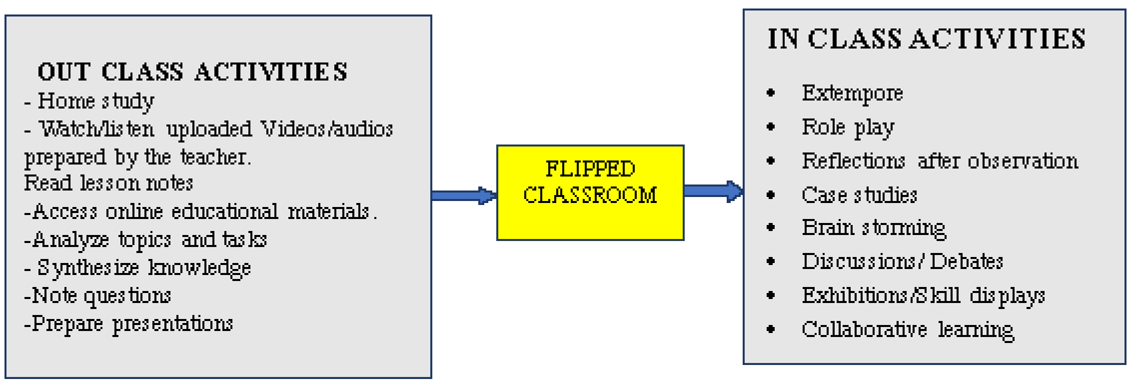
5.7. Technology Application in Computer Science Instruction: The educational sector remains one of the fields with the highest influence of technology (Michael, 2019). In flipped learning approach, Computer Science educators upload lesson materials for students' using various technological tools, platforms and applications. Students can easily access the uploaded materials from any location, and then study them ahead of the face-face interactions in the classroom. The use of flipped learning could go a long way to promote the use of digital tools and other educational technologies in Computer Science Instruction, which would also enhance the digital literacy of both students and teachers.

5.8. Improved Academic Achievement: Studies have shown that the use of flipped classroom strategy is one of the most promising pedagogical model for promoting productivity in education and enhancing students' academic achievements (Onyema et al, 2021; Lesage et al, 2019). This means that if flipped classes are properly implemented, students performance would improve.

6. PROTOTYPE OF FLIPPED CLASSROOM PROCESS IN COMPUTER SCIENCE INSTRUCTION

From figure 2, the teachers (facilitator) formulate topics such as "Python programming". The teacher then represents the various concepts in Python programming using both lesson notes, audio and visual materials. He can record audios or videos on how to develop applications using Python programming language, the various steps that must be taken while developing the application, and the use of Python functions. The teacher must ensure that the prepared notes or supportive materials are concise, simple, but rich to avoid compromise of course content, and to ensure easy comprehension by the students. Thereafter, the teacher sends or uploads the lesson notes and lecture materials to the students through e-mails or other digital learning platforms before the scheduled discussions in the classroom. The materials may be in form of recorded videos, audios or slides, and digital notes presented in Word or PDF format etc. Thereafter, the students would go through the sent materials at home and prepare questions or presentations ahead of the class which would be facilitated by the teacher. The provision of the lecture materials before the class discussions prepares students to participate and contribute actively in Extempore/ debates/ Discussions during the interactive flipped class sessions. Here, students play more roles during the brainstorming sessions while teacher assumes coaching roles.

Figure 2. Prototype of Flipped Classroom process in Computer Science Instruction (Source: Own)



7. CHALLENGES OF FLIPPED LEARNING IMPLEMENTATION IN COMPUTER SCIENCE INSTRUCTION

Computer Science instructors are not immune to the challenges that often accompany the transitioning to new teaching and learning approaches. According to Estes et al. (2014), not all instructors have been predisposed to learner-centered environments, and the thought of moving to a flipped instructional design can be daunting. The implementation of flipped learning strategy in Computer Science may be affected by the followings:

7.1. Lack of flipped classroom experiences: The teacher and students are the major actors in any flipped arrangement. Hence, their experiences on the implementation of the strategy are critical in achieving the set objectives of any flipped learning arrangement. The lack of experience, especially on the part of the teacher may likely affect the level of coordination and facilitation of flipped learning process, and the expected outcomes. A well experienced teacher would ensure robust coaching and facilitation to enhance productive participation of students and achievement of set teaching and learning objectives.

7.2. Resistance: Research show that, the lecture method remains the favourite choice among faculty to deliver instruction in higher education (Dusenbury & Olson, 2019). The introduction of flipped learning strategy may be resisted by teachers due to the fear of loss of control or domination. This is because flipped learning gives greater control to the students, and teachers act more as facilitators of knowledge and not as masters as is the case in conventional classroom.

7.3. Technology issues: The modern implementation of flipped learning requires the use of technological tools, devices and platforms such as e-learning platforms, mobile devices and internet technology. These technologies may not be readily available or evenly distributed considering the problem of digital divide. Also, network issues may hinder the uploading and accessing of lesson notes before classes as supposed.

7.4. Time constraints: Time factor may pose a big challenge to the use of flipped learning strategy. Teachers may be overloaded with courses and other administrative activities which may likely hinder their consistency in providing lesson materials, including recorded videos, audios or notes to students before the class. Also, the time allocated to some courses may not also be enough to accommodate long students' discussions in flipped classrooms particularly in Computer Science instructions.

7.5. Inadequate Infrastructures: These include inadequate; classrooms, laboratories, internet connectivity, electricity and other supportive infrastructures and environment that enhance flipped learning implementation in Computer Science instructions.

7.6. Poor digital literacy: Digital knowledge and skills are very critical to success of today's flipped learning classrooms. Many teachers depend on the use of digital media to make lesson notes available to students before the classes. Therefore, they need to be digitally fit or tech savvy to be able to sustain the flipped classroom method. However, lack of digital skills by both students and teachers could hamper the implementation of Flipped classroom strategy in Computer Science instructions.

8. POSSIBLE SOLUTIONS TO THE CHALLENGES OF FLIPPED LEARNING IMPLEMENTATION IN COMPUTER SCIENCE INSTRUCTION

Based on the challenges outlined above, the following solutions can be adopted to overcome these challenges:

8.1 Training of Teachers and Students: Schools have to organize more capacity building programmes on flipped learning to train teachers and students on modalities to adopt to maximize the potentials of flipping strategy. This would improve experiences of both teachers and students and acceptance of the flipped technique.

8.2 Investment in Technology: The uneven distribution of technology among students and teachers can be tacked through more investment in technology by education authorities and governments. This would reduce the problem of digital divide and increase the availability and accessibility to technological devices and software tools needed to implement flipped class room arrangement.

8.3 Provision of Supportive Infrastructures: The success of flipped learning depend on the availability of key infrastructures such as high speed internet access, laboratories, Learning Management Systems, energy and multimedia facilities etc. Teachers and students would need these infrastructures to be able to upload or download materials prior to classes or discussions.

8.4 Increased Staff Number: The problem of time constrains often brought about by the allocation of many courses to teachers thereby overburdening them and reducing their time and commitment to innovative teaching techniques like the flipped learning. Thus, schools have to engage more staff to ensure that teachers are not overloaded with courses to afford them more time to engage students in the flipping approach.

8.5. Curriculum Review: There is the need for schools to periodically review their curriculum to accommodate emerging realities in education, including the adoption of innovative teaching and learning techniques such as flipped classroom. This would enhance students experience and employability skills.

9. CONCLUSION

The study shows that the use of flipped classroom strategy could potentially enhance students' active participation and learning outcomes in Computer Science instruction, if properly implemented. However, the school closure and other restrictions due to the COVID-19 pandemic lockdown coupled with the problems of poor infrastructures hinder the implementation of flipped classroom in Computer Science pedagogy. Education authorities have to put measures in place to address the problem of infrastructures to enhance smooth flipped learning activities.

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Chapter 13
The Prevalence and Predominance of Artificial Intelligence in YouTube Advertisements in Shaping the Lifestyle of the Budding Generation

Aruna Kasinathan
https://orcid.org/0000-0002-5800-0340
Karunya Institute of Technology and Science, India

Deepa Kasthurirangan
Kumaraguru College of Liberal Arts and Science, India

Sunandha Bhagavathy
Karunya Institute of Technology and Science, India

ABSTRACT

The prevalence of AI in marketing and promotion has taken the role of the personal relations personnel of an ad promotion organization. This chapter attempts to study the cognitive manipulation done by YouTube advertisements with the presence of artificial intelligence. This is where artificial intelligence, which keeps track of the preferences of the user, intervenes, reads the mind of the viewer, and tries to convert the viewer into a potential customer. With the emergence of the pandemic and the enhanced usage of gadgets and the internet, YouTube advertisements are rulers of the minds of the budding generation. This has explained that with the increase in educational qualification, the likelihood to gain information from YouTube advertisements increases. Further, the study reveals that attention towards advertisement and the resulting desire to purchase the product leads to conversion of viewer into consumer. The study has led to the development of a model that highlights the presence of AI in YT ads.

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INTRODUCTION

Globalisation's speed has resulted in rapid economic advances, with significant ramifications for information and technology. People become aware of the range of goods and services accessible in the market in a fraction of a second after receiving information. Marketers in today's world must understand the buying habits of young people when creating commercials in order to get the intended effect. Advertisements are critical in instilling a positive picture of a product in the minds of young consumers. Advertisements must be appealing to consumers and convey useful information, particularly to the younger generation. Advertisements have had the greatest impact on YouTube when compared to print media, radio, and, more recently, television. Advertisements do not have a direct impact on the purchasing decisions of young customers, but they do serve to raise awareness. Some elements, such as culture, family, and brand image, have a major impact on consumer buying behaviour. Advertisers expend a significant amount of money in order to affect the thoughts of young consumers when they advertise their goods.

This blog series on YouTube advertising is meant to provide an introduction to the technical side of YouTube advertising, highlight best practises, and provide marketers with all the tools they need to launch and run a YouTube advertising campaign.

The study was carried out with the following goals in mind:

- Observing YouTube commercials to determine the demographic profile of the upcoming generation.
- To investigate the time spent by the budding generation on the internet during the pandemic period and their attraction towards YouTube pop-up ads
- To assess the role of artificial intelligence in YouTube advertisements, attracting the younger generation.

BACKGROUND

Advertisement Formats for YouTube

Marketers can utilise numerous ad formats created for YouTube depending on their advertising goals. These are the ad formats that are available.:

1. In-stream advertisements that can be skipped
2. In-stream advertisements that can't be skipped
3. Advertisements on bumpers
4. Ads for video discovery
5. Advertisements in the masthead
6. Display advertising that are responsive

YOUTUBE WORKING

Although there are many distinct types of YouTube commercials, they can be divided into two groups: skippable advertisements and non-skippable advertisements.

Adverts that cannot be skipped: These are 15-20 second advertisements that play before the videos. This type of YouTube ad is more effective for engagement because it cannot be avoided, but it is disliked by the viewers because it appears forced. These advertisements are sold at a cost per thousand impressions (CPM) to advertisers. Although bumper advertisements are essentially non-skippable, they are just six seconds long. These advertisements are sold at a cost per thousand impressions (CPM) to advertisers. These ads can be used on their own or in combination with larger non-skippable adverts.

Advertisement that you can skip: True View commercials are sometimes known as skippable ads. These are normally skippable after 5 seconds. In-stream or through Discovery Ads, this form of YouTube advertisement can be seen in one of two ways. Advertisers must only pay for commercials that have been watched for 30 seconds or longer (for videos lesser than 30 sec).

On YouTube, users can find discovery advertisements in the search results, on the homepage, in related videos, and as video overlays. These films can be as long as you want them to be.

Aside from the types of YouTube Ads described above, there are a few other ways to advertise on YouTube:

Advertisements that appear above the suggested YouTube videos on the YouTube page are known as display advertisements. A text or banner display ad that plays at the bottom of the video being played is the most popular type of YouTube overlay advertisement.

ARTIFICIAL INTELLIGENCE, ITS FORMS AND APPLICATIONS

In 1956, during The Dartmouth Conference, an American computer scientist named John McCarthy coined the phrase “artificial intelligence.” It has become a catch-all term for everything from robotic process automation to robots themselves. AI can outperform humans in tasks like detecting patterns in data, helping businesses to acquire a better understanding of their data. AI can be used to map poverty and climate change, automate agricultural processes and irrigation, personalise healthcare and education, forecast consumption patterns, and streamline energy use and waste management by examining massive amounts of data.

Artificial intelligence can be classified in a number of ways. The first distinguishes between two types of AI: weak AI and strong AI. Weak AI, also known as narrow AI, is a type of artificial intelligence that is designed and taught to do a certain purpose. When faced with a novel task, strong AI, also known as artificial general intelligence, is an AI system with generalised human cognitive abilities that can complete it successfully. The Turing Test was devised by mathematician Alan Turing in 1950 to determine whether a machine can think like a human Arend Hintze, an assistant professor of integrative biology and computer science and engineering at Michigan State University, provides the second example. Artificial intelligence is split into four categories, according to him:

Type 1: The first type is Reactive Machines. Deep Blue, an IBM chess programme, is an example of a programme that can recognise and anticipate pieces on the chess board. The most serious issue is that it lacks memory and is unable to learn from past occurrences in order to make better judgments in the future. It also examines the potential moves of both its own and its opponents. Deep Blue and AlphaGO were designed with certain objectives in mind.

Type2: Memory is a finite resource. These AI systems can use their previous experiences to aid in future decision-making. This is how the majority of autonomous automobiles' decision-making functions were developed.

Type 3: A person's understanding of their own ideas and intentions, which determines their decisions, is referred to as their theory of mind. At the moment, this form of artificial intelligence does not exist.

Type4: Self-awareness. This category includes AI systems that have a feeling of self and consciousness. Machines that are self-conscious are aware of their current state and can utilise this information to infer how others are feeling. Artificial intelligence in this form does not yet exist.

Artificial intelligence (AI) is a rapidly growing market. Artificial intelligence refers to a variety of technologies and tools, including the following:

Natural Language Generation (NLG) is a computer programme that creates text from data. Current applications include customer service, report generating, and summarising business intelligence findings.

Speech Recognition: This technology transcribes and translates human speech into a computer-readable format. It's currently used in interactive voice response systems and mobile applications.

A virtual agent is a computer-generated, animated, artificial intelligence virtual character that operates as an online customer service representative (sometimes with an anthropomorphic appearance). It converses with users intelligently, responds to their questions, and displays acceptable nonverbal behaviour. An example of a standard Virtual Agent is Louise.

Machine Learning: Provides methodologies, APIs (Application Program Interfaces), data, and computational capability for developing, training, and deploying models in applications, processes, and other machines. Currently used in a wide range of business applications, the majority of which involve categorization or prediction.

Deep Learning Platforms are a sort of machine learning that uses artificial neural networks with multiple abstraction levels. Applications that use very large data sets for pattern recognition and classification are now being used.

Biometrics are methods for recognising people based on one or more basic physical or behavioural features. In specifically, biometrics is used in computer science as a kind of identity access management and access control. It's also used to track down people who are being watched in groups. This word is being used in market research right now.

Robotic Process Automation (RPA) is the use of scripts and other methods to help companies run more efficiently by automating human actions. When human execution of a task is inefficient, this method is currently used.

Natural language processing (NLP) uses statistical and machine learning methodologies to aid in the understanding of phrase structure and meaning, sentiment, and purpose, and so leverages and supports text analytics. Currently working in the fields of fraud detection and security, as well as a variety of automated assistants and data mining applications.

ARTIFICIAL INTELLIGENCE AND ADVERTISING

The capability to produce data regarding an ad's viability and acceptance is nearly limitless with digital advertising across search, content, and social media platforms. Humans have a limited ability to predict and foresee outcomes. Artificial Intelligence (AI) dominates this field, making it a logical fit for advertising. AI-powered ad systems can recognise trends in advertising data at scale and anticipate what adjustments to campaigns will increase performance against a certain KPI with the correct data. All of this can be done in seconds, as opposed to the hours, days, or weeks it would take a human to review, test, and iterate across multiple campaigns. Large advertising expenditures are incurred by businesses, particularly when offering a product or service that does not yield immediate cash. Advertising AI has the potential to increase revenue while reducing staffing, time, and unproductive marketing costs.

An anecdote from the life of an entrepreneur, Naomi Simson, owner of an online company, Red Balloon, Australia gives a clear idea as to the application of AI in promotion of her products. Before she found the AI, she spent around $45,000 per month to an ad agency for promotion of her products. Later in 2018, she discovered an Artificial Intelligence tool, Albert, which used sophisticated tools to analyse ad campaigns, targeting of the market, testing the product and estimating budgets. The technology was able to create 6,500 different variations of a Google text ad in a single day and learned from the experience. This made Naomi Simson expand her market to the US and UK. She could reap 1,100% of profits, unrealised earlier.

For huge retailers, artificial intelligence in YouTube advertising has become a popular medium. This is because cell phones are the best friends of the upcoming generation, of its great potential as an audio-visual communicator, Artificial Intelligence has a strong presence on YouTube. In YouTube commercials, artificial intelligence plays a crucial role in introducing a product, establishing familiarity with the product, and persuading people to buy it.

There has been a paradigm shift from viewership of TV to viewership of YouTube programmes. Studies have revealed that, in the United States YouTube has more adult followers when compared to television (Tankovska, 2021). People of the age group between 18- and 49-years access mobile phones more, consequently watching YouTube. A report (Statista, 2021) states that 77% of the internet users of the U.S. ranging in the age group of 15 and 25 years are YouTube viewers

SCOPE OF THE STUDY

The research was carried out in TamilNadu among young people aged 18 to 27.The age group is more vulnerable to social media, thus coming across YouTube advertisements almost every day. This age group has been taken as this group of people are tech savvy, they don't wish to watch programmes on the television and are either occupied with i-phones or androids for purposes like watching academic or entertainment videos, downloading contents for their assignments or projects. This age group also focuses on the freshers, who have joined jobs and are working via various meeting platforms. This study is appropriate in this pandemic period, since the majority of official and educational transactions are happening using gadgets. The prevalence of Artificial Intelligence in the advertisements is also attempted to be explored.

RESEARCH METHODOLOGY

The study is exploratory in nature, conducted among 127 respondents of Tamilnadu. A structured questionnaire in Google forms had been circulated among the young consumers of the age group of 18 to 27 years. Convenient sampling technique has been used in the study to exact the data since all the respondents are users of electronic communication gadgets like android phones, i-phones or laptops. Simple Percentage Analysis has been used to analyse the data and arrive at the relevant results pertaining to the objectives.

REVIEW OF LITERATURE

Negricea et al., (2020) investigated the effect of intention-to-purchase on purchase among South African and Romanian generation y respondents as a result of YouTube advertising, in order to determine whether usage and demographic variables have an impact on this behavioural relationship in a country. The hypothesised link was tested using structural equation modelling (SEM) and multi-group SEM.

Apritika Dermawan et al. (2020) studied social media web-based technology elements that influenced the growth and evolution of website-based communities. Furthermore, relevant web-based apps have become the major channel for value generation and information transmission. Because of its extensive availability, accessibility, and immediacy, many firms have utilised social media as a marketing technique.

Elmira Diafarova et al.., (2020) identified that the tourism industry with the highest expenditures on online advertisements, has experienced major changes throughout the increasing promotions in social media. The study evaluated the effectiveness in YouTube advertising in the context of tourism. To create brand awareness or remind customers of the products. The you tube advertising is less suitable for advertising focusing on persuading tourism customers to purchase.

Paul Covington, Jay Adams, Emre Sargin (2016) also provided an elaborate insight of seep networks of YouTube Recommendations which the paper is split according to the classic two-stage information retrieval dichotomy: ðrst, we detail a deep candidate generation model and then describe a separate deep ranking mode

Hairong Li (2019) stated in his article about the discussions in a conference held at Shanghai in the year 2018. Discussions regarding application of Artificial Intelligence in the field of fast-growing digital advertising. AI can be used to register audience response, create programmed advertisements, provide creative thinking and generate intelligent advertisements after adequate pre-testing of the premises.

Xuebing Qin and Zhibin Jiang (2019) has made a study on the application and effect of Artificial Intelligence in advertising in China. Consumer insight research, ad development, media planning and procurement, and ad impact evaluation are the four processes highlighted in the AI ad process. Traditional advertising methods have been updated by the new venture, albeit many regions still need to be reengineered.

Duygu Firat et al. (2019) investigated the factors that influence the value of YouTube advertising and the impact it has on purchase intent. Basic regression analysis was done to estimate the effect of the factors on YouTube advertising value, and an ANOVA test was utilised to determine the difference between demographic groups using YouTube advertisement value.

MAIN FOCUS OF THE CHAPTER

A study on the impact of YouTube adverts on young customers was attempted by the researcher. This is particularly relevant at this time because young children rely on mobile phones and other electronic devices such as tablets, laptops, Android, and other similar devices for their education and entertainment. While they use this gadget, youTube advertisements popup and tempt them to watch. The presence and predominant features of Artificial Intelligence in the advertisements attract the viewers. Advertisements are constantly played in between videos. Though there is a regular feature to 'skip ads', sometimes young people tend to watch the ads. Moreover, there is a considerable reduction in TV viewership of the budding generation in recent days. The study is an attempt to identify the role played by the features of Artificial Intelligence in YouTube advertisements. These influence the purchase pattern of the present generation youth depending on their lifestyle.

HYPOTHESIS

H0: There is no link between educational attainment and the informational value of YouTube commercials.
H1: There is a link between educational qualifications and the information element of YouTube ads.

Figure 1.

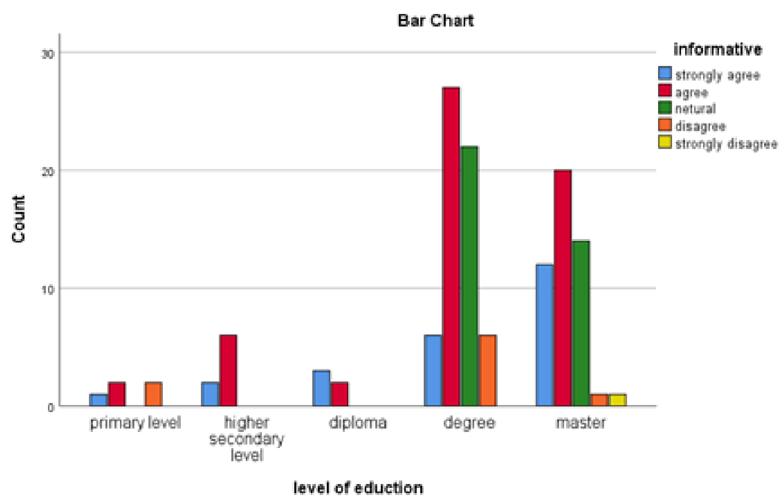

Table 1. Chi-Square Tests

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	28.965[a]	16	.024
Likelihood Ratio	30.311	16	.016
Linear-by-Linear Association	.036	1	.850
N of Valid Cases	127		
a. 19 cells (76.0%) have expected count less than 5. The minimum expected count is .04.			

At a 5% threshold of significance, the value of P is less than 0.05. As a result, there is a link between educational attainment and the information provided by YouTube commercials. As a result, it may be concluded that as one's degree of education rises, so does the likelihood of obtaining information from commercials.

H_o: There is no correlation between educational attainment and the desire to purchase a product after seeing YouTube advertising.

H_1: There is a significant disparity between educational qualifications and the desire to purchase a product after viewing advertising on YouTube.

Figure 2.

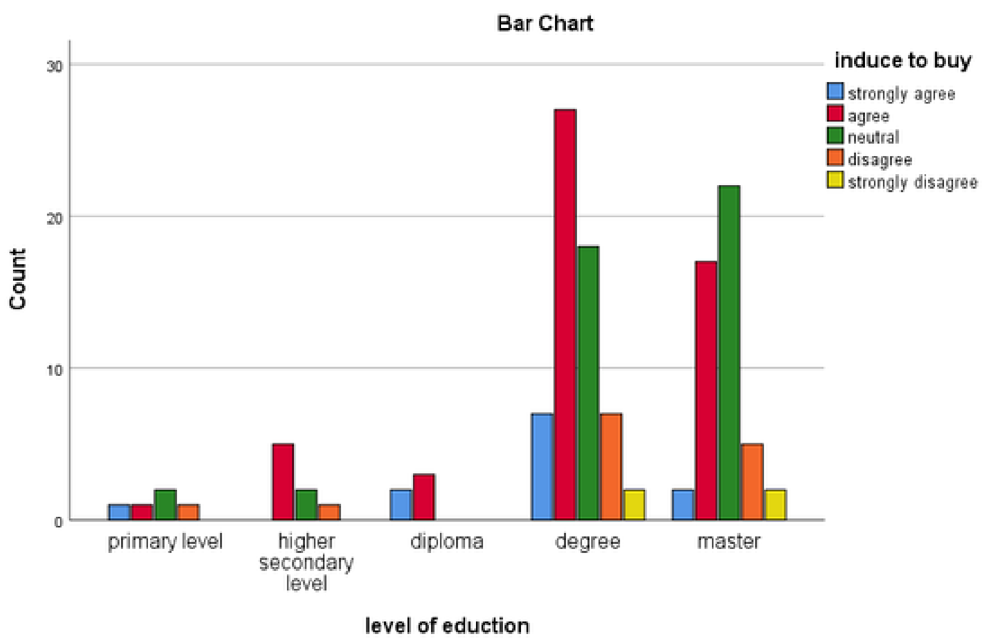

Table 2. Chi-Square Tests

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.186[a]	16	.440
Likelihood Ratio	17.586	16	.349
Linear-by-Linear Association	1.839	1	.175
N of Valid Cases	127		
a. 18 cells (72.0%) have expected count less than 5. The minimum expected count is .16.			

At a 5% threshold of significance, the value of P is bigger than 0.05. As a result, there is no link between educational attainment and the desire to purchase a product after viewing YouTube advertising. As a result, it can be deduced that attention to the advertisement and the product only leads to a desire to purchase the product.

SOLUTIONS AND RECOMMENDATIONS

Demographic Profile of the Respondents

Table 3. Demographic Profile of the respondents

		Frequency	Percent	Valid Percent
Gender	Male	73	27.6%	27.6
	Female	92	72.4%	72.4
Total		127	100.0%	100.0
Age	18 to 12	7	5.5%	5.5
	13 to 15	4	3.1%	3.1
	16 to 19	11	8.7%	8.7
	20 to 27	105	82.7%	82.7
Total		127	100.0%	100.0
Level of education	Primary level	5	3.9%	3.9
	Higher secondary level	8	6.3%	6.3
	Diploma	5	3.9%	3.9
	UG	61	48.0%	48.0
	PG	48	37.8%	37.8
Total		127	100.0%	100.0

(Source: Primary data)

According to the preceding table, male respondents make up 27.6% of the total, while female respondents make up 72.4 percent. As a result, the majority of respondents are female when it comes to viewing YouTube commercials, whilst male respondents are active on Facebook, Instagram, and other online games. Almost 82.7 percent of the respondents are between the ages of 20 and 27, according to the data. The majority of respondents in the age group of 20-27 years favour YouTube advertising, according to a study conducted in Tamil Nadu, India. Furthermore, the preceding table shows that 48 percent of the sample has a UG degree and 37.8% has a PG degree. As a consequence, it was discovered that the majority of respondents between the ages of 18 and 27 are exposed to YouTube commercials.

TIME SPENT BY THE BUDDING GENERATION ON THE INTERNET AND ATTRACTION TOWARDS YOUTUBE POPUPS:

Table 4. Time spent on the internet and attraction towards Youtube popups

Time spent on the Internet per day			
Time spent (Hours)	**Frequency**	**Percent**	**Valid Percent**
Upto 2 hours	17	13.4%	13.4
2 to 4 hours.	29	22.8%	22.8
4 to 6 hours	36	28.3%	28.3
Above 6 hours	45	35.4%	35.4
Total	127	100.0%	100.0
Access to Social Networks			
Social networks	**Frequency**	**Percent**	**Valid Percent**
You tube	68	53.5%	53.5
Instagram	44	34.6%	34.6
Face book	9	7.1%	7.1
Other media	6	4.7%	4.7
Total	127	100.0%	100.0
Attraction towardsYoutube advertising pop ups			
Attraction	**Frequency**	**Percent**	**Valid Percent**
Yes	93	73.2%	73.2
No	34	26.8%	26.8
Total	127	100.0%	100.0

(Source: Primary data)

From the given data, it can be determined that 28.3% of respondents spend 4 to 6 hours on the internet. 35.4 percent of those asked say they spend more than 6 hours per day on the internet. It is expected that the respondents, who are young and growing up, spend more than six hours every day on the internet. 53.5 percent of respondents use YouTube, 34.6 percent use Instagram, 7.1 percent use Facebook, and 4.7 percent use other media, according to the data. As a result, it's no surprise that the vast majority of respondents are YouTube users. The study also shows that 73.2 percent of respondents pay attention to YouTube pop-ups, whereas 26.8% do not pay attention to internet advertising. Pop-up advertisements on YouTube are said to appeal to the younger generation.

ROLE OF ARTIFICIAL INTELLIGENCE IN YOUTUBE ADVERTISEMENTS, WHICH ATTRACT THE YOUNG CONSUMERS

The role of Artificial Intelligence in youtube advertisements has been examined in two stages - first, by analysing some attitudinal factors present in advertisements and second by assessing and understanding the outcome of the factors. The outcome of attitude is behaviour (Frenk van Harreveld, et. al, 2015). The prevalence and predominance of Artificial Intelligence, in combination with the attitudinal factors, transforms the viewer into a customer.

Table 5. Attitudinal factors in advertisements

S. no	Details	SA	A	N	D	SD	Total
1	**Information**	28.6%	14.5%	3.7%`	23.1%	30.1%	100
2	**Creating awareness**	15.6%	27.3%	11.9%	25.2%	20.0%	100
3	**Create interest on the product**	16.7%	28.5%	12.6%	22.7%	19.5%	100
4	**Attraction**	26.7%	32.4%	13.6%	17.2%	10.2%	100
5	**Inducement to buy Product**	31.5%	13.3%	16.5%	27.3%	11.4%	100

(SA- strongly agree A- agree N- neutral D-disagree SD- strongly disagree)
(Source: Primary data)

The above table is about the attitudinal factors present in YouTube advertisements. The advertisements are played in between the videos and induce the viewers to watch them repeatedly and ultimately buy the products. From the table, it may be inferred that 2.86% of the youth strongly agree that YouTube advertisements provide information on the new arrival of products, 27.3% of the young people agree that the advertisements create awareness about certain schemes introduced by the government, for example, a mobile hospital van for all villages. The importance of using a mask, sanitising oneself and social distancing is also awareness created by YT adverts. It is stated that 28.5% of the respondents agree that the advertisements create interest in the minds of young viewers. The fact that the advertisements shown repeatedly create an urge to purchase the product is strongly agreed by 31.5% of the youth.

The above table gives an idea about the items preferred to be purchased by the budding generation after watching YouTube advertisements. The highest purchased product is clothes, agreed by 43.3% of the respondents. This is followed by purchase of cosmetics agreed by 35.4% of the young consumers, shoes and sandals are purchased by 32.3% of the respondents and home appliance purchase is agreed by 31.5% of budding generation consumers. The table also states that gold and jewellery are purchased by 27.6% of the respondents, followed by the purchase of electronic accessories agreed to be purchased by 26.8% of the sample, 26% of the young customers buy eatables and 25.2% of the respondents buy vehicles after watching YouTube advertisements.

Thus, it can be understood that the majority of the respondents purchase clothes and the least preferred article is vehicles. The budding generation customers determine their preferences after watching YouTube advertisements.

Table 6. Products purchased by the young consumers after watching Youtube Advertisements

S.no	Products	SA	A	N	D	SD	Total
1	Eatables	26.0%	18.8%	20.5%	19.7%	15.0%	100
2	Clothes	13.4%	43.3%	23.6%	12.6%	7.1%	100
3	Cosmetics	35.4%	26.0%	15.0%	15.0%	8.6%	100
4	Gold and jewelry	8.7%	27.6%	16.5%	29.1%	18.1%	100
5	Stationery items	7.1%	22.8%	34.6%	22.0%	13.5%	100
6	Toy and games	12.6%	23.6%	29.9%	16.5%	17.4%	100
7	Shoes and sandals	14.2%	32.3%	23.6%	16.5%	13.4%	100
8	Home appliances	11.8%	31.5%	26.8%	17.3%	12.6%	100
9	Groceries	15.3%	23.6%	23.3%	19.7%	18.1%	100
10	Electronic accessories	11.8%	26.8%	25.2%	19.7%	16.5%	100
11	Vehicle	8.7%	25.2%	24.3%	20.5%	21.3%	100

(SA- strongly agree A- agree N- neutral D-disagree SD- strongly disagree)
(Source: Primary data)

FUTURE RESEARCH DIRECTIONS

Model Showing the Role of Artificial Intelligence in YouTube Advertising and Determining the Buying Behaviour of the Budding Generation

An attempt has been made to bring out a model to explain the prevalence of Artificial Intelligence tools in youtube commercials, the predominant features of AI that collate with the attitudinal factors of advertisements and the outcome of the blend. The following diagram explains the relationship between the variables.

The study has identified certain features in AI tools. These are viewership analysis tests, repetition of ad campaigns, managing targets and estimating budgets. AI tests the mind of the viewers. There may be viewers who do not show interest in ads. So they may skip the ads. Now the feature of AI tools, namely repetition of the ad campaign arises. Sometimes, a caption saying" Video will be played after this ad" is also tagged to the ad. In this case, the viewers cannot escape from the advertisement.

Advertisements for products like 'Horlicks lite', 'Junior Horlicks', 'Dairy Milk', 'Byjus', 'Vedantu', 'Zomato', 'Hyundai', to name a few are repeatedly shown. This repetition instigates the viewer to stay up and watch the ad. So, the target customer is found now. The next step is preparing budgets based on the interest shown by the viewers. This is the prime role played by Artificial Intelligence in reaching and occupying the minds of the potential customers.

There are some attitudinal factors present in advertisement. Whatever be the mode of advertisement, the main aim is to attract the onlookers and finally end up with purchase of the advertised product. The study has taken five attitudinal factors such as information, attraction, creating awareness, creation of interest in the product and inducement to buy. The advertisement gives information of the arrival of a new product in the market. Attractive advertisement design becomes a feat to the eyes of the viewers, taking them to the next step to know more about the product. Having received off handed information about the product, the viewer may express his interest in the product to gather further knowledge of the item. After the attraction and analysis part is done with, the ultimate step, that is buying the product, is done by the viewer.

Thus, the study tries to emphasise that the features of AI along with the factors of attitude influence the buying behaviour of the young generation, shaping their minds and upgrading their lifestyles to products introduced in the market.

The above diagram can be held as a base and further research may be conducted in this area. The other areas of research relating to the topic can be –

- A study on assistance of Artificial Intelligence in other social media applications and networks.
- Research can also be done to identify the revenue generated through social media advertising with and without the help of Artificial Intelligence.
- A study can be done on various marketing strategies adopted in the digital mode of marketing

Figure 3.

CONCLUSION

The present era is in the hands of technology and electronic gadgets. The rise of the pandemic has put everyone indoors, changing lifestyle, education methods and corporate working styles. The usage of gadgets for studies, office work and entertainment has become inevitable in the present situation. The concept of 'Lockdown', 'Work from home' 'Study from home', etc. has increased YouTube viewership from 0.8 billion as of 2008 to 2.3 billion in 2020. The creation and posting of YouTube videos, online course method of learning, entertainment, promotion of products manufactured by individuals has increased activity in YouTube in the current scenario. It may be noted that the revenue of YouTube has increased remarkably from $0.8 billion in 2010 to $19.7 billion in 2020. YouTube has been a platform of promotion, not only for corporations, but also for individuals. 'Meesho' is a glaring example, wherein individuals can advertise and sell their own products. The Artificial Intelligence component prevalent in advertisements, pops up the ads in between videos. Feedback about the advertisement content, product features, etc. can be obtained immediately in the comment box. The traditional rudimental methods of getting feedback are now ruled away. With technology gripping the world, Artificial Intelligence is a great support to ad agencies and marketers. The AI tool reads the mind of the viewers, encapsulates their minds, and persuades them to buy the advertised products by repeating the ads. TV viewing and advertisements are slowly losing the charm. Undeniably, the lifestyle and mentality of the budding generation will be shaped by Artificial Intelligence,

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KEY TERMS AND DEFINITIONS

Budding Generation: The word for the young generation of adults, which includes students pursuing higher education and recently hired graduates.

Cognition: The sum of the states and processes involved in knowing, which include perception and judgement. Cognition encompasses both conscious and unconscious processes that lead to knowledge acquisition, such as perceiving, recognising, conceiving, and reasoning.

Lifestyle Changes: These are adjustments in behaviour that promote beneficial life changes. Consider how people's lifestyles have changed as a result of the current pandemic.

Pandemic Situation: It's a word coined by the World Health Organization to describe a situation in which a new illness has spread globally.

Persuasion: It is an attempt to sway a person's thoughts, feelings, intentions, motivations, and actions.

Viewership: Viewers of a television programme or a motion film.

YouTube Advertisements: Digital advertising appear on YouTube before or during the playback of a video.

YouTube Popups: Pop-up ads, or pop-ups, are a sort of online advertising that appears when you visit a website. A pop-up is a visual user interface (GUI) display area, generally a small window, that emerges suddenly in the foreground of the visual interface ("pops up").

Chapter 14
Peculiarities of Mutual Influence of the Components of the Fiscal Space of Ukraine

Halyna Vasylevska
West Ukrainian National University, Ukraine

ABSTRACT

The chapter deals with the formation and functioning of the fiscal space of the state and peculiarities of the mutual influence of its main components—political, economic, social, and financial ones—in order to ensure their effective interaction in the projected development of the state. The author's interpretation of the definitions of "the fiscal space" and "the fiscal environment" has been presented, which made it possible to clarify their theoretical basis and outline prospects for practical research. The key factors of influence upon the formation and functioning of the fiscal environment as a basic element of building the eponymous state space within the legal field have been established. There have been reasoned the mechanisms of mutual influence of complementary components of the fiscal space on the basis of dynamics of investigated statistical indicators of revenues and expenditures of the State Budget of Ukraine and with the help of correlation coefficient which made it possible to draw certain conclusions about the efficiency of taxpayer fund use in Ukraine.

INTRODUCTION

Modern transformations of economic processes occurring on the basis of intensive globalization and the need for stable development of socially oriented market economy, and therefore, ensuring economic growth in Ukraine, require a comprehensive study of the fiscal space functioning in order to ensure its effective evolution. By forming a proper resource base subject to its rational use and civilized legal relations the government of the country can create and implement effective tools of state regulations as well as influence the relevant processes within the society and provide optimal conditions for its development and self-improvement.

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The purpose of the article is a comprehensive study and substantiation of the mutual influence of the components of the fiscal space of the state in order to ensure the effectiveness of their interaction in the future.

The issues of searching for the new structural opportunities for the development of the effective fiscal space have been investigated by many foreign and Ukrainian scientists such as: S. Blackburn, J-F. Brun, G. Chambas, J-L. Combes, P. Dulbecco, A. Gastambide, A. Ghosh, G. Grazios, Grądalski F. S. Guérineau, S. Guillaumont, P. Heller, V. Heyets, T. Iefymenko, J. Kim, A. Krysovatyy, P. Kulawczuk, G. Mendoza, I. Ostry, S. Owsiak, M. Qureshi, Samuelson P., Stiglitz J. etc. The works of these researchers have covered various concepts of structural transformations, evaluated the effectiveness of the mechanisms for regulating structural shifts within the context of ensuring balanced development of the fiscal space of the state, and substantiated the ways to implement state policy for its improvement and optimal use. In spite of the considerable experience in the field of studying the issue raised by us, the issues related to the study of the components of the fiscal space from the point of view of their functioning and mutual influence remain unaddressed.

The methodology and logics of the cognitive process is based on the multicomponent principle of the analysis of the fiscal space structure, as well as the principles of the study of its components interaction and identification of the key features of its functioning and development. Methods of monitoring empirical data, statistical and correlation analysis have been used to provide an objective evaluation of the correlations among the components of the fiscal space of Ukraine, to establish their mutual influence and to specify qualitative changes and effective transformations of the spatial structure of the national economy.

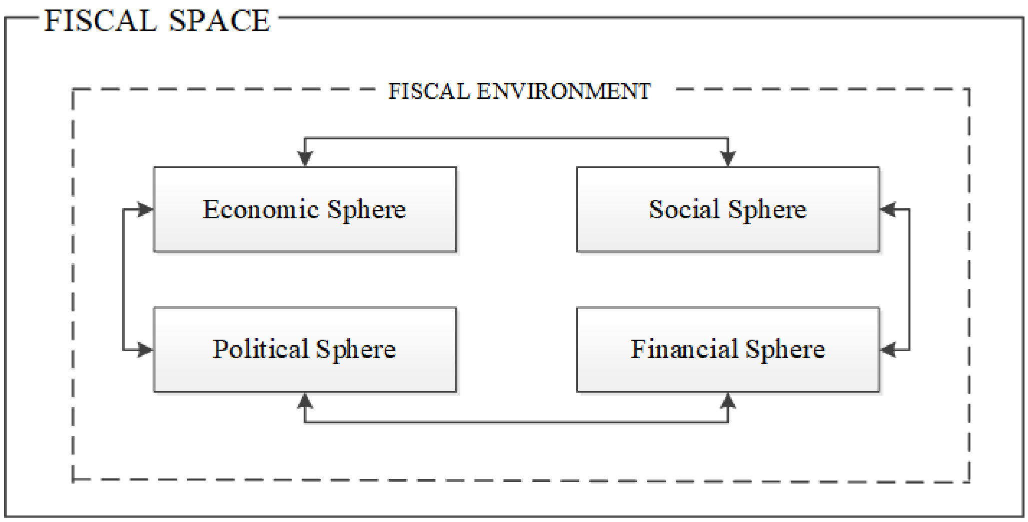
OUTLINING THE ESSENCE OF FISCAL SPACE AND ITS COMPONENTS

In general terms, the fiscal space structure is a set of relations which reflect the interconnections and interdependencies among its individual elements in the process of their development. Accordingly, in the context of our study, it is appropriate to consider the components of the fiscal space of the state and to study their mutual influence both in statics and dynamics in terms of its formation and evolution which will characterize the structural development of the national economy, contribute to positive transformations, which is extremely important for the economic growth opportunities, economic system adaptability to changes in the world economic order, national security, improvement of public welfare, etc.

First of all, it should be noted that the fiscal space is a stable concept, its formation, presence and development does not depend on the qualitative features of the complementary elements. The multifaceted scientific opinions and views of experts allowed to critically analyze the basic designations of the definition under study and to outline the fiscal space as the set of economic, political, financial and social relationships that arise between the state and society concerning ensuring the protection of their interests in the process of fiscal policy implementation in order to distribute and redistribute gross domestic product, balance budgetary resources, as well as form stable sources of financing the main areas of state activities predetermined by the respective goals and objectives.

Thus, the effective formation of the fiscal space of the state and its prospects in the context of optimal use require a detailed study and analysis of the mutual influence of its components: political, economic, social and financial spheres (Fig. 1)

Figure 1. Components of the fiscal space of the state and their relationship
Note: *compiled by the author.*

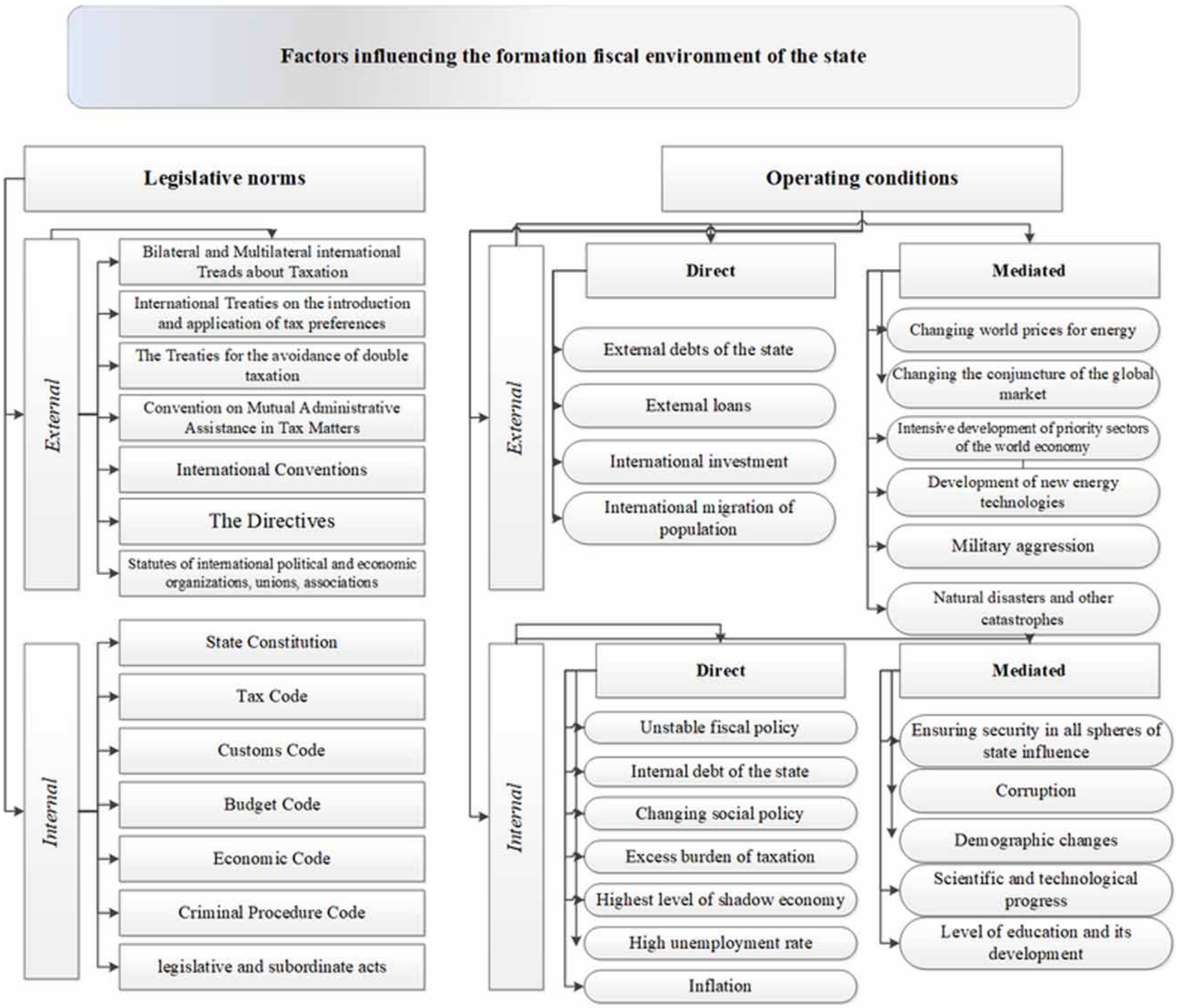


Therefore, to ensure the establishment and development of the fiscal space, the important aspect is the study of interdependent spheres that determine the appropriate conditions and trends for its formation. All of them are equally dependent on each other, cannot function autonomously and outside the fiscal space of the state.

The basic element in this process, though not identical to the space, is the fiscal environment, which can be considered as the set of conditions caused by the regulatory measures of the state in the process of fiscal policy implementation contributing to the establishment and functioning of the fiscal space. At the same time, defining the fiscal environment solely from the perspective of a set of certain conditions is incomplete, because we lose the key aspects of fiscal relationships formation that should be determined by the core plane of the eponymous space. Thus, for a more meaningful definition of the fiscal environment, we consider it appropriate to define it as a supporting element for the construction of the space which depends on the functioning conditions of legal, political, economic and social nature established by the state, as well as the state rules of revenues and expenses formation. Therefore, in our opinion, the fiscal environment is a system of interconnections and circumstances which occur within the framework of organizational and legal relations of taxpayers aimed at the formation and development of the fiscal space of the state.

In fact, the fiscal environment is an integral component in the system of effective interaction and development of both financial and tax environment, as well as the institutional environment which contains the total of the above (tax, financial, and fiscal ones). At the same time, all of them are formed by the corresponding state regulation tools and certain factors of the global world: legislative norms and appropriate functioning conditions (Fig. 2).

Figure 2. Factors influencing the formation and functioning of the fiscal environment
Note: *compiled by the author.*



Thus, the legal norms should include the entire legal framework that either directly or indirectly affects the socio-economic development of the state and the interaction of all subjects of social relations, as well as external and internal circumstances which usually outline the corresponding macroeconomic indicators. At the same time, the fiscal environment is a formally outlined foundation of the fiscal space construction established by the state in the form of respective rules and regulations, as well as by certain conditions for its formation and development. Through current legislation the political component influences the processes of functioning and transformation of the national economic system which, in its turn, affects the social level of the society development and, eventually, all of the above is directly related to the structural delineation of fiscal tools the basis of which is the financial capacity of the state to perform its direct functions. At the same time, the cyclical nature of the economic development that occurs due to interrelated processes causes some fluctuations in the world economy and enhances the formation of corresponding trends. Thus, deformations of the fiscal space occur caused by the activities of any external and internal factors of influence, in particular:

- change of the political mood of the society;
- the impact of global and local economic crises;
- various manifestations of terrorism threats;
- exacerbation of military aggression and confrontation;
- formation of undiscovered forms and types of diseases;
- occurrence of natural disasters and various force majeure incidents;
- change in population numbers due to all possible circumstances (birthrate, mortality rate, migration, emigration, etc.).

All of them may create corresponding distortions of development of the fiscal space of the state and cause destructive changes in its functioning. As a result, the fiscal space may change its configuration not to the benefit of either the state or society which is characterized by the expansion (narrowing) of the space, its overranging the previous optimal functioning limits, although it aims at overcoming the cyclicality of the economy and usually causes negative effects in the form of fiscalism maximization, uneven tax pressure, the spread of the shadow economy, corruption, the emergence of the tax devastation case (Owsiak, 2017, pp. 259 – 260), social tensions intensification and, as a result, the decline of the national economy and the overall welfare of the citizens.

MONITORING MUTUAL INFLUENCE OF THE COMPONENTS OF THE FISCAL SPACE OF UKRAINE

Nowadays, Ukrainian society is at the Point of changing cultural, political, social and economic values. On the one hand, Russian military aggression, annexation of the Crimea, and the invasion of a part of the eastern regions of Ukraine prompted citizens to restore patriotic consciousness, strengthen national identity, and enhance civic engagement in advocating their own interests. However, on the other hand, destruction as a result of permanent crisis phenomena, frequent change of political elites and lack of effective reforms which did not respond to the public demand at all exacerbated the negative impact of unresolved economic problems and social discontent increase. According to the experts' evaluation, at the end of 2017 the social tension level indicator was 6.79 points on the ten-point scale (Sotsialna napruga, Instytut sotsiologii, 2019), whereas in 2018 and 2019 this indicator only increased within 7-8.12% range (Balakirieva and Dmytruk, 2018, p.105 - 124). 68% of the population are convinced that the reasons for this state of affairs are, first of all, the continuation of hostilities in eastern Ukraine, 48% of respondents attribute the maximization of tension to the effect of economic factors – rising unemployment, rising costs of goods and services, as well as increasing utility fees, while the quality of service industry products is deteriorating in spite of the permanent increase in their value. Significant tension is caused by processes related to negative assessments of the authorities (44%) and distrust of citizens towards authorities (34%), corruption, impunity and arbitrariness of officials and judges (over 41%) etc. (Balakirieva and Dmytruk, 2018, p.105 - 124). All of the factors mentioned above, among other things, are inevitable consequences of the mutual influence of business and politics, and vice versa, determine the corresponding risks for both society and the state as a whole. This assumption is confirmed by the statistical data (Table 1).

Table 1. The dynamics of revenues and expenses indicators of the State Budget of Ukraine during the years when the election campaigns of various types were held from 2007 to 2020

Indicators		2007	2010	2012	2014	2019	2020
1	Revenues of the budget of Ukraine (SBU[1]), million UAH	165939.19	240615.24	225273.45		998344,87	842437,8
2	Share of TR in revenues of the SBU	70.31	69.35	38.11	78,46	80,11	76.52
3	Share of expenses of the SBU on PEC[2] in TR[3], %	0.16	1.00	1.14	0,27	0,12	0,08
4	Share of expenses of the SBU on PEC in general expenses of the SBU, %	0.08	0.55	357084,24	0,17	0,05	0,11
5	Share of expenses of the SBU on PEC in state defense expenses, %	2.00	14.66	6.73	2,72	0,44	0,80
6	Share of expenses of the SBU on PEC in environmental protection expenses, %	8.41	72.57	18.40	28,61	7,40	20,40
7	Share of expenses of the SBU on PEC in health care expenses, %	0.71	19.00	1.67	7,02	1,21	0,91
8	Share of expenses of the SBU on PEC in spiritual and physical development expenses, %	3.31	32.21	7.15	15,25	4,69	10,24
9	Share of expenses of the SBU on PEC in education expenses, %	0.43	5.78	0.96	2,59	0,9	1,70
10	Share of expenses of the SBU on PEC in SPW[4] expenses, %	0.39	2.40	0.78	0,92	0,21	0,27

Note: SBU[1] – State Budget of Ukraine; PEC[2] – pre-election campaigning; TR[3] – tax revenues; SPW[4] – social protection and welfare.

Source: compiled by the author based on the statistical data of the State Treasury Service of Ukraine https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu, State Statistics Service of Ukraine http://www.ukrstat.gov.ua/, Central Election Commission of Ukraine https://www.cvk.gov.ua/metod/vydannja/.

The table (Table 1) shows the statistical indicators of revenues and expenses of the State Budget of Ukraine during the years when election campaigns of various types were held which leads to the conclusion that financing of any election race is quite expensive for the national budget, since the expenses of the State Bank on key positions such as: health care, education, spiritual and physical development, environmental protection, state defense, etc., are insufficient for the socio-economic development of the country. Instead, the expenses of the SBU related to the election process have an impact on the financing of direct state responsibilities. Thus, we shall look at a number of indicators that can form an overall picture of the mutual influence of components of the fiscal space, identify the trends of its future functioning and development. It is logical that such indicators will have all indicative features and will serve to justify the sanogenic reflections of the formation and development of the optimal fiscal space of the state.

First of all, it should be noted that the statistical survey method used is to identify the degree of dependence among the selected factors, in which the calculation of the correlation coefficient C *(x, y)* has reflected the most significant tendencies of mutual influence of the components of the fiscal space of Ukraine (Table 2):

Table 2. Evaluation of the mutual influence of the main items of revenues and expenses of the State Budget of Ukraine during the years when the election campaigns of various types were held from 2007 to 2020

Indicators *x, y*		The formula for calculating the correlation coefficient *C* (*x,y*)	Calculation of *C*
1	Revenues of SBU and TR	$$C(E,C)=\frac{\sum(E-\overline{x})(C-\overline{y})}{\sum(E-\overline{x})^2\sum(C-\overline{y})^2}$$	0.89
2	TR and expenses of the SBU on PEC		0.08
3	TR and state defense expenses of the SBU		0.84
4	TR and environmental protection expenses of the SBU		-0.51
5	TR and health care expenses of the SBU		-0.75
6	TR and spiritual and physical development expenses of the SBU		-0.66
7	TR and expenses of the SBU on education expenses		-0.71
8	TR and expenses of the SBU on SPW expenses		-0.24
9	TR and economic activities expenses of the SBU		-0.73

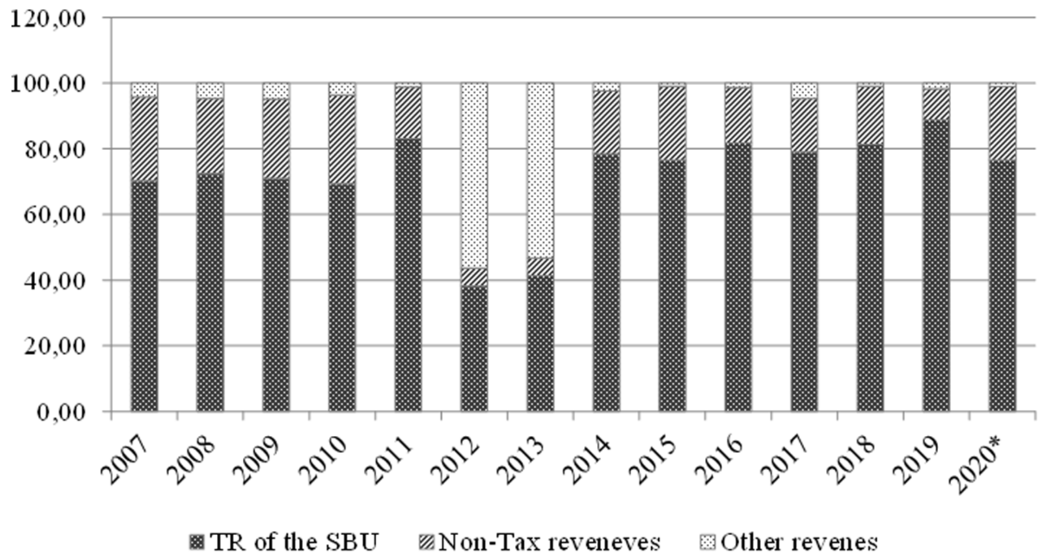
Note: in which *x* and *y* are sample averages, *C* is correlation coefficient.

Therefore, the following features of correlation analysis should be mentioned: when the value of *C*, takes values close to +1 or -1, then the relationship between *x* and *y* is significant. When the value is +1 such relationship is considered positive, and an increase in variable *x* causes an increase in variable *y* and vice versa, and it is considered negative (-1) when an increase of one variable causes the decrease of the other.

In the context of Ukrainian realities this influence is rather ambiguous with respect to the main items of expenses of the State Budget of Ukraine which characterize the components of the fiscal space of the state during the years when various types of election campaigns financed at the expense of taxpayers were held. The highest correlation coefficient between budget revenues and tax revenues indicates a significant correlation between these indicators. Instead, items of budget expenses which are the main indicators of the state fulfilling its direct functions and are usually financed by taxpayers show a negative correlation with tax revenues, with the exception of the SBU expenses on state defense ($C = 0.84$) (Table 2). There are several reasons that may explain this situation. First, the state budget is largely made up of non-tax revenues (loans, various credits, repayments of subventions, revenues from state-financed institutions, the National Bank of Ukraine, etc.). Second, taxpayers' funds are not used for their intended purpose as evidenced by the poor performance of the state functions.

Regarding the first, it should be recalled that the correlation coefficient *C* (TR, revenues of the SBU) (Fig. 3) is 0.89, which indicates a rather high level of correlation, and the advantage of other revenues over tax revenues can be traced only during the period of 2012-2013, which is inconsistent evidence for outlining trends. On the other hand, the second reason is more objective in view of the socio-economic situation in Ukraine over the years 2007-2019, and is therefore a key issue that causes the formation of corresponding asymmetries of the fiscal space of the state with the negative consequences of attempts made by the government to level or balance them.

Figure 3. The structure of revenues of the State Budget of Ukraine in the dynamics from 2007 to 2019
** data for the first quarter of 2019.*
Source: compiled by the author based on the statistical data of the State Treasury Service of Ukraine https://www.treasury.gov.ua/ua/file-storage/vikonannya-derzhavnogo-byudzhetu



CONCLUSION

Studies of the fiscal space of the state have been conducted for decades. World practices prove the necessity of such research, because various global crises affect the functioning and development of individual states in different ways. At the same time, the contradictions in the development of the national economic system of a certain state have different effects on the formation of trends in the world economy. In any case, the search for effective ways to overcome global and local economic challenges requires financial resources, which are accumulated in differentiated ways, involving the participation of taxpayers. Therefore, specifying the theoretical foundations of the formation and functioning of the fiscal space is of particular importance for finding effective mechanisms for its transformation.

Studying the details of the functioning and development of the fiscal space of the state, we focused on the peculiarities of the interaction of its components (Political Sphere, Economic Sphere, Social Sphere, Financial Sphere). An important aspect in this context was to state and substantiate the presence of four components of the fiscal space without limiting its functioning and development with only certain additional facilities of the state budget to have the resources provision to finance vital needs in the context of financial stability or economic stability (Heller, 2005), or to determine its capability by the ability to mobilize resources to overcome poverty in the state (Brun J-F, 2006, p. 3 - 9), or to minimize its significance to the prospects of financing the budget deficit exclusively in the context of absence of occurrence of negative effects of the national economy (Ghosh, 2011). Our vision of the fiscal space has been based on the views of the scientists who considered the way a financial resource was used to fulfill the direct functions of the state within the boundaries of current legislative norms to be the basis of the formation and functioning of the phenomenon under study. Obviously, these processes are impossible without the support and participation of taxpayers who are the main investors of the state. At the same time, it would be illogical to disregard factors that go beyond the legal field but occur within the fiscal space and pose corresponding risks to the formation of the shadow economy within the national economy. These factors include tax avoidance and tax evasion processes which involve both fraudulent taxpayers and corrupt officials. Certainly, these problems are considered to be among the most significant factors affecting the vector of fiscal space asymmetries, which require immediate resolution in the legal field. Otherwise, all the attempts to counteract fiscal torts will be futile, and the efforts to balance the divergence of the fiscal space of non-criminal origin for the sake of long-term development of the national socio-economic system and improve the well-being of citizens will be extremely difficult.

Thus, studying the peculiarities of the formation, functioning and development of Ukraine's fiscal space against the background of modern global challenges, we have identified the close relationship of all four components of the fiscal space of the state: political, economic, social and financial ones, and we have determined that effective mechanisms aimed to improve and enhance such components are possible through budgeting the funds available in the state. At the same time, as it was noted by Margaret Thatcher, the 71st Prime Minister of the United Kingdom, *there is no* such thing as *public money*; *there* is only *taxpayers*' *money* (Thatcher, 1983), it is necessary to understand how important it is at present to improve and enhance the functioning of the fiscal space of the state, develop all of its components systematically and reasonably. On the other hand, the society should be more responsible for its political preferences, economic opportunities and social priorities, which are financially funded directly by its members, i.e. taxpayers.

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Chapter 15
Load Balancing Improvement Through Flexible Assignment of Jobs in the Grids

Jalay Saurin Maru
Gandhinagar Institute of Technology, India

Raxit Jani
Gandhinagar Institute of Technology, India

Nishith Parmar
Gandhinagar Institute of Technology, India

ABSTRACT

Grid computing has emerged as a striking computing concept due to the availability of high-speed wide area networks and low-cost computational capital. This represents a novel load balancing algorithm for grid systems by allowing for node allure. The set of partners and neighbours are created for each node using the prestige of the job. For each job, in the gird, the given algorithm uses the popularity of other nodes in the grid to form k number of partners and p number of neighbours. The methods for constructing neighbours and partners are existing. A new job arriving to a node is immediately dispersed to the originating node or to its partner nodes. The load adjustment is approved incessantly, and reciprocal information administration is used to minimize the communication overhead in the elaborated load balancing algorithm. The given algorithm is self-motivated, sender-initiated, and decentralized.

INTRODUCTION

The advances in computers and communications have distorted society noticeably. At the same time, the computers can pool resources with the budding high-speed networks by creating massive computing power which helps in running advanced computational exhaustive jobs, in a short time.

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Several particular computers or workstations are cooperative to form cluster systems which shall be used to run circulated submissions through a high speed network. The shortcoming of using the cluster systems is, they are restricted to a fixed area, making the job stationary in terms of its recital.

The geologically detached cluster systems associated by a network form a computational grid for implementing distributed jobs. As compared with the predictable clustered systems, grid totaling uses internet connections to provide large scale resource sharing and improved resource utilization. A Grid computing offers more processing power and quality of service in executing scientific jobs rather than the cluster systems. It also reduces the response time of the jobs. Computational grids will emerge as next generation computing and it will be a significant alternative for the computation problems in industry, academic and government organizations.

Models of resource management: There are two types of resource management models, each with its own set of metrics.

Load balancing is another important feature of cloud computing that has evolved significantly since its introduction.

Since its inception in 2007, cloud computing has provided massive infrastructure, scalability, storage, virtualization, resource pooling, and a variety of other services.

A diverse range of services are available via the internet. Load balancing was established to increase the speed and performance of nodes in the cloud system, as well as to avoid individual devices from exceeding their performance thresholds by lowering their performance. Load balancing algorithms are required because they ensure that users receive uninterrupted service. In a distributed setting, load balancing must consider two key tasks: resource provisioning or resource allocation and job scheduling. The efficient provisioning of resources and job scheduling will ensure that: a. Resources are readily available on demand. b. Under high/low load scenarios, resources are efficiently utilised. b. There is a reduction in the amount of energy used in case of low load (i.e. when usage of cloud resources is below a certain threshold). d. Cost of using resources is reduced.

[Jalay Stated] This load balancing is motivated by two factors: efficiency and extensibility. Because of recent advancements in computer and communication technologies, a multi-computer strategy can be less expensive than a mainframe system with comparable performance, assuming that all computing resources are utilised effectively. A distributed system's extensibility should allow for the addition of new processors as needed.

Both of these considerations are addressed by a well-designed load balancing strategy. The purpose of such systems' design is to disperse global service requests created at various workstations among dynamically available computer resources. The resources' potential gains from dynamic load redistribution.

[Raxit Stated] Information regarding the state of the distributed system is exchanged and maintained by the information element. Different techniques have been presented as to what information should be retained, how much information should be maintained, how often it should be updated, and how extensive the balancing region 1 2 should be. Many studies have been conducted on the load index and its measurement mechanism.

[Raxit Stated] To alleviate congestion and increase performance, the control element analyses this information to determine when it is advantageous to redistribute the load, who makes this choice, which processes to transfer or migrate, and where to transfer a process.

[Nishith Stated] More realistic system features, both in terms of load balancing overheads and system model properties, must be taken into account to acquire accurate insights into the performance of load balancing in distributed systems.

LOAD BALANCING TECHNIQUES

Round Robin

One of the most basic and often used load balancing algorithms is round-robin load balancing. In a rotating fashion, client requests are delivered among application servers. If you have three application servers, for example, the first client request will be sent to the first application server in the list, the second client request will be sent to the second application server, and the third client request will be sent to the third application server, the fourth to the first application server and so on (El-Zogdhy, Kameda, & Li, 2006).

This load balancing algorithm does not take into consideration the characteristics of the application servers i.e. it assumes that all application servers are the same with the same availability, computing and load handling characteristics.

Least Connection

Client requests are distributed to the application server with the fewest number of active connections at the time the client request is received using the least connection load balancing algorithm (Chang, Lin, & Lin, 2012). An application server may be overburdened due to longer-lived connections in circumstances where application servers have identical specifications; this approach takes the active connection load into consideration.

Weighted Round Robin

Weighted Round Robin is used to accommodate for different application server characteristics, Robin expands on the fundamental Round-robin load balancing technique. To demonstrate the application server's traffic-handling capability, the administrator provides a weight to each application server based on criteria of their choosing. If application server #1 is twice as powerful as application server #2 (and application server #3), application server #1 is provisioned with a higher weight and application server #2 and #3 get the same weight. If there five (5) sequential client requests, the first two (2) go to application server #1, the third (3) goes to application server #2, the fourth (4) to application server #3 and the fifth (5) to application server #1 (Lu & Zomaya, A hybrid policy for job scheduling and load balancing in heterogeneous computational grids, 2007)

Weighted Least Connection

Weighted Least Connection is used to account for different application server characteristics, the Least Connection load balancing technique is used. To demonstrate the application server's traffic-handling capability (Zeng & Veeravalli, 2004), the administrator provides a weight to each application server based on criteria of their choosing. The load balancing criteria are set by the LoadMaster based on active connections and application server weights.

Resource Based (Adaptive)

It is a load balancing mechanism that necessitates the installation of an agent on the application server that reports the load balancer's current load. The application server's availability and resources are monitored by the deployed agent. To assist in load balancing decisions, the load balancer requests the output from the agent..

Resource Based (SDN Adaptive)

It's a load balancing method that takes into account information from Layers 2, 3, 4, and 7, as well as input from an SDN Controller, to make better traffic distribution decisions. This permits information about the servers' state, the status of the applications executing on them, the health of the network infrastructure, and the level of network congestion to all play a role in load balancing decision making.

Fixed Weighting

It's a load balancing algorithm in which the administrator assigns a weight to each application server based on their own criteria to demonstrate the application server's traffic-handling capability. The traffic will be directed to the application server with the highest weight. If the highest-weighted application server fails, all traffic is routed to the next-highest-weighted application server.

Weighted Response Time

It's a load-balancing method that uses the application servers' response timings to choose which one gets the next request. The application server weights are calculated using the application server response time to a health check. The next request is sent to the application server that responds the fastest (Lu & Zomaya, A hybrid policy for job scheduling and load balancing in heterogeneous computational grids, 2007).

Source IP Hash

Source IP hash is a load balancing algorithm that generates a unique hash key by combining the client and server's source and destination IP addresses. The key is used to assign a client to a certain server (Ashok, A, & D., 2012). The client request is forwarded to the same server it was using earlier because the key can be regenerated if the session is broken.This is useful if it's important that a client should connect to a session that is still active after a disconnection.

URL Hash

URL Hash is a load balancing algorithm to distribute writes evenly across multiple sites and sends all reads to the site owning the object.

System Centric

The grid involves independent jobs which are acquiesced at dissimilar times and necessitate different extents and resources for their employment. When a job reaches a grid, the scheduler will scrutinize the load condition of every node and select one node to run the job. The development policy at this stage must enhance the total demonstration of the whole system. The development system must recognize the load balancing and increase the system throughput and resource consumption, if the grid system is heavily loaded. This type of scheduling is confidential as "system-centric scheduling", for which the objective is to optimize system performance. The main focus here is the system –level resource (Benmohammed-Mahieddine).

Application Centric

The number of tasks of a parallel submission arrives within a unit scheduling time –slot, the arrangement system will apportion a node and finish it in terms of a defined objective. Usually, the detached is the minimal conclusion time for the entire application. Here the preparation policy is submission oriented and hence it is referred a bid centric scheduling.

Application- centric models deal with three kinds of submissions. First is task producing, in which numerous self-determining jobs arrive instantaneously. The second is a co-allocation application, where each task is showed as acting all-to-all announcement patterns throughout its execution. The last kind of submission can be characterized as direct acyclic graph indicating data-dependency between the tasks (Chang, Lin, & Lin, 2012).

Considerable Transfer Cost

The transfer cost of inaccessible job execution at the local area network can be disregarded because the computers in the LAN are associated through a high speed network. However, the transference cost is an apprehension for the scheduling process to execute the job in the isolated system in the grid, due to the low speed Internet links (Elsässer, Monien, & Preis, 2000).

Uneven Job Arrival Pattern

The operation of computers outdoes the maximum bulk at peak intervals and drops to a minimum in the night hours. A bursty traffic produced by the nodes in the grid atmosphere will be balanced by allotting the workloads to different clusters. Hence, load harmonising optimises the supply usage and conniving a load balancing procedure in a grid atmosphere is more complex. The main inspiration of this study is to recommend, decentralized dynamic load balancing explanations that can supply to these exclusive characteristic of Grid computing atmosphere.

BACKGROUND

Many load harmonising algorithms are currently being developed. Cataloguing of the load balancing procedures is useful for the design and examination of new load harmonising processes.

A. SDN Architecture

The SDN architecture is one of the innovative network architectures. It creates a network environment in which the network is managed centrally by an SDN controller (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006). The OpenFlow protocol is the most appropriate standard for implementing SDN architecture. SDN architecture using the OpenFlow protocol, which makes use of controllers, provides a superior method for processing flows than traditional networks (El-Zogdhy, Kameda, & Li, 2006).

In the realm of networking, SDN symbolises a true revolution. Both the control and data planes are housed in typical network devices. However, SDN refers to a network architecture in which the data plane (forwarding plane) and the control plane are clearly separated. The network's brain is the control plane, which is in charge of centrally operating the network. The data plane is comprised of the network's core equipment, such as switches and routers. The Open Networking Foundation divides SDN architecture into three major planes (ONF) (Z., 2016).

Application Layer:One or more end-user apps capture an abstract picture of the network as part of an SDN application layer, allowing them to demonstrate their internal decision-making process. The northbound API is used by programmers to communicate with the controller and is utilised by programmers to implement their applications (Penmatsa & Chronopoulos, 2006).

Control Layer: The control plane is made up of the intermediate level. The network platform is controlled by a Network Operating System (NOS). The control plane has two tasks: on the one hand, it is responsible for the administration of the switches, which will be instructed on the packet routing methods in transmission; on the other hand, it is responsible for the administration of the switches, which will be instructed on the packet routing methods in transmission. However, it must serve a higher level by providing an abstract and centralised view of the underlying infrastructure. The controller communicates with network devices via the southbound API. The most important southbound API is the OpenFlow protocol. Load balancing algorithms can be implemented on the load balancer, which is a component of the SDN controller that is positioned in a logical central point of decision (El-Zogdhy, Kameda, & Li, 2006).

Data Layer: The Infrastructure Layer is the most basic layer of architecture. The data plane of the network is represented by this level, which consists of physical and/or virtual devices such as switches. The most important role of a switch is to forward packets according to a set of rules provided by the SDN controller.The definition and placement of these rules on the flow table of switches is the responsibility of the SDN controller.

B. Load Balancing in SDN

Load balancing technology is mostly used in distributed systems to increase overall cluster performance. Load balancing can be implemented in both software and hardware. It is in charge of distributing load across multiple resources of the same type (Lu & Zomaya, A hybrid policy for job scheduling and load balancing in heterogeneous computational grids, 2007). Different techniques of load balancing exist; these approaches can be static, dynamic, or a combination of both. The ability to access prior system information is a key aspect of these static approaches. Static load balancing methods can be inefficient in a network since the rule is directly written in the load balancer. Because the behaviour of the user cannot be predicted, static load balancing methods can be wasteful. TLoad balancing in IP networks and load balancing in SDN networks are the two primary methods of load balancing. In a conventional IP-based network, the Load Balancing Router (LBR) balances the load, and each new flow that enters the network will first pass via. Following that, the LBR selects a server as the new flow's target server based on the current network condition. The target server's IP address is then included into the packet of the new flow. The packet will then be sent to its destination server through the computed path, utilising routing protocols (Lu & Zomaya, A hybrid policy for job scheduling and load balancing in heterogeneous computational grids, 2007). In an IP-based network, on the other hand, when picking the destination server, the routing choice is solely based on the network state at the moment of the target server selection. To achieve the appropriate load balancing in an SDN network, the controller must perform a sequence of Real-time Least Loaded Server selections (RLSs) (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006). The RLS is used to indicate the destination server of a new flow and to compute a path going to the target server while the new flow enters a domain for the first time. The RLS determines the forwarding decision for each new flow based on the current network environment .However, utilising RLS as a centralised controller in the SDN has some drawbacks, including single-controller bottlenecks, responsiveness, dependability, and low scalability. To avoid the aforementioned issues, a simple method to fulfil the job of the logically centralised controller is to use numerous distributed controllers working together.

C. Load Balancing Parameters

STo specify the better load balancing algorithm and recognise its advantages and shortcomings, some factors are required to evaluate a load balancing algorithm and compare it to prior techniques. These metrics are referred to as qualitative parameters (Chang, Lin, & Lin, 2012). Various qualitative indicators, such as throughput, usage, and delay, are used in articles. The following are the most important qualitative criteria for load balancing in the SDN:

The number of synchronizations each minute on average is: In SDN with dispersed controllers, it is the average number of controller state synchronisation per minute.

Overhead: Overhead is defined as any combination of excessive or indirect computing time, memory, bandwidth, or other resources required to complete a task. Communication overhead, flow theft overhead, synchronisation overhead, and flow statistics collection overhead are all examples of overhead (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006).

Overload Ratio:In order to integrate precise load definition networks, Rangisetti and Tamma [36] created a new cell overload definition called OverLoad Ratio (OLR). In LTE networks, a cell's OLR is determined during a given time period by examining its resource block use and GBR User Equipment QoS fulfilment (UEs). For example, a given cell with OLR = 0 indicates that all GBR UEs in that cell can get 100% of their organised GBR. Furthermore, with OLR = 0.7, GBR UEs can only receive 30% of their specified GBR

Static vs Dynamic

Load balancing actions shall be carried out at compile time or through run time. Load balancing procedures may necessitate priori information about all the features of the jobs, nodes dispensation capacity and the statement speed between the nodes. Deterministic or probabilistic load harmonising decisions are made through compile time and those conclusions remain constant during run time (Chang, Lin, & Lin, 2012).

The static load balancing algorithms offer less run time overhead and are simple. However they do not consider dynamic run time environment and may lead to load imbalance on some nodes which suggestively increases the job answer time. The nodes in the cluster atmosphere exhibit dynamic load conduct varied with time and require active scheduling decisions based on the load value of the nodes. The dynamic load balancing algorithms uses run time state information to share load among the nodes in the system. The system performance is increased by distributing the load among the by better responding to the current system state.

Non-Pre-Emptive Vs Pre-Emptive

Dynamic load balancing policies may be pre-emptive or non- pre-emptive. A non-pre-emptive load balancing policy assigns a new job to a best node in the system. Once the job execution begins at that node, it is not moved even if the node run time characteristics change. However it is desirable that the load at each node need not be fully equalized. This property allows devising load balancing schemes that deal with large grain dissection of the workload such as tasks and it does not necessitate high speed announcement between nodes (El-Zogdhy, Kameda, & Li, 2006).

In contrast, a pre-emptive load balancing will perform load balancing among the nodes whenever an imbalance exists among the nodes. A job can be transferred to another node even if the job is in its course of execution (Benmohammed-Mahieddine). Initially, though load distributions across nodes appear to be balanced, they will become unbalanced as shorter jobs complete and leave behind an uneven distribution of longer jobs. Job migration allows these imbalances to be corrected among the nodes. However, job migration in course of execution incurs more overhead which results in performance degradation. If the pre-emptive policies are attempted in loosely coupled systems, more messages are to be generated among the nodes and it will cause congestion in the communication system which will result in the system performance degradation

Node-Level vs Grid-Level

When a job arrives at a node, the load –balancing algorithm of the cluster will analyse the load situation of every node in the cluster and will select an appropriate node to run the job. Even if the cluster is heavily loaded, each job in the cluster must queue and wait for its turn. This kind of load-balancing is classified as cluster-level load balancing which optimizes the system performance in a single cluster. Many traditional load balancing algorithms fall in the category of cluster-level (Z., 2016).

Centralized vs Distributed

Load balancing policies can be classified as centralized or distributed. In centralized policies, there will be one master node which will take decisions about scheduling. The master node assigns newly arriving jobs to different processing nodes. The information collection about job arrivals and departures will be easy in the centralized policies. The major disadvantage of centralized policies is the possible performance and reliability bottleneck due to the possible heavy load on the master node. For this reason, centralized policies are inappropriate for large scale systems (Zeng & Veeravalli, 2004). The distribution policy is referred as individual optimal policy, in that each job optimizes its own response time independently of others.

SYSTEM MODEL

The system model for the load balancing algorithms is composed of a (i) Cluster model (ii)Job queue model (iii) communication model (iv)Job model (v) Job migration model and (vi)Performance objective. The Grid architecture consists of a collection of clustered systems and job queue model provided as a two level architecture for the job waiting queue at each cluster. The communication model provides an estimate of expected communication costs for information exchange between nodes and job transfer among cluster nodes. The job model defines the information about the job required by the load balancing algorithms. The load balancing algorithm is designed in such a way that it has to reduce the chances of job thrashing and starvation at any node. The performance objective of the load balancing algorithm will be system utilization and average response time of the jobs (Zeng & Veeravalli, 2004).

Also, Yong et al.have proposed an SDN-based dynamic Load Balance solution (SDN-LB) with applying the SDN technology to the cloud data center and solve the load balance problem by employing SDN architecture. They have utilized the Plug-n-Server as an SDN architecture. The Plug-n-Server includes three main parts: the underlying objective composite by servers and clients; OpenFlow switch network; SDN controller and decision platform. The controller contains four modules: traffic detection module, dynamic load scheduling module, load calculation module and flow management module. Traffic detection module is used for dynamic traffic monitoring and statistics; load calculation module aims to estimate the load distribution of the cloud environment. In dynamic load scheduling module, they have a new hybrid load balancing algorithm to achieve high-performance load balancing for cloud center; flow management module responsibility is deployment load balance strategy based on hybrid load balance algorithm. The performance of SDN-LB has assessed in the comparison with other three versions of a state of the art hash-based solution via simulations (El-Zogdhy, Kameda, & Li, 2006). The simulation results have proven that SDN-LB achieves higher throughput than traditional methods. This method uses a single controller, for this reason, it has low scalability, low availability and system bottleneck. Furthermore, latency and utilization metrics have not been considered. Also, uniformity of the load distribution among servers have not been measured.

The majority of web services and sites are hosted by diverse types of cloud services, and such systems require efficient load-balancing policies to order some level of QoS which is possible through choosing multiple clouds. Kang and Choo have introduced an SDN-enhanced InterCloud Manager (S-ICM) that assigns network flows in the cloud environment. The approach contains two main parts, monitoring and decision making. For monitoring, S-ICM utilizes SDN control message that observes and collects data, and decision-making is made in accordance with the measured network delay of packets. Measurements are also employed to evaluate S-ICM and to compare it with a round robin tasks allocation where the workload is distributed via a Honeybee Foraging Algorithm (HFA). The evaluation results have shown that in term of avoiding the system saturation, S-ICM is better than HFA and round robin under the heavy load formula. Measurements are also employed to examine whether a simple queueing plan can be employed to predict the efficiency of the system for many clouds being operated under round robin scheduling strategy, and finally, they have proven the validity of the theoretical approximation. But, S-ICM generates additional control messages continuously into the whole network. In addition, uniformity of the load distribution among servers and throughput has not been measured (El-Zogdhy, Kameda, & Li, 2006).

Additionally, an SDN based solution has been by Raza, et al. to provide load balancing among mobility anchors based on the PMIPv6 domain. Proxy Mobile IPv6 (PMIPv6) is an IP mobility protocol where local mobility anchor is involved in control as well as data communication. The PMIPv6 standard enables the possibility of having multiple mobility anchors to reduce the load on a mobility anchor and avoid a single point of failure. In the solution, a mobility controller acts as a central control entity and performs load monitoring. The controller moves the traffic from highly loaded mobility anchor to less loaded mobility anchor. Analytical modeling based on performance assessment results have shown that while the load balancing is being accomplished, the scheme reduces the disruption duration of uplink and downlink traffic. However, this paper has not included the algorithms to perform load detection and mobile node selection. Moreover, this scheme suffers from low scalability, low availability and system bottleneck due to using a single controller. Also, throughput and degree of load balancing metrics have not been considered (Lu, Subrata, & Zomaya, An efficient load balancing algorithm for heterogeneous grid systems considering desirability of grid sites, 2006).

Switch migration commonly utilized by load balancing methods, which dynamically adjusts the mapping between controllers and switches based on controller workloads. Generally, switch migration-based methods face some challenges under the burst traffic due to their overhead and longer detection periods. Song et al have presented the flow stealer which is a lightweight load balancing technique for distributed SDN controllers. Flow stealer utilizes a low-cost flow-stealing approach, in which idle controllers share workloads temporarily with overloaded controllers. The flow-stealing technique can respond to variations of network traffic more rapidly, and the frequency of switch migration is eventually reduced. Furthermore, flow stealer joins both flows stealing and switch migration to adapt and burst the traffic and long-term traffic variations. Simulation results have shown that flow stealer efficiently balances the workloads between controllers, especially under burst traffic, whereas energy consumption and latency of the method have not been evaluated. Also, the complexity of the method is high due to the using multiple controllers (Benmohammed-Mahieddine).

Furthermore, in order to use the advantage of SDN flexibility, Zhong et al. have a Load Balancing scheme Based on Server Response Times, named LBBSRT. LBBSRT is under the SDN architecture employing the controller to attain ultimately the real response time of each server so that it can choose a server with more stable response time to solve some load balancing issues in the traditional networks such as upper deployment costs and lower efficiency. Simulation experiments have shown that the scheme process demands with a low average server response time and achieves a good load balancing. Also, the implementation of the method is simple and efficiently solves the load balancing issue with low cost and proper scalability, but, the authors have not taken into consideration the energy saving issue. Also, this method uses one controller, therefore, it suffers from low availability, low scalability, and system bottleneck (Elsässer, Monien, & Preis, 2000).

Also, Ma et al. have a load-balancing mechanism for using in a multiple-controller SDN that implements a hierarchical control plane with a local and a meta control plane. The meta-control plane investigates the resources and the utilization of the local control plane to improve processing performance. In order to optimize data plane performance and remove the bottleneck of the central control, this mechanism supports the load balancing of the local control plane. The results have indicated that using the meta control-based management mechanism, the loading of the control plane is reduced. Also, it improves the load balancing of SDN controllers and enhances the bandwidth utilization of the SDN environment relative to that obtained by means of single and multiple controllers without the meta control-based manager. But, it uses multiple controllers hence it suffers from high complexity. Also, energy consumption and execution time of the mechanisms have not been investigated (G, N, & ND, 2015).

Moreover, in the LTE networks, User Equipment (UEs) are commonly connected to a nearby cell (evolved Node B (eNB)), spatiotemporal variation in traffic requirements cause to load imbalance problem in the LTE networks. Because of the distributed nature of eNB operation in LTE Radio Access Network (RAN), conventional solutions to address load balancing issue might result in excessive overhead over X2 interface. Therefore, one of the challenging issues in the existing distributed LTE RAN is handling densely deployed cells. Rangisetti and Tamma have presented a centralized Software Defined LTE RAN (SD-LTE-RAN) framework and a new QoS Aware Load Balance (QALB) algorithm. For making load balancing decisions, the algorithm considers loads of neighbor cells, QoS profiles of UEs and their estimated throughputs. The method in comparison with other existing load balance algorithms (MinTHT and HLFB), maintains a remarkable degree of load balancing among cells and also improves entire network-wide GBR satisfaction and subsequently minimizes the total network overload. They have shown that the QALB algorithm is able to preserve better QoS data rates for more than 80% of the cells in the network. In this paper, static UEs and mobility scenarios are also examined, these scenarios can reflect conditions in busy places such as airports, shopping malls, and railway stations. Not only in static scenarios, but also in mobile scenarios, QALB can minimize average network OLR in comparison to previous load balance algorithms (Lu & Zomaya, A hybrid policy for job scheduling and load balancing in heterogeneous computational grids, 2007). However, other QoS parameters such as delay and jitter have not been considered. Also, this method uses single controller hence it suffers from low scalability, low availability, and system bottleneck.

Finally, Lin et al.have a method to deal with Wi-Fi congestion in the SDN because of an unevenly distributed load among Access Points (APs). The conventional methods typically allow client stations know APs' load status and choose APs in a distributive manner. But, such a client-driven method lacks a global vision to make exact load balancing decisions and may result in frequent changes in the client-AP association. Their solution applies standardized OpenFlow protocol and SDN controller technology to establish the SDN controller and the APs into a two-tier architecture so that the controller can analyze the load balancing degree in the APs and choose which load level of the APs can accept association requests without referring to the controller. Experimental results have shown that approach enhances the degree of Wi-Fi's load balancing and obtains a development of Wi-Fi's re-association time over generic centralized load balancing approaches with positive control (Penmatsa & Chronopoulos, 2006). However, this approach uses single controller hence it suffers from low scalability, low availability, and system bottleneck. Also, they have not investigated more factors like user priorities, QoS limitations and traffic patterns of the associated devices in the load balancing decisions.

A non-deterministic approach is an algorithm that may have different behaviors on different runs for the same input. It often applied to acquire approximate solutions, when an exact solution is difficult or costly to acquire using a deterministic algorithm. In order to solve an NP-complete problem, a solution can be found by a nondeterministic algorithm in polynomial time. Considering that load balancing problem has the nature of NP-complete, it can be solved using a non-deterministic approach. In Section 1, the selected non-deterministic approaches are discussed and in Section 2, a summary of non-deterministic approaches are presented (Chang, Lin, & Lin, 2012).

1) Overview of the Selected Non-Deterministic Approaches

Chou et al. have offered an OpenFlow-based load balancing system using the genetic algorithm. This system can efficiently distribute the data from clients to various servers based on load balancing strategies. Additionally, with the preconfigured flow table entries, each flow can be directed in advance. When the traffic burst or server loading unexpectedly increases, the method can assist to balance the workload of server farms. The results have proved the high efficiency of the method in comparison to other methods including round-robin, random and load-based approaches. However, they have only used the arithmetic average for the coefficient of variation metric. Moreover, utilization and overhead of the algorithm have not been evaluated. Also, this method uses single controller hence availability and scalability are not achieved and the system has a bottleneck. Furthermore, since this method uses the genetic algorithm, it suffers from high computation time (G, N, & ND, 2015).

Additionally, the conventional traffic engineering techniques compute the optimal routing using a single traffic matrix. However, they are not able to address unexpected traffic adjustments. Accordingly, to deal with multiple feasible traffic scenarios, it is of interest to find a suitable routing structure. There are two main methods to reach load balancing for multiple traffic matrices; destination-based and explicit routing. It has been demonstrated that explicit routing does better than destination-based routing for multiple traffic matrices. On the other hand, explicit routing has high complexity and needs large Ternary Content Addressable Memory (TCAM) in the routers. Zhang et al. has presented a method named hybrid routing to accomplish load balancing for multiple traffic matrices with high scalability and low complexity. The main idea of the method is to complement destination-based routing with a small number of explicit routing forwarding entries to take benefit of both approaches. Hybrid routing substantially minimizes the number of forwarding entries in comparison to pure explicit routing. A heuristic algorithm has been implemented to attain the near-optimal hybrid routing configuration. The experimental results have shown that the hybrid routing obtains near-optimal load balancing compared to pure explicit routing. Specifically, a hybrid routing saves the TCAM resources in all practical networks. Whereas, latency, overhead, and utilization of the approach have not been considered (Z., 2016).

On the other hand, existing data centers are not improved for cloud-based software services. Real data centers may suffer from lower throughput, as well as high latency and low QoS, because of the changeability of traffic load. Tu et al. have introduced a programmable middlebox that can evenly distribute traffic to solve this problem. The middlebox is based on a Clos network, a multi-stage network which is by Clos. It designs and uses SDN to improve bandwidth utilization while ensuring QoS. The aim of the middlebox is to discover the optimal path for the traffic within the data center hence it uses a matrix called price matrix to depict the costs to transmit data from one to another server. A greedy algorithm is used to calculate the price matrix. The SDN controller of the middlebox gathers the information from switches and achieves load balancing by using the traffic distribution and server loads information. When implemented in a data center, the middlebox can significantly enhance bandwidth utilization and minimize latency. Since the middlebox does not rely on any specific characteristic of the data center, it can simply be applied in the existing data centers. However, they have not evaluated more QoS constraints. Also, the overhead of the middlebox and energy consumption of the approach have not been measured (Chang, Lin, & Lin, 2012).

Moreover, the Internet of Vehicles (IoV) is considered as a typical application of the Internet of Things (IoT) in connection with the Intelligent Transportation System (ITS). Less mobility support, location awareness, and high processing latency still give rise to IoV suffering. To deal with the aforementioned problems, He, et al. [44] have integrated the fog computing with SDN. In order to apply the Software Defined Cloud/Fog Networking (SDCFN) architecture in the IoV, they have a new SDN-based adapted constrained optimization particle swarm optimization algorithm which utilizes the reverse of the mutation particles flight and linear inertia weight to improve the efficiency of constrained optimization particle swarm optimization. The results have demonstrated that the algorithm decreases the latency and improves the QoS in the SDCFN architecture. However, other QoS parameters such as security and capacity have not been evaluated. Also, energy consumption, load balancing degree, and utilization parameters have not been taken into consideration (El-Zogdhy, Kameda, & Li, 2006).

Current OpenFlow specification is not able to set the service rate of the queues inside OpenFlow devices. This lack does not let to apply most algorithms for the satisfaction of QoS requirements to new and established flows. Boero et al. have an alternative solution implemented over some modifications of Beacon (the popular SDN controller). The solution uses real-time statistics from OpenFlow devices and Beacon will re-route flows on some queues to ensure the observance of deadline needs and/or an effective queue balancing in an OpenFlow SDN switch. Aiming at equalizing the traffic burden in each queue, three schemes have been proposed. Based on the greedy heuristic, one of these schemes is called multi-way. In the multi-way, at the beginning, all the flows are queued into q0 . The controller runs a system that sorts out the flows in decreasing order in compliance with the computed estimated rates. The established estimated rates order is analyzed and each flow is assigned to a queue with the lowest utilization to balance the load among the queues. The modification in the SDN controller will be the base for the design of a class of new re-routing algorithms which are able to ensure deadline constraints and queue balancing. They have not made any change to the OpenFlow specification, in addition to OpenFlow devices. Evaluation results have shown that multi-way schemes have a very satisfying behavior and better performance. However, they have not any new primitive or modification of the OpenFlow standard. Also, the overhead of the approach and its execution time have not been investigated (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006).

Furthermore, to facilitate the elasticity of the SDN controllers, the elastic scaling and the load balancing with effective switch migration is vital, however, it is still not easy to improve the migration efficiency. Wang et al. have designed a switch migration scheme for the load balancing in the SDN controllers. They primarily have checked the real-time controller load information gathered by the monitoring module and then decided whether to perform the switch migration. Later, to preserve the balance between the migration cost and the load balance rate, the migration efficiency model was built. Finally, based on a greedy method, they have designed an efficiency-aware migration algorithm to utilize the migration efficiency model and therefore, make the selection of migration actions feasible. According to the simulation results, the new method using switch migration makes the elasticity of SDN controllers possible and subsequently, enhances the migration efficiency. However, they have not implemented the method in a real large-scale wireless access network with more real-world traffic. Moreover, the latency of the method and its throughput have not been investigated (Chang, Lin, & Lin, 2012).

Finally, in the SDN, it is usually required to regularly collect state/statistics of entire flows, which may cause too large overhead on control links. Xu et al. have performed load-balanced routing using the traffic knowledge by carefully taking flow statistics collection to reduce the flow re-routing overhead. An important challenge is to achieve effective almost-optimal load-balanced routing with less overhead based on the quality of flow statistics collection. To deal with this challenge, a Partial Flow Statistics Collection (PFSC) problem is proposed, in which it is required to inquire statistics of flows from a subset of switches such that the flow recall ratio on every switch is at least a given value $\beta \in (0,1]$ while minimizing the number of queried switches. They have proved that the PFSC is an NP-Hard problem and have presented an algorithm relies on primal-dual with an approximation factor f/β in most situations, in which f is the maximum number of switches visited by each flow. To further reduce the overhead, they have designed an adaptive flow statistics collection mechanism, as a complementary scheme for PFSC, based on link load similarity measurement. Experimental and simulation results have shown that their methods can reduce the overhead in comparison to previous collection method while preserving a similar routing performance. However, the effects of the proposed method have not been evaluated when multiple controllers exist in the network. Moreover, the execution time of the approach and its latency, as well as its energy consumption, have not been considered (Chang, Lin, & Lin, 2012).

2) Summary of Non-Deterministic Approaches

In this section, a side-by-side comparison of the selected non deterministic techniques as well as their main advantages and disadvantages are shown in Table 4. Articles of non-deterministic approaches category have used methods including greedy, meta-heuristic and approximation. Genetic algorithm, multi-objective particle swarm, and particle swarm have been used in the articles of this category. Some of the advantages of these methods are: improving utilization, reducing latency and improving the degree of load balancing. Also, some of the disadvantages of this method are: high computationally time and unacceptable energy consumption. Additionally, these articles have not considered some of the metrics (El-Zogdhy, Kameda, & Li, 2006).

ARCHITECTURE MODEL

The clusters consist of N number of processors and the communication bandwidth is shared by all the processors. The previous research such as condor and Load sharing facility has addressed the management of the jobs at cluster level.

The heterogeneity in system can be expressed in terms of processors speed, memory and disk I/O. A practical solution is to consider CPU speed. It is also assumed that a machine with powerful CPU will have matching memory and I/O resources. The nodes in the grid system may have different processing power. Processing power of a node n_i is denoted as Pi. For i≠j, Pi may be different from Pj. Pi means the ratio of the processing power of a node n_i to the processing power of the slowest side sj in the system (Penmatsa & Chronopoulos, 2006).

COMMUNICATION MODEL

The nodes N are fully interconnected and there exists at least one communication path between every two nodes in N. The message passing mechanism is used as a communication between the nodes and there exists a transfer delay on the communication network between the nodes. The transfer delay is different between different pairs of nodes. The underlying network protocol guarantees that messages sent across the network are received in the order sent (Neghabi, Navimipour, Hosseinzadeh, & Rezaee, 2018).

Two parameters such as a transfer delay and data transmission rate are used to represent the network performance between any two nodes (n_i, n_j). Transfer time required for sending a message of Q bytes between two nodes is given by

$$TD_{ij} + \frac{Q}{BW_{ij}}$$

The above equation represents the total time required to traverse all of the links on the path between n_i and n_j. BWij is represented as effective data transferring rate in bytes per unit time or is characterized in terms of kb/s. TD_{ij} includes a start-up cost and delays incurred by congestion at intermediate links on the path between n_i and n_j.

For a given node $n_i \in$N, jobs will arrive to the nodes belong to C^i, where Ci denotes the cluster consisting of N nodes. The arrival of jobs are random with an average delay, λ, between two successive arrivals and follow poisson rate and the delay between the arrivals will be Exponential distribution. The jobs can be executed at any node and are computationally intensive. The execution of the jobs are not time shared and can be executed at any single node. The job is assigned to exactly one node for execution and on completion of job, the results will be transferred to the originating node of the job. The set of all jobs generated at node S will be denoted as $J= \{j_1,j_2,\ldots,j_r\}$. The system automatically creates the following parameters related to the job.

- orgNode(j_i): the originating node of job j_i
- exeNode (j_i): the executing node of the job j_i
- startTime (j_i): the time of the job generated at orgNode (j_i) which is the arrival time of the job.
- endTime(j_i): the completion time of j_i which includes the job transfer time from orgNode to exeNode(j_i), waiting time queued at the exeNode(j_i), execution times at the exeNode(j_i) and the transfer time it takes to return the execution results from exeNode(j_i) to bornNode(j_i)
- respTime (j_i):the time the job jitaken for execution. respTime (j_i) =endTime (j_i) – startTime (j_i).

Each job j_x is represented by two parameters, the amount of computation and the amount of transfer time. The unknown values of these two parameters may be estimated by probabilistic techniques. The amount of computation has one of the following formats.

An Expected execution time ETC(j_x, N_{std}) for processing the job, is the time that would be taken at a standard platform with processor speed equal to 1 . Hence the expected execution time of a job ETC (j_x, n_i) will be $\frac{ETC\left(j_x, N_{std}\right)}{APW_i}$

Performance Objective

The major critical performance object in the grid computing is to minimize the response time of all jobs submitted in the system denoted by ART.

$$ART = \frac{\sum_{i=1}^{n} responsetime(j_i)}{n}$$

The performance of the mentioned algorithm is evaluated by its improvement factor over the another algorithm X as follows in terms of average response time of jobs

$$\frac{ART(X) - ART(A)}{ART(X)},$$

Where ART (A) denotes the average response time of jobs using algorithm A and ART(X) denotes the average response time of jobs using algorithm X. A positive value indicates an improvement over the existing algorithm and negative value implies the degradation over the existing algorithm.

THE METHOD

A novel load balancing procedure for heterogeneous systems has been accessible with deliberation of job passage to the remote nodes. Job immigration from a local node to remote node deliberates processing power of a remote node and the announcement delay to the remote node. The load harmonising algorithm for each node n_i forms a set of K partners and C neighbours and the material collection overhead from the national and partner nodes are reduced by using reciprocal information organization (RIM). The algorithm presented in this is dynamic, sender-initiated and regionalized. Job that arrives at each node n_i is allotted either to n_i or to its neighbouring nodes. The adjustment of loads has been made continuously among neighbours of node n_i.

Many existing algorithms in the literature have used an instantaneous run queue length (the number of jobs being served or waiting for service at a given instant) as the load index. The time required for calculating the load index is based on the queue length of the node. The load index of a node consisting of more than one CPU is calculated based on the total queue length of that node divided by the number of CPUs at that node. The parameters such as average processing power and the transfer delay are used to assign a job to a node in the node.

The node- clustering algorithm considers N number of nodes for the processing power of each node n_i. The nodes are chosen randomly in such a way that the processing power of each node varies large enough with other node. The nodes are sorted by processing power in descending order before applying node-clustering method. A reference vector $<d_1,d_2,d_3,\ldots,d_n>$ is calculated based on the difference in processing power Pi of node n_i to the other nodes in the system and nodes with similar reference vector close to each other in terms of processing power are clustered into $c_1,c_2,c_3,\ldots,c_m$ clusters. Finally empty clusters in $c_1, c_2, c_3, \ldots, c_n$ are removed so that only $c_1, c_2, c_3, \ldots, c_q$ ($q \leq m$) will remain in the order of decreasing average processing power.

The Partners

Each node n_i has K number of partner nodes P_{set} used by the scheduler to select partner nodes for assigning newly arrived jobs. When a node joins the grid system, it will determine its partners. A simple heuristic is employed to find partner nodes including heterogeneous nodes in terms of their computing power. An algorithm to select partners for the nodes is presented in the below algorithm (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006).

A preferable collection of nodes of N of forms a set Q_i used in proposed Partners Adjustment Policy have greater or comparable processing power to node n_i .The set of favoured nodes Q_i will be updated by the algorithm as necessary. The above approach may not guarantee in finding the optimal partners, however it may provide a scalable and efficient approach in the initial formation of partner nodes.

Algorithm 1: Find Partners (n_i,K)

Find all nodes $n_j \in N(i \neq j)$ with $p(n_j) \leq P(n_i)$. The set of nodes are denoted as Q_i.

```
if β >=K (β is the size of Qi)
select K nodes from Qi randomly and add them to Pseti
else
{
M= K-β;
Add Qi to Pseti
v←P(nj)
do
{
Qi ← Qi ∪ Cv
if β̲ >=M(β̲ is the size of Cv)
{
Select M nodes from Cv randomly and add them to Pseti;
break;
}
else
{
Add Cv to Pseti
M=M-β̲
v = v + 1;
}
} While M>0
}
```

The Neighbours

The set N_{seti} maintains C number of neighbouring nodes by each node n_i. The scheduler will reduce the communication cost by selecting the neighbouring nodes for migrating the jobs and hence reduces the transfer delay for the load movement and enable quick response to load imbalances. The neighbours have been selected in such a way that nodes are lightly loaded and minimum transfer delay between the sender node and the receiver node. n_j is considered as neighbouring node to n_i if the communication delay between the nodes n_i and n_j is minimum. The neighbouring nodes are sorted in the ascending order based on the transfer delay and the least ranked node is chosen as the nearest node. The transfer delay is described as follows:

$$\varepsilon = \frac{TD_{ji}}{TD_{near}}$$

The transfer delay from node n_j to node n_i is denoted by TD_{ji}. The transfer delay from the nearest node of n_i is denoted by TD_{near}.

Partners Adjustment Policy

When a node receives a load information message from neighbour nodes or partner nodes, it triggers dynamic partner adjustment policy. The dynamic Partners Adjustment Policy is triggered whenever a node n_i receives load information message from a neighbour or partner. If a node n_j in the preferred nodes Q_i of n_i is found in the message, it will be involved in the partner adjustment of n_i. when node n_j load is lower than highest load in the partner nodes of n_i, then it is possible that n_j becomes a partner node of node n_i. Algorithm 2 describes the procedure of Partners. Adjustment Policy when n_i receives an information message from its neighbour or partner node n_i

Algorithm 2: Partners Adjustment (n_j,K)

{

$N_I \leftarrow \varnothing$;

$\forall n_y \in N:$ if $\left(n_y \notin Nset_j \cup P_{setj}\right)$ and $((n_y \in Q_j) N_1 \leftarrow N_1 \cup n_y)$

if $N_1 \neq \varnothing$

{

$N_1 \leftarrow N_1 \cup Pset_j$

Sort N_I by load difference in ascending order

Remove all nodes from P_{setj}

Select the first k nodes from N_1 and add them to P_{setj}

}

Information Policy

The reciprocal information management system restricts the load information exchange to partner and neighbouring nodes to n_i. When a node n_i transfer a job j_x to its neighbour or partner node n_j for processing. Node n_i appends load information to itself, r_p, random neighbours or partners who have sent the job transfer request TR to n_j. The load information is updated by n_j by comparing the timestamp, by inspecting whether a request is from it is neighbours or partners. Similarly n_j inserts its current load information and r_p radon nodes from its N_{seti} and P_{seti} in the job acknowledge AR or completions reply CR to n_i, So n_i can update its state objects.

For any node $n_i \in N$ if the state object element $O_i[j](\forall n_j \in N_{seti} \cup pset_i)$, $i \neq j$ has not been updated for a predefined period T_p, then the load-balancing scheduler will send information exchange message to n_j. The procedure is the same as the algorithm 4.3.

Algorithm 3: Instantaneous Distribution Policy

$\forall j_x \in J$ with born mode $(j_x) = n_i \in N$
Let $LD_{\min} \neg \text{Min}\{O_i[K].LD | n_k \in n_i + P_{seti}\}$
/* the minimal load among node n_i and its P_{seti}*/
If $O_i[i].LD - LD_{\text{Min}} < \theta$)
/* θ is a positive real constant close to 0 */
$GJQ(n_i) \leftarrow$ enqueue(j_x) /* put the job j_x in the global job queue GJQ (n_i)*/
else
{
Transfer the job j_x to the partner node n_j having LD_{Min}
Update $O_i[j].LD$
}

Transfer Policy and Location Policy

The transfer and location policies used in this algorithm are combination of instantaneous and load adjustment policy.

Instantaneous Distribution Policy

The instantaneous distribution policy is used to decide whether a new job is assigned to the originating node or one of its neighbour nodes. If the existing neighbour nodes of n_i are overloaded then the job is put in the global queue of n_i which is later scheduled to run on the partner nodes. This policy will try to control the job processing rate at each node and highly computational jobs are run on the high end nodes or very less overloaded nodes. If there are two partner nodes with the same minimum load, the nearest partner node is chosen for executing the job and this can reduce the communication delay. Algorithm 4.4 describes the IDP for n_i

Algorithm 4: Load adjustment Policy

if O_i[i].LD>LDavg

{
$j_x \leftarrow$ dequeue($GJQ(n_i)$)
Transfer the job j_x to a neighbour node n_j where O_i[i].LD= Min{$O_i[k].LD|\ n_k \in Nset_i$}
}

Load Adjustment Policy

The Load adjustment policy reduces the load difference between node i and its neighbour nodes by transferring jobs from heavily loaded nodes to the lightly loaded neighbouring nodes. This policy is triggered when the load information is received by node I from its neighbouring nodes. This policy uses the most recent load information to decide to initiate the transfer of jobs. The threshold policy used in this method is dynamically adjusted based on the system load and the nodes with loads higher than the average load of the system are considered as senders and the last job waiting in the node I is considered as the candidate for transfer to the remote node. If the neighbouring nodes have the same minimum load, then the candidate node for transferring the job is chosen based on the network delay. The node with less transfer delay as considered for transferring the job.

RESULTS AND DISCUSSION

Sender-Initiated algorithms are used for routine estimation. The algorithm (RWLA) is compared with two of the prevailing algorithms in the literature. For the NB, each node is limited to collect load gen from within its own province, which consists of itself and its neighbours. The load balancing action is originated if a load of node outdoes the average load of its sphere.

Simulation Model

Simulations are preformed to study the performance of the algorithm by associating with the existing algorithm diffusion Algorithm prevailing in the literature Robert Elsässer(2000). The reproduction model consists of N nodes with dispensation power of nodes is assigned in a range [0.0 to 1.0] (Lu, Subrata, & Zomaya, Towards decentralized load balancing in a computational grid environment, in: Proceedings of the first International Conference on Grid and Pervasive Computing, 2006). It is possible to produce different heterogeneous systems by varying the processing power of the nodes, it is possible to produce different heterogeneous systems. Jobs arrive at each node n_i, i=1, 2..., N according to a Poisson process with rate $\lambda_i = \lambda X P_i$ where $p_i = \frac{1}{N}$. The actual inter arrival time of jobs is adjusted to average system loading. The execution times of jobs are assumed to be an exponential distribution with a mean of T time units. The transfer delay between any two nodes assumed to be lognormal distribution with a mean of τ time unit and a standard deviation σ_c. The partner set of each node is provided in prior to the stating of the algorithm. The neighbours are chosen based on the transfer delay generated from the distribution of mean transfer delay and it has been provided as input to the algorithm before it starts to run. The average load of the system is denoted by ρ and defined as the ratio of average job arrive rate divided by the average job processing rate. The mean inter-arrival time $\frac{1}{\lambda}$ to get the desired value of .

Table 1 shows the simulation parameters used in the experiment and table 2 shows the heterogeneous system configurations used in simulation.

Table 1. Simulation parameters

Simulation parameter	Value
Size of system, n	16
The number of reference nodes, m	6
Mean processing time of jobs	0.5 Time units
Computation to communication ratio	{0.05,0.1,0.25,0.5,1,2.5,5}
Mean transfer delay	0.0025 Time units
Standard deviation of transfer delay	25
Period for periodic information exchange	20
Number of random partners/neighbours for information update, r_p	4

The below (Elsässer, Monien, & Preis, 2000) table shows heterogeneous system configurations, and the value is chosen randomly from [0.0 to 1.0]. The first 2000 jobs are used to make the system into a steady state. The arrival processing time and finish time has been traced from J1000 To J4999. Here μ equals to 4000 (for evaluation purpose). For each node, the numbers of completed jobs are recorded. The computed average r (htt)esponse time of jobs (ART) has been measured after each simulation run. The measurement has been carried out five times with different random seeds.

Table 2. Heterogeneous system configurations

Heterogeneous systems	Average processing power
1 To 8 nodes	0.1
9 to 16 nodes	0.2
17 to 24 nodes	0.5
25 to 32 nodes	1.0

Effect of System Size

The simulations have been carried out for varying system sizes to check for the stability of the existing and newly developed comparing and existing algorithms. Both algorithms are scalable and stable. However the average response time offered by the algorithm is better than the diffusive load balancing algorithm. The results are shown in the figure 2

Figure 1. Effect of System heterogeneity

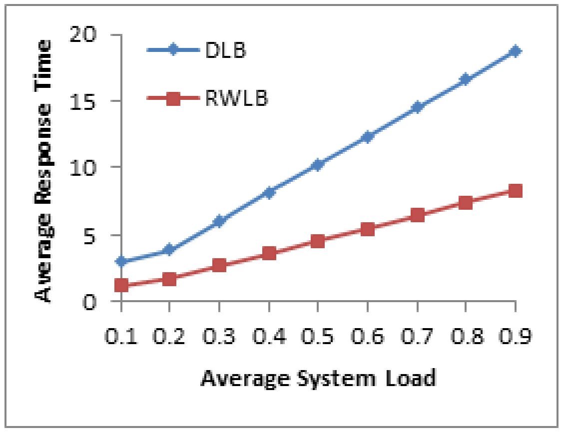
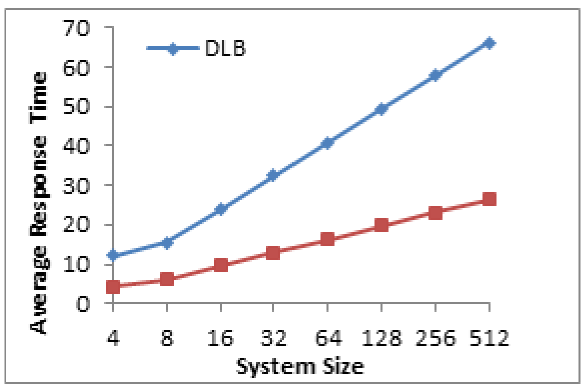


Figure 2. Effect of System Size



CONCLUSION

The resource aware dynamic load balancing algorithm (RWLB) given here is by considering the scalability of the grid system which consists of heterogeneous processing nodes and addressed considerable communication overhead involved in collecting the information from the various nodes in the grid (Zeng & Veeravalli, 2004). The simulation revealed the performance of the newly generated load balancing algorithm compared with the existing diffusion load balancing algorithm and the experimental results show that the newly generated algorithm has done better than the diffusion load balancing algorithm and reduces the average response time of the jobs.

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Chapter 16
Air Miner:
An Air Pollution Detection and Alert System

Raxit Girishkumar Jani
Gandhinagar Institute of Technology, India

Ramesh T. Prajapati
https://orcid.org/0000-0003-4267-0531
Shree Swaminarayan Institute of Technology, Bhat, India

Anilkumar Suthar
https://orcid.org/0000-0003-3267-8636
L.J. Institute of Engineering and Technology, India

ABSTRACT

Air miner gathers live data about the carbon monoxide indoors. It significantly reduces the chances of residents contracting respiratory disorder owing to its proactive alert systems. It utilizes the NodeMCU (ESP-8266) for the smaller-scale micro-controller board to interface with the gas sensors, Django for the front end web interface, and Python in the backend for systematic AI. A comprehensive indoor air monitoring and analysis system shall serve like a fitness tracker for your house. This system will proactively alert users if it can predict a rise in the concentration of gas levels. The primary purpose of 'air miner' is to alert users proactively about a probable surge in the concentration of carbon monoxide. Along with this, it will give a complete analysis of the similar metrics. Air quality monitoring system for city uses multiple sensors with location co-ordinate. AQI LED indicator is actuated as per pollution level, and the real-time pollution level is visualized using the line graph.

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INTRODUCTION

Wireless sensor networks (WSNs) are gradually affecting normal living. A WSN is a community along with sensor nodes. Each sensor can come across positive elements like air pressure, air composition, and water quality. WSNs are utilized in a huge kind of settings, which include non-public space, commercial floors, agriculture, domestic application tracking structures, manufacturing facility automation, automotive, and plenty of different fields. WSNs are associated with the idea of IoT. In IoT, gadgets are interconnected to transmit records thru allotted sensor networks. IOT has beneficial programs withinside the scientific field. Devices consisting of smartphones and sensing structures may be related to create an infrastructure that offers get entry to to fitness care facts and services. This method is mentioned as "Mobile-Health" (Dhingra et al., 2019). Mobile-Health may be regarded because the effect of the convergence of wi-fi conversation structures, WSNs, and worldwide computing tools.

Governments and Citizens are looking for scientific intellect to challenge the common threat of pollution in its many procedures.

Currently cell apps are capin a position to perform capabilities like reporting reputation of air excellent, air excellent forecasts, air excellent tracking in a specific area, and dangers highlighting linked with threshold breaking excellent, etc. There also are cell apps designed for mass polluting sectors like industries. Industries or company businesses are actually capable of combine and streamline environmental processes, which include air emissions analyses, water and strength management, and waste discount particular to them, via such apps. Around 90% of the populace in low and middle salary countries are supplied to perilous ranges of encompassing air infection. The World Bank works with developing countries and development accomplices to decrease infection through helping checking and examination, administrative changes, and ventures. In 2016 for instance, the Bank conferred US$1 billion to permit China to decorate air excellent through lessening discharges of unique air poisons from mechanical, shipping and USA. reassets withinside the territory of Hebei, and through increasing energy effectiveness and smooth energy via inventive financing withinside the Beijing-Tianjin-Hebei district (in any other case referred to as Jing-Jin-Ji locale) that covers the capital place and neighboring regions. Death related to encompassing air infection have improved in intensely populated, brief urbanizing areas, even as dying diagnosed with cooking and warming houses with robust energizes have stayed steady despite development additions and enhancements in health administrations. Illnesses credited to the 2 styles of air infection brought about 1 of each 10 deaths in, as a minimum 2013 than six instances the amount of dying because of intestinal sickness.

The Cost of Air Pollution: Strengthening the economic case for interest, a joint research of the World Bank and the Institute for Health Metrics and Evaluation (IHME), appears to appraise the prices of surprising losses diagnosed with air contamination, to improve the case for interest and inspire simple management with reference to uncommon assets. An evaluated five.five million lives had been misplaced in 2013 to ailments associated with outdoor and own circle of relatives unit air contamination, inflicting human enduring and lowering economic improvement. While pollution-associated deaths strike in particular younger kids and the elderly, untimely deaths additionally bring about misplaced exertions earnings for working-age guys and women. The document unearths that annual exertions earnings losses cost (Santi et al., 2018) the equal of just about 1 percentage – 0.eighty three percentage -- of Gross Domestic Product (GDP) in South Asia. In East Asia and the Pacific, in which the populace is ageing, exertions earnings losses constitute 0.25 percentage of GDP, at the same time as in Sub-Saharan Africa, in which air pollution (Lo Re et al., 2014) impairs the incomes capacity of more youthful populations, annual exertions earnings losses constitute the equal of 0.sixty one percentage of GDP.

We newly sold MQ-7 CO sensor, however now no longer as soon as had time to gather a schematics for it, so this became the appropriate time to do so. After an hour of looking net for any directions, I found out that I cannot discover any manual that on the identical time follows sensor creator's commands supplied in its datasheet and explains something at all (one instance regarded to have pretty excellent code, however it wasn't clean a way to observe it, others had been overgeneralized and would not paintings well).

So we spent approximately 12 hours for growing plans, making and printing 3d case, checking out and calibrating the sensor, and tomorrow went to the suspicious boiler. It grew to become out that CO tiers there had been extraordinarily high, and might be deadly if CO insurance time had been longer. So I agree with everybody who has comparable situation (like fuel line boiler or different combustion taking place interior a residing space) need to get such sensor to save you something awful from taking place. All that passed off weeks ago, due to the fact then I stepped forward schematics and application pretty a lot, and now it appears to be moderately excellent and comparatively simple (now no longer 3-lines-of-code simple, however still). Although I desire that a person with specific CO meter will offer me a few remarks on default calibration that I positioned with inside the sketch - I suspect it's miles a ways from excellent.

Internet of Things (IoT) consists of normal objects ("Things") which have community availability, letting them ship and get records. "Things" consist of people, records, software program agents, or some other digital taking part actors. There are 5 sorts of "Things" applied on this chapter: Arduino Uno (Microcontroller), ESP8266 (Wi-Fi Module), Cloud provider (Ubidots), fuel line sensors, and Android. These "Things" are coordinated to make a framework such that every "Thing" can paintings personally and might gather, keep, and get better records to deal with the problem. The essential IoT version is a three-layered layout composed of the Application, Network, and Sensor Layers (htt1) (Figure 1). In the Sensor Layer, information is attained from the actual world. The Network Layer gets information dispatched with the aid of using the Sensor Layer. This layer acts as middleware among sensor layer and alertness layer. Lastly, the Application Layer affords offerings to include or look into the information that has been acquired from the preceding layers. In these paintings, a 3-layered structure changed into used. Global Positioning System (GPS) GPS sends information to receivers which are set up at the ground. Data is amassed from satellites orbiting across the earth. Anyone can make use of GPS free of charge with a appropriate receiver. This era is used for navigation systems. Google Maps Navigation changed into applied as part of this research. Google Maps Navigation is a flexible software that has been included into the Google Maps cell software. Google Maps Navigation makes use of a web connection to get admission to the GPS navigation gadget to discover the person's area. The person can input a vacation spot into the software, for you to plot a course from supply to vacation spot. The software indicates the person's development alongside the path and it troubles directions.

Android Platform Recently, enhancements in phone era have modified the significance of mobile telephones. A tele cell smartphone isn't simply used for speaking however has additionally turn out to be a essential a part of everyone's day by day life. Presently the digital marketplace is obtained with the aid of using Android era. Over time, smartphones and the Android gadget are have turn out to be greater prevalent. In these paintings, we used Java language, the Eclipse platform, Android ADT, and the Android SDK (htt2) to expand the IoT-Mobair android software. The IoT-Mobair software makes use of person area information (through GPS gadget), the Internet of Things (IoT), sensors, and widespread web sites to offer air exceptional information. If a person is starting up to a vacation spot, the pollutants degree of the whole path is predicted, and a caution is displayed if the pollutants degree is simply too excessive in order that the person can re-path his journey.

The records passage for indoor infection may be located right here Air infection may be characterised because the outflow of hurtful materials to the air. This expansive definition consequently, exemplifies numerous toxins, including: sulphur dioxide (SO2), nitrogen oxides (NOx), ozone (O3), particulate matter (small suspended debris of various sizes), carbon monoxide (CO) and unstable natural compounds (VOCs). Carbon dioxide (CO2) and different greenhouse gases aren't commonly taken into consideration inside this class and are handled one by one on Our World in Data.

BACKGROUND

In 2020, air pollutants is risking to the human beings healthy, in particular, Bangkok metropolis that the residents are growing rapidly. Not simplest the growing of the dense metropolis, however additionally the developing up of industrials accomplishing to the needs of marketing. Thailand 4.zero has come to be a strategic coverage that to force the economic system primarily based totally on virtual transformation, wherein the improvement human beings high-satisfactory and elevating the enterprise sectors. Smart metropolis is part of the growing of human beings high-satisfactory primarily based totally on IoT network. Presently, the studies demanding situations on clever metropolis are to clever metering, clever water, air high-satisfactory tracking, fitness tracking, and so on.

From a reporting of pollutants manage department, Ministry of Natural Resource and Environment in 2018 observed that the ar pollutants in Bangkok metropolis and Chiang Mai metropolis has been very risked from the particulate count (PM2:five) and ozone (O3). Figure 1 indicates the reporting information withinside the Bangkok metropolis and smoke place in Chiang Mai metropolis that laid low with the air pollutants. According to the IoT paradigm, the whole thing and anyone may be related . Nowadays, LTE Release thirteen has been lunched a standardization of latest radio get right of entry to network (RAN) generation that so-referred to as NB-IoT which has a frequency at 2 hundred kHz carrier. Essentially, NB-IoT has been supplied for lengthy battery lifestyles, low value, lengthy coverage, and assist to a big range of gadgets. The kingdom of the artwork assessment of the spectrum sensing utilization of NB-IoT withinside the present offerings for which air high-satisfactory is focusing in a clever metropolis for tracking the electricity of living, climate tracking, waste management, visitors management, noise tracking, parking management, electricity consumption, management, and additionally air high-satisfactory tracking may be very important. There are numerous studies focusing at the improvement of sensor technology in clever metropolis. Literature paintings on a clever car tracking machine for air pollutants detection is proven in via way of means of the usage of of wi-fi sensor network (WSN) for software of environmental tracking. The sensors had been established to the car which has extra 20 cellular nodes, wherein the sensors are related to the clever telecellsmartphone to be able to display the humidity, temperature, CO, and NO2. The luminosity sensor (LDR) and noise sensor (dB) has been supplied interestingly.

However, an answer of IoT is specializing in a decrease energy huge place network (LPWAN), wherein the layout and implementation of LPWAN for air high-satisfactory tracking is supplied in, the structure of the LPWAN primarily based totally air high-satisfactory tracking is therein as Fig.1. With a place variety of some to tens of kilometers and battery lifestyles of lengthy time, LPWA answers are growing for the IoT, low-value, lowpower, and low-throughput. A very lengthy variety of LPWA primarily based totally on clever chip allows gadgets to transport and unfold over big place areas. Normally, the air pollutants tracking station is excessive value. Most of researchers were targeted on layout and implementation for clever metropolis. The transportable sensor in low value has been supplied in, comparing is emphasize. While the forecasting version primarily based totally on system gaining knowledge of set of rules may be very interesting.

HazeEst is a platform of system gaining knowledge of to estimate air pollutants each constant and cellular station as defined in. As famous that the improvement of air pollutants detection sensor is designed via way of means of the usage of WSN as defined on this bankruptcy, we gift a improvement of the air pollutants detection sensors primarily based totally on NB-IoT for clever towns in Thailand. While the sensors inclusive of carbon monoxide: CO, ozone: O3, particulate count: PM10, nitrogen dioxide: NO2, and sulfur dioxide: SO2 is supplied on this bankruptcy. The relaxation of the bankruptcy is defined as follows: The phase II gives the descriptions of layout and implementation. Section III mentions to the experimental end result, map place, size end result and AQI evaluated. Finally, the concluded of this bankruptcy is drawn. Firstly Ozone sensor (O3). The specification of product length became 32 mm 22 mm 30 mm, working voltage at DC five V, and the decision of sensor is 1 ppm to 500 ppm, and interfaced with analog circuit. Secondly, carbon monoxide: CO and nitrogen dioxide: NO2 sensor. The decision of CO sensor is 1 ppm to a thousand ppm below DC five V, and is zero.05 ppm to ten ppm for NO2 sensor via way of means of the usage of I2C interface. Thirdly, sulphur dioxide: SO2 sensor module, length as 32 mm 22 mm 33 mm, the operating voltage DC five V, and the principle chip is primarily based totally on LM393 fueloline sensing probe with the decision is 10 ppb to at least one ppm. Fourthly, the particulate count or dirt sensor (PM10), (PM2:five) and (PM1). The decision of sensor is zero g=m3 to a thousand g=m3 and interfaced via way of means of the usage of RS232.Air pollution in large urban areas has a drastic effect on humans and the environment. Ecological issues in India are growing quickly.

Air contamination is mainly caused by vehicles and industries which cause various respiratory diseases such as asthma and sinusitis. The quality of air is inferior in metropolitan cities like Kolkata, Delhi, and Mumbai due to a large amount of carbon dioxide and other harmful gases emitted from vehicles and industries. An extensive number of projects have been described in the literature that utilize low-cost air pollution sensing devices that can be carried by individuals or by versatile vehicles. In two studies, the authors demonstrated an environmental sensing approach that reinvigorates attention and sympathy of citizens toward pollution. Exposure Sense is a portable participatory sensing framework that is used to screen one's everyday activities.

In another study, the authors present a cloud-based system that uses knowledge-based discovery to find real-time air quality data. The data are collected by monitoring stations that are placed in various geo-locations. This system uses mobile clients for monitoring purposes. An Android application which provides users with information about air quality: By joining user area information and metropolitan air quality data provided by monitoring stations, this application provides a ubiquitous and unobtrusive monitoring framework that is ready to advise users about their daily air pollution exposure.

Reshi et al. designed a WSN platform, called VehNode, that provided automobiles with the capacity to monitor the level of pollutants in smoke released by the vehicle. Mujawar e al. outlined an air pollution contamination measuring system utilizing WSN for use in Solapur City. Micro-sensor nodes detect the target gas by measuring the sensing layer's electrical conductivity. When the gases touch the surface of the sensor they are assimilated and the conductivity changes. Also, a semiconductor sensor is used at the emission outlet of the vehicle to sense the level of pollutants and transmit this level to the microcontroller

In another study by De Nazelle et al., the authors demonstrated environmental sensing approaches that reinvigorated the awareness and sympathy of individuals towards pollution.

"Air pollution is a challenge that threatens basic human welfare, damages natural and physical capital, and constrains economic growth. We hope this study will translate the cost of premature deaths into an economic language that resonates with policy makers so that more resources will be devoted to improving air quality. By supporting healthier cities and investments in cleaner sources of energy, we can reduce dangerous emissions, slow climate change, and most importantly save lives," said Laura Tuck, Vice President for Sustainable Development at the World Bank.

The report of air pollution is a burden of disease associated to urgent call the government for necessary action," said Dr. Chris Murray, Director of IHME. "Of all the different risk factors for premature deaths, this is one area, the air we breathe, over which individuals have little control. Policy makers in health and environment agencies, as well as leaders in various industries, are facing growing demands – and expectations – to address this problem."

One day a lady called us at the middle of the night because she felt really sick - she had shakiness, tachycardia, nausea, high blood pressure, she even fainted for unknown time (probably ~5 minutes, but there is no way to tell), all without any outward reason. She lives in a small village far away from hospitals (60 km from our place, 30 km to the closest hospital, 10km without any normal road in between), so we rushed to her and got there soon after the ambulance. She got hospitalized and in the morning she felt almost well, but doctors weren't able to find the cause of it. The next day we had an idea: it could have been CO poisoning, since she has gas water boiler (on the photo), and was sitting close to it for the whole evening when it happened. An Arduino board. I prefer Chinese clone of Arduino Nano for its exceptional price of $3, but any 8-bit arduino will work here. Draft uses some advanced timers operation, and was tested only on atmega328 microcontroller - even if probably it will work well on others too. Pollution in earlier days was negligible. Currently, however, pollution is increasing day-by-day because of various reasons such as industrial growth, development of automobile industries, and chemical industries. Therefore, to reduce the level of pollution from such sources and to protect humans and the environment from harmful gasses, this air pollution kit was developed that helps a person to detect, monitor, and test air pollution in a given area. The kit has been integrated with the mobile application IoT-Mobair that helps the user in predicting the pollution level of their entire route. Further, data logging can be used to predict AQI levels. This proposed air pollution monitoring kit along with the integrated mobile application can be helpful to people suffering from respiratory diseases. The app had following features, indices of air quality for a specific city using real-time computation, air quality daily forecasts, timing outdoor activities for different recommendation of generation, air quality dips related to health risks, specific reports for air quality measures based on locations, air quality maps generation. The proposed system faces with computational complexity particularly when we are dealing with big sensor data. One solution could be using fog computing, instead of cloud computing to reduce computation complexity and enhance the performance of the system. We can also implement zero tolerance fast big data real-time stream analytical tools to process such a complex system.

A MQ-7 CO sensor. Most commonly available with this Flying Fish sensor module, it has to run through a small modification, details in the next step, or you can use a separaten MQ-7sensor.

A NPN bipolar transistor. Virtually any NPN transistor that can handle 300 mA or more will work here. PNP transistor won't work with a mentioned Flying Fish module (because it has heater pin soldered to sensor's output), but can be used with a discrete MQ-7 sensor.

Resistors: 2 x 1k (from 0.5k to 1.2k will work fine), and 1 x 10k (that one is best kept precise - although if you absolutely must use a different value, adjust reference_resistor_kiloohm variable in the sketch accordingly).

Capacitors: 2 x 10uF or more. Tantalum or ceramic ones are required, electrolytic won't work well due to high ESR (they won't be able to provide enough current to smooth high-current ripple).

Green and red LEDs to indicate current CO level (you can also use a single dual-color LED with 3 terminals, as we used in our yellow box prototype).

One Piezo buzzer to indicate high CO level.

One Breadboard and wires (you also can solder everything to Nano pins or squeeze into Uno sockets, but it's easy to make a mistake this way).

Module Modification or Discrete Sensor Wiring

Sensitive material of MQ-7 gas sensor is SnO2, which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor's conductivity is more higher along with the gas concentration rising. When high temperature (heated by 5.0V), it cleans the other gases adsorbed under low temperature. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-7 gas sensor has high sensitity to Carbon Monoxide. The sensor could be used to detect different gases contains CO, it is with low cost and suitable for different application.

For module, you must desolder resistor and capacitor, as shown on the photo. You can desolder basically everything if you want - module electronics is totally unusable, we use it only as holder for the sensor itself, but these two components will prevent you from getting true readings, If you are using discrete sensor, attach heater pins (H1 and H2) to 5V and transistor's collector correspondingly. Attach one sensing side (any of A pins) to 5V, another detecting side (any of B pins) to 10k resistor, just like the analog pin of the module in schematics.Why we need all these obstacles at all, why not to attach 5V, ground, and just get readings? Well, you won't get anything useful this way, appropriately. According to MQ-7 datasheet, sensor has to run through high- and low-heating cycles in order to get proper measurements. During low temperature phase, CO is absorbed on the plate, producing expressive data. During high temperature phase, absorbed CO and other compounds evaporate from the sensor plate, cleaning it for the next amount.

So in general operation is simple:

1. Apply 5V for 60 seconds and don't use these readings for CO measurement.
2. Apply 1.4V for 90 seconds and use these readings for CO measurement.
3. Go to step 1.

But here's the problem: Arduino can't provide enough power to run this sensor from its pins - sensor's heater requires 150 mA, while Arduino pin can deliver no more than 40 mA, so if attached directly, Arduino pin will burn and sensor still won't work. So we must use some kind of current amplifier that takes small input present to control large output current. Another problem is getting 1.4V. The only way to reliably get this value without introducing a lot of analog mechanisms is to use PWM (Pulse Width Modulation) approach with feedback that will control output voltage.

NPN transistor solves both problems: when it is continually turned on, voltage across the sensor is 5V and it is heating for high-temperature phase. When we apply PWM to its input, current is pulsing, then it is smoothed by the capacitor, and the average voltage is kept continuous. If we use high frequency PWM (in the sketch it has frequency of 62.5KHz) and average a lot of analog readings (in the sketch we average over ~1000 readings), then the end result is quite reliable. It is critical to add capacitors according to schematics. Images here illustrate dissimilarity in signal with and without C2 capacitor: without it, PWM ripple is noticeably visible and it significantly distorts readings.

Schematics and Breadboard

If you are trying to add Wifi connectivity to an existing Arduino project or have serious aspirations for developing a Internet of Things (IoT) solution, Arduino + ESP8266 wifi module is one of the top choices. Especially the Nano because it is super cheap (<$3) and is very small in size. Using a few kind of web-server at once on ESP8266 (e.g. thru Lua) would not reduce it because of the shortage of IO pins on ESP8266. You can get a complete IoT node out at under $12 with some sensors, Arduino Nano and a ESP9266 module (aside from the strength deliver). Inspite of a plethora of posts on-line it grew to become out to be very tough for me to get this to aggregate to paintings. I spent atleast three-four days till I absolutely were given this proper. The fundamental hassle I see is that a whole lot of the answers on-line are absolutely down-proper incorrect, now no longer-advocated or for different comparable boards (e.g. Arduino Mega). Also there are some gotchas that have been now no longer typically referred to as out. Before I begin permit me get all of these out of the manner Arduino Uno/Nano could be very unique from say Mega that could deliver greater cutting-edge and feature unique quantity of UART. The steps to make a Uno and Nano paintings aren't like them. Power Supply ESP8266 is powered through three.3V and NOT 5V. So you can't have a not unusualplace strength deliver among Arduino and ESP8266 ESP8266 attracts manner greater cutting-edge (200mA) then it is able to be provided through the three.3v pin at the Uno/Nano. Don't even strive them, I do not purchase all people who claims to have executed this. Maybe they have got a few different excessive strength variation of Arduino (Mega??) which can do this.

Figure 1. Schematics

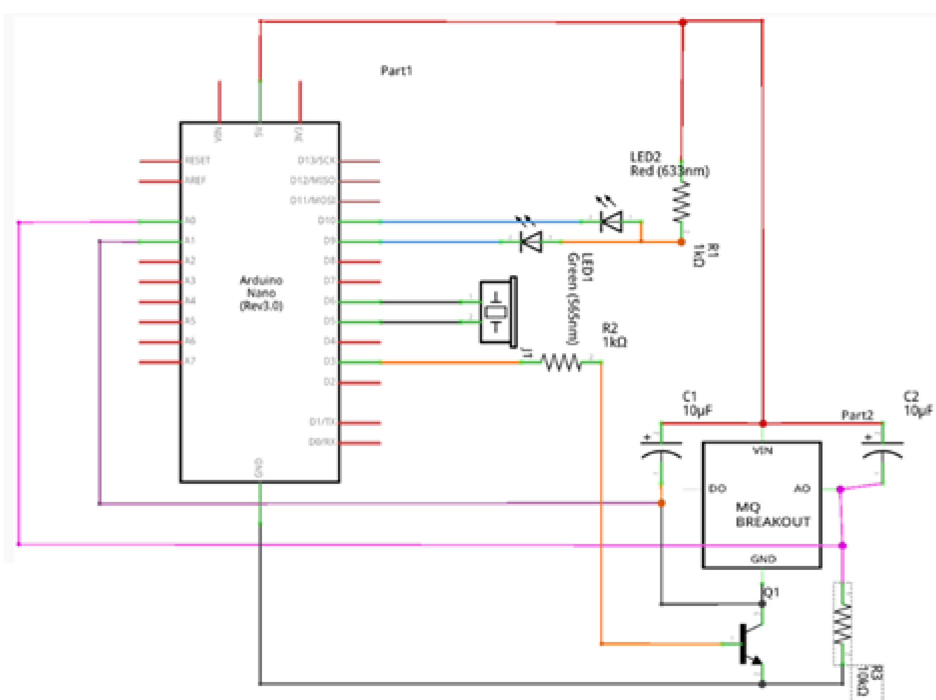
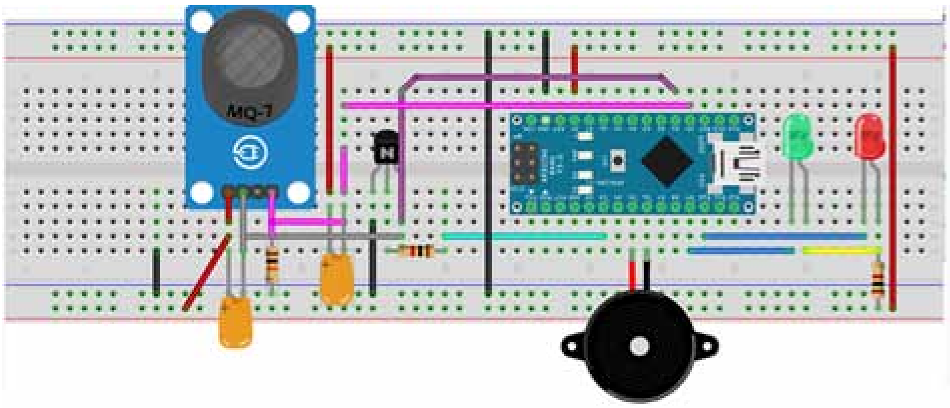


Figure 2. Breadboard assembly



So you both use a three.3v 1A strength deliver to ESP8266 with not unusualplace floor with the 5V powering Arduino, or you operate a step down 5v to three.3v (e.g. like here).

Arduino <-> ESP8266 All the ESP8266 I offered got here with the UART serial IO pace (BAUD) set to 115200. Now the hassle is that Uno/Nano has best one HW serial, which is ready for use for speaking with the PC over USB with that you are debugging. You can use every other IO pins to speak to the ESP8266 the usage of SoftwareSerial, however it does now no longer aid that excessive a BAUD pace. If you strive 115200 to speak with Arduino <-> ESP8266 you may get rubbish. A lot of articles on-line display a setup with Arduino Mega which does have HW serial IO the usage of which you could without problems get 115200 and greater. So you want to dial the ESP8266 settings to transport the conversation pace to a greater viable BAUD of 9600 Arduino IO pins have 5V and ESP8266 accepts three.three v (max three.6). I actually have visible human beings at once join the pins however you're over using the ESP8266. If it doesn't burn out immediately (the inexpensive ones does), it's going to burn out soon. I endorse you operate a voltage divider the usage of easy resistor to have Arduino transmission (TX) pressure ESP8266 receive (RX) For a few unusual motive D2/D3 pins on Arduino Nano didn't paintings for me for the speaking with ESP8266. I haven't any reason behind this and it came about on separate Nano. The Arduino might simply examine an entire bunch of rubbish character. So I needed to flow to the pins 8/9. In spite of anything I did, rubbish characters might nevertheless are available in sometimes. So I wrote a small clear out out code to disregard themCAUTION! Variation of a preferred breakout module is required! Without amendment module is useless. Modification is defined withinside the 2d step. It is fundamental to apply pins D9 and D10 for LEDs, for the reason that there we've got outputs of hardware Timer1, it's going to permit to easily fluctuating their colors. Pins D5 and D6 are used for buzzer, due to the fact D5 and D6 are outputs of hardware Timer0. We will represent them to be inverse one to another, so they'll transfer among (5V, 0V) and (0V, 5V) states, accordingly generating sound on buzzer. Warning: this impacts Arduino's fundamental timing interrupt, so all time-based functions (like millis()) won't yield accurate consequences on this sketch.

Pin D3 has hardware Timer2 output joined to it (in addition to D11 – however it's much less handy to place twine on D11 than on D3) – so we're the usage of it to supply PWM for voltage regulatory transistor. Resistor R1 is used to manipulate brightness of LEDs. It may be everywhere from three hundred to 3000 Ohm, 1k is as an alternative most advantageous in brightness/strength consumption. Resistor R2 is used to certain transistor's base cutting-edge. It shouldn't be decrease than three hundred Ohms (to now no longer overload Arduino pin), and now no longer more than 1500 Ohms. 1k there's a secure choice.

Resistor R3 is utilized in collection with sensor's plate so one can create a voltage divider. Voltage on sensor's output is same to R3 / (R3 + Rs) * 5V, wherein Rs is gift sensor's resistance. Sensor resistance relies upon on CO concentration, so voltage modifications consequently. Capacitor C1 is used to easy enter PWM voltage on MQ-7 sensor, the better is its capacitance the more, however additionally it has to have low ESR – so ceramic (or tantalum) capacitor is favored here, electrolytic one won't execute well. Capacitor C2 is used to stage sensor's analog output (output voltage relies upon on enter voltage – and we've got pretty a excessive cutting-edge PWM here, that impacts all schematics, so we want C2). The modest answer is to apply the identical capacitor as C1. NPN transistor both conducts cutting-edge all of the time to offer excessive cutting-edge on sensor's heater, or works in PWM mode accordingly falling heating cutting-edge.

Arduino Program

As mentioned above I first set the ESP8266 BAUD rate to 9600. If yours is already 9600 then nothing to be done, if not you need to make the following connection PC (USB) <-> FTDI <-> ESP8266 Then using specific AT commands from the PC set the 9600 BAUD rate on the ESP8266. I used the following circuit. Where the connections are as follows

FTDI TX –> Via voltage divider (to move 5v to ~3.3v) to ESP8266 RX (**blue** wire)
FTDI RX –> Directly to ESP8266 TX (**green** wire). A 3.3v on Nano I/0 pin will be considered as 1.
FTDI GND to common ground (**black**)
ESP8266 GND to common GND (**black**)
ESP8266 VCC to 3.3v (**red**)
ESP8266 CH_PD to 3.3v via a 10K resistor (**red)**
Power supply GND to common GND PC to FTDI USB.

Calibration is described in the following steps. Rough calibration is very simple, precise is quite complex. On the general level, program is rather simple: First we calibrate our PWM in order to produce stable 1.4V prerequisite by sensor (proper PWM width depends on a lot of parameters like exact resistor values, this exacting sensor's resistance, transistor's VA curve etc etc - so the best way is to try various values and use one that fits best). Then, we endlessly run through cycle of 60 seconds heating and 90 seconds measurement. In implementation it gets somewhat complicated. We have to use hardware timers because everything that we have here needs high-frequency stable PWM in order to function properly. In the program there are 3 tasks that handle timers: setTimer0PWM, setTimer1PWM, setTimer2PWM. Each of them sets timer in PWM mode with given parameters (commented in the code), and sets pulse width according to input values. Measurement phases are switched using functions startMeasurementPhase and startHeatingPhase, they handle everything inside. and set proper timer values for swapping between 5V and 1.4V heating. LEDs state is set by function setLEDs which accepts green and red brightness on its input (in linear 1-100 scale) and alters it into corresponding timer setting.

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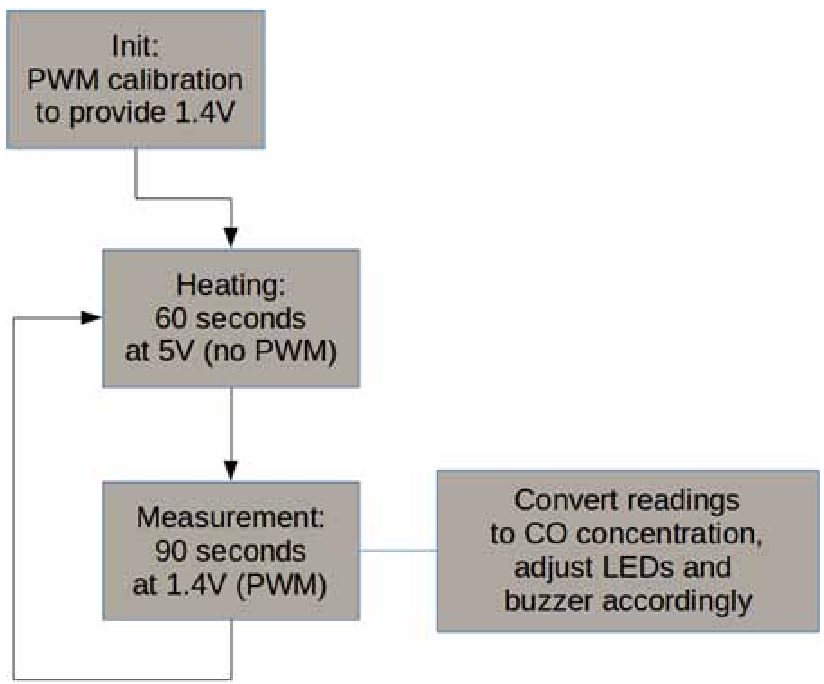
Figure 3. System Flow
CAUTION: SENSOR REQUIRES PHYSICAL CALIBRATION FOR ANY PRACTICAL USE. WITHOUT CALIBRATION, BE CONTINGENT ON PARAMETERS OF YOUR PARTICULAR SENSOR, THIS SKETCH MIGHT TURN ON ALARM IN CLEAN AIR OR NOT IDENTIFY LETHAL CARBON MONOXIDE CONCENTRATION.



Buzzer state is controlled using purposes buzz_on, buzz_off, buzz_beep. On/off functions turn sound on and off, beep function produces precise beeping sequence with period of 1.5 seconds if it is periodically called (this function returns straightaway so it doesn't pause the main program - but you have to call it again and again to produce beeping pattern). Program first tracks function pwm_adjust that finds out proper PWM cycle width in order to achieve 1.4V through measurement phase. Then it beeps a few times to designate that sensor is ready, shifts into measurement phase, and starts the main loop. In the main loop, program authorizations if we spent enough time in current phase (90 seconds for measurement phase, 60 seconds for heating phase) and if yes, then changes current phase. Also it constantly updates sensor readings using exponential smoothing: new_value = 0.999*old_value + 0.001*new_reading. With such parameters and gaging cycle, it averages signal over approximately last 300 milliseconds. If you collected everything properly, after running sketch you will see roughly like this in Serial monitor: adjusting PWM w=0, V=4.93 adjusting PWM w=17, V=3.57

This part is adjusting PWM width in order to produce sensor's heater voltage as close to 1.4V as possible, measured voltage is subtracted from 5V, so our ideal measured value is 3.6V. If this process never ends or ends after a single step (resulting in width equal to 0 or 254) then something is wrong. Check if your transistor is really NPN and is properly associated (make sure you used base, collector, emitter pins right - base goes to D3, collector to MQ-7 and emitter to ground, don't count on Fritzing breadboard view - it is wrong for some transistors) and make sure that you associated sensor's input to Arduino's A1 input. If everything is fine, you should see in Serial Plotter from Arduino IDE something similar to the image. Heating and measurement cycles of 60 and 90 seconds length are running one after another, with CO ppm measured and updated at the end of each cycle. You can take some open flame close to the sensor when measurement cycle is nearly finished and see how it will affect evaluations (depending on flame type, it can produce up to 2000 ppm CO concentration in open air - so even though only a small portion of it actually goes into sensor, it still will turn on the alarm, and it won't go off until the end of the next cycle). I presented it on the image, as well as the response to fire from the lighter.

App for pollution management, industries based specifically, streamline and integrate environmental processes, including air emissions analyses, water and energy management, and waste reduction. Such apps provide visibility for users, specifically industries into the risk of incidents such as chemical leaks, oil spills and toxic substances improper disposal, while compliance strengthening with environmental standards and regulations. Development outsources assistance for such apps that can cover areas like:

1. Common platform to track and manage initiative environment across organizations
2. Track compliance with ISO 14001 and other industry specific environmental standards
3. Real-time environmental processes view, audit incident and findings
4. Trigger notifications for threshold breaches
5. Risk highlights related with threshold breaks

The app had Air Quality Monitoring following features,

1. Indices of air quality for a specific city using real-time computation, air quality daily forecasts,
2. Timing outdoor activities for different generation recommendation,
3. Air quality dips related to health risks,
4. Specific reports for air quality measures based on locations,
5. Air quality maps generation.

The design of the air pollution monitoring system involves three main phases:

Phase 1: detect the concentration of air pollutants in the area of interest via sensors.
Phase 2: develop a user-friendly and portable interface – an Android application, which the user can use to know the pollution level in his/her particular area.
Phase 3: predict air quality using the analytical module.

Phase 1: Detection of air pollutants level

In this section, air pollution detection kit is developed using IoT. This is built in two steps:

Step 1: the first step deals with the collection of data from gas sensors connected to Arduino board and information is sent to a cloud platform (i.e., Ubidots) that stores it.
Step 2: the second step portrays accessing this information utilizing Android platform.

For this purpose, the data is generated by gas sensors (viz. Carbon monoxide, Carbon dioxide, Methane) that read concentration of gas in the region. In the previous step, Arduino was connected to the cloud (i.e., Ubidots) such that sensor data is sent from the Arduino board to Ubidots. In this step, the developed Android application IoT-Mobair receives sensor data sent by Arduino using Ubidots services. The following steps are undertaken in order to accomplish these tasks: Develop Android client: To handle the HTTP connection to the Ubidots server, an Android client is developed. For security purposes, the authentication token is used. Handle JSON format to read data: After requesting remote services by the android application, a JSON response is received that is analyzed to extract data, i.e., the variable value (sensor information), timestamp, and AQI.

Phase 2: Creating the front-end Android interface

This phase consists of two steps:

Step 1: draw a route that shows the user their exposure to air pollution.
Step 2: display the data collected by IoT over app using google maps with pollution color codes mentioned in table 2 through big data predictive analytics.

These steps are described below:

Step 1: Draw route from source to destination

For a user traveling from a source to a destination, the pollution level of the entire route is predicted and a warning is displayed if the pollution level is too high so that the user can re-route his journey.

The data collected from the sensors and other trusted websites is made as are placed in a large database. When the user enters his destination of travel, the IoT-Mobair android application first converts the address into corresponding latitude/longitude form. The latitude and longitude are searched in the cloud-based database.

Step 2: Prediction and Analysis

Historical data can be used to predict pollution levels for subsequent days.

A dataset (Figure 8) is maintained so that an evaluation of consecutive days can be done. Suppose AQI is mapped to 7 consecutive days at a particular time such that on

Day 1: From time 12:00-15:00 the AQI is 423 (High)

Day 2: From time 12:00-15:00 the AQI is 500 (High)

Similarly, for the next five days, the AQI is very high from 12:00-15:00. Therefore, we can predict that the pollution level on the eighth day at the same place and time will be high (i.e. ~400-500). Therefore, if the system is capable of logging daily data, it can be used to warn the user not to travel during that time. This same data can be represented in the form of scatter plots and histogram in order to make the analysis easier. The high concentration of dots in the time duration 12-15 shows that during this time particular region is highly polluted. Unfortunately if you try to power the esp from the nano the com port will stop working, to get the Wifi module running you will need to power it externally. The easiest way to do this is to use a second arduino, any will work you just need the 3.3v pin and the Gnd pin.

Arduino pins
3.3v --> Vin on esp8266
Gnd --> Gnd on esp8266
pin 10 --> esp8266 TX pin
pin 11 --> esp8266 RX pin

As the Arduino nano takes male jumper cables while the ESP 8266 requires female jumper cables, a bread board can be used to make the connections. Its also useful as both the CH_PD and VCC pins on the ESP 8266 require power.

To program it using the Arduino IDE, choose "Generic ESP8266 module" as your board from the menu. Now, also connect the Nano's RST pin to GND. This is important. Connect the Nano to your PC's USB port. Here comes the hard part: hit the upload button. Once the two lines of white text that inform you that the sketch has been compiled show up, disconnect the RST pin from GND. The timing here is very tricky and you need to be very patient. I get it right about 1¤10 times, which sucks. If it works, you should be able to see the progress in the Arduino IDE and also see the ESP-01's led flash. In which case, you should connect the RST to GND again, and start over. Rinse and repeat until it works. Once you're done programming the ESP-01, remove the GND connection from the GPIO0 pin. If you need to monitor the serial console, swap the TX and RX pins. Otherwise you can remove them completely too. Also remove the connection from CH_EN pin, you only need the VCC and GND pins connected for the ESP-01 to operate. That's it, your ESP8266 should be working now and if you added code to connect it to your wifi network, you should be able to see it. The ESP-01 by default comes with nonOS SDK bootloader that communicated via AT commands, you can find the complete command set from Expressif here. This is designed for an MCU (like Arduino Nano) to use it purely as an WiFi module rather than using it as a stand-alone MCU (for which it will require NodeMCU SDK). If you ever upload an Arduino sketch up to the ESP-01, it will erase the AT Command firmware. Assuming your ESP-01 is still having the AT Command firmware. What @Ben provided is a sketch that allows you to type AT commands via the Serial Monitor to internact with the ESP-01, it is manual, and good for testing if ESP-01 is working (you type AT and press return on Serial Monitor, the ESP-01 will ack with Ok) but not practical as a real application. The minimum commands required to established an WiFi connection with ESP-01. As for hardware interface, please noted that what provided is correct in principle, but you need to be aware that the ESP-01(ESP8266 to be precise) is a 3V3 MCU, so the connection is depended on what kind of host board you are using. If you are using Arduino Uno/Nano, both are having a 5V MCU, you will need a voltage divider (two resistors to drop the voltage to 3v3 before connecting to ESP-01) or a level shifter chip at least for the ESP-01 Rx pin to avoid the potential damage to the ESP-01.

Sensor Calibration

According to industrialist's datasheet, sensor should be running heating-cooling cycles for 48 hours in a row before it can be calibrated. And you ought to do it if you intend to use it for a long time: in my case, sensor evaluation in clean air changed for about 30% over 10 hours. If you won't take this into account, you can get 0 ppm result where there is really 100 ppm of CO. If you don't want to wait for 48 hours, you can monitor sensor output at the end of measurement cycle. When over an hour it won't change for more than 1-2 points - you can stop heating there.

Rough Calibration

After consecutively sketch for at least 10 hours in clean air, take raw sensor value in the end of the measurement cycle, 2-3 seconds before heating phase surprises, and write it into sensor_reading_clean_air variable (line 100). That's it. Program will estimate other sensor parameters, they won't be exact, but should be enough to differentiate between 10 and 100 ppm concentration.

Precise Calibration

I highly endorse to find a calibrated CO meter, make 100 ppm CO sample (this can be done by taking some flue gas into syringe - CO attention there can easily be in the range of several thousands ppm - and slowly putting it into closed jar with calibrated meter and MQ-7 sensor), take raw sensor reading at this attention and put it into sensor_reading_100_ppm_CO variable. Deprived of this step, your ppm measurement can be wrong several times in either direction (still ok if you need alarm for dangerous CO attention at home, where normally there should be no CO at all, but not good for any industrial application).

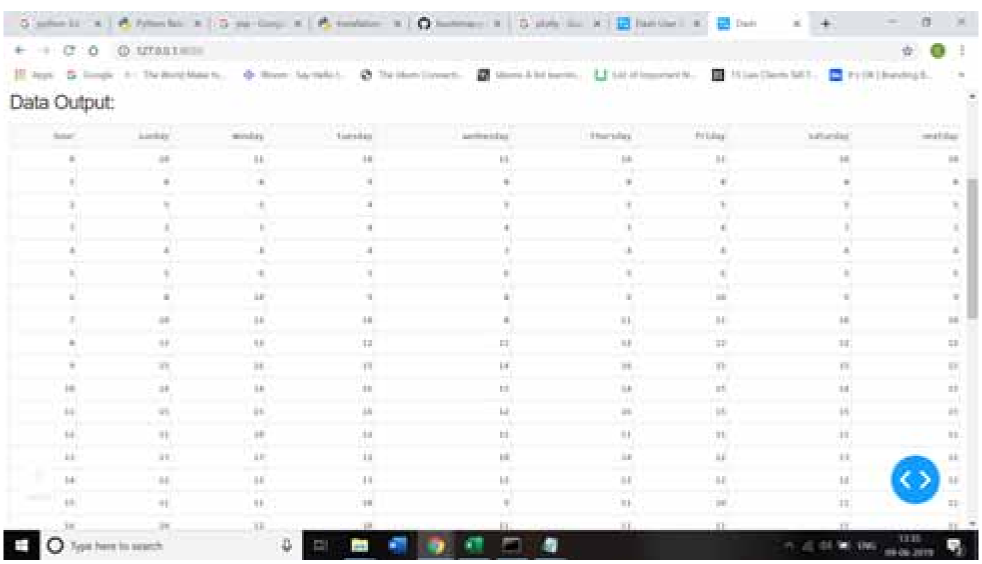
As I didn't have any CO meter, I used a more sophisticated approach. First I prepared high absorption of CO using combustion in isolated volume (first photo). In this chapter I found the most useful data, including CO yield for different flame types - it isn't in the photo, but the final experiment used propane gas combustion, with the same setup, consequential in ~5000 ppm CO concentration. Then it was diluted 1:50 in order to achieve 100 ppm, as illustrated in the second photo, and used to determine sensor's orientation point. Legitimate Peripheral Participation, Empathy and E-learners

Having recognized how research and applied linguistics illuminates the quality of online engagement and some of the variables that uphold or undermine e-learning within the virtual ecology, the question remains: how can we approximate the magic of classroom unrestricted within traditional face-to-face instructional settings? At this point, let's pause to consider today's student. It is widely known that millennials are more narcissistic and less empathic (Konrath, 2012). Within the language socialization branch of applied linguistics, Lave and Wenger's (1991) notion of legitimate peripheral participation posits that visit is always undermined by the plethora of communities of practice in which any of us engage. As traditional notions of combined identity confront the increasing array of digital identities (avatars, Facebook or Instagram accounts, gaming characters, etc.), it is not difficult to see how empathy is weakened and narcissism favored. One way to bridge the empathy gap is to set blogs for open access. In this author's online Spanish classes, maiden the WordPress settings has ushered in unexpected 'dropins' from native speakers of the language students are learning. This recruitment of involvement from outside the class need not be haphazard; the instructor might invite master practitioners of the sub- ject area to respond to blogs, offering opportunities for students to acquire both a deeper paradigmatic mastery of key builds and concepts of the subject area, as well as a more syntagmatic sense of how professional discourses are structured

Some Experimental Data

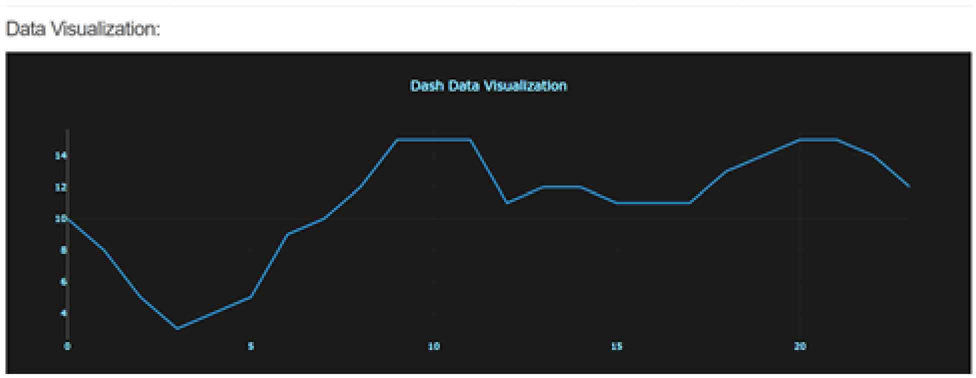
Though this chapter has already proposed some specific lessons for e-learning from research in applied linguistics, what follows is a discussion of explicit e-learning technologies that the reader may utilize to address improvements in the areas of collaboration, teaching and testing, as well as the challenge of promoting a sense of class community. Though there are many web 3.0 tools currently available, many of which are free (Google), there are possibly many more instructional technologies yet to be created, which will confidently address more specifically the needs highlighted in this chapter. Such a convergence will depend on close partnership between pedagogues and those specializing in software design. More notably, and by way of addressing the tension between the professoriate and e-learning, we need to underscore the importance of attending to pedagogues with specialization in the education of specific subject areas.

Figure 4. Weekly Sensed data



In my case, sensor worked fairly well - it is not very sensitive for really low absorptions, but good enough for detecting anything higher than 50ppm. I tried to surge concentration gradually, taking measurements, and manufactured a set of charts. There are two sets of 0ppm lines - pure green before CO exposure and yellow green after. Sensor seems to slightly change its clean air resistance after exposure, but this effect is small.

Figure 5. Graph Visualization of sensed data



It doesn't seem to be able to clearly differentiate between 8 and 15, 15 and 26, 26 and 45 ppm concentrations - but the trend is very clear, so it can tell whether concentration is in 0-20 or 40-60 ppm range. For higher absorptions dependence is much more distinctive - when exposed to exhaust of an open flame, curve goes up from the start without going down at all, and its dynamics is totally different. So for high concentrations there is no doubt that it everything reliably, although I can't confirm its exactness since I don't have any rated CO meter.

Also, this set of trials was done using 20k load resistor - and after that I decided to recommend 10k as the default value, it should be more subtle this way.That's it. If you have a reliable CO meter and will have assembled this board, satisfy share some response about sensor precision - it would be great to collect figures over various sensors and improve default sketch assumptions.

FUTURE RESEARCH DIRECTIONS

We've finally created the all in one classification that we wanted; we've consolidated the IOT and backend to make a complete finished product. We're seeing forward to making changes in the future. Thus, a safer and more sustainable approach may be exploiting the number of area to be covered so we can analyses and monitor a greater volume of air. Companies having IoT based project or having work i.e. data mining on data generated by mechanisms of device. Next stage will try to monetize and market this idea as the market opens up to IOT and Data Mining. The Whole system will: Spread consciousness about the silent killer i.e. indoor air pollution. Reduce the amount of preventable deaths from respiratory problems. Authorize every client by giving them an item that essential of a wellbeing health tracker for their home.

CONCLUSION

Air Miner gathers live data about the indoor focus dimensions of Carbon Monoxide indoor. It significantly reduces the chances of residents contracting respiratory disorder owing to its proactive alert systems. It utilizes the NodeMCU (ESP-8266) for as the smaller scale micro controller board to interface with the gas sensors, Django for the front end web interface and Python in the backend for systematic AI.

A comprehensive Indoor Air Monitoring and Analysis system that shall serve like a fitness tracker for your house. Purpose of 'Air Miner' is solved to alert users proactively about a probable surge in the concentration of Carbon Monoxide, along with this it will also give a complete analysis of the and similar metrics for the indoors. Air Quality Monitoring System for City: In plug and sense device method, it Uses multiple sensors with location co-ordinate, AQI LED indicator is actuated as per pollution level and the Real time pollution level visualized using the line graph.

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Chapter 17
Beyond the Pandemic: Survival of the Human Race and Challenges

Manas Kumar Yogi
https://orcid.org/0000-0001-9118-2898
Pragati Engineering College, India

Jyotsna Garikipati
https://orcid.org/0000-0003-2712-644X
V.R. Siddhartha Engineering College, India

ABSTRACT

The COVID-19 pandemic is changing our lives in an unanticipated manner. Various sectors like healthcare, education, business, entertainment, tourism, etc. are affected. Many disruptive technologies like AI, blockchain, 3D printing, robotics, genomics, distributed power systems, etc. made a huge impact during the pandemic. Wearing masks, frequent handwashing, maintaining social distance, etc. are the new normal. The Sustainable Development Goals (SDG) that were targeted for 2030 are moving against the goals. Due to COVID, online shopping increased, reported crime rates reduced, cybercrimes increased, school dropouts increased, financial instability increased, etc. Many researchers are affirming that only after attaining herd immunity, the corona virus will vanish. But another question to be answered is whether it is possible to achieve herd immunity with so many variants of the virus spreading all over the world. This chapter discusses various disruptive technologies, how humans are struggling to live along with the virus, and a future look on how the world will be after the pandemic.

INTRODUCTION

COVID-19 is perhaps the most uttered word in the past one and half years in almost every country. When it was first identified in China in December 2019, it was thought to be an outbreak, later it was realized as an epidemic. Now it is a pandemic. In the realm of infectious diseases, a pandemic is a worst-case scenario. It has its impact in almost every field and on every individual either directly or indirectly.

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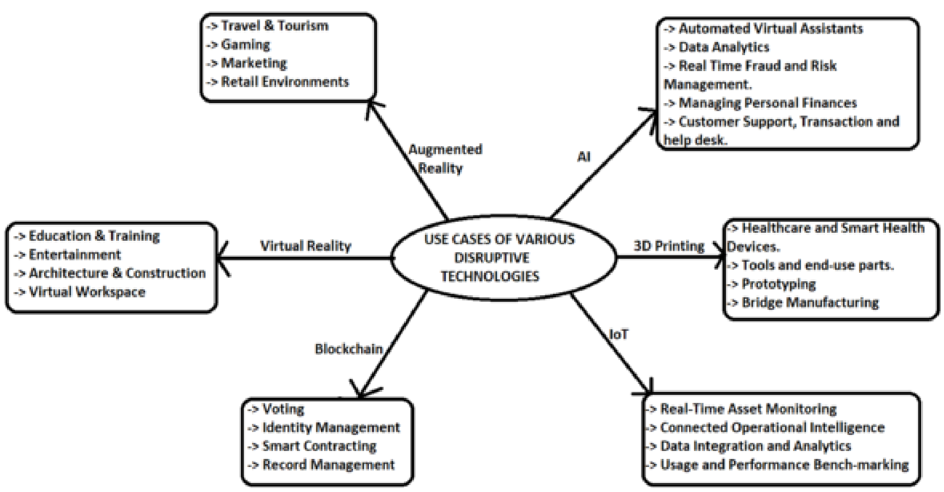
Millions of people have lost their lives and many are getting affected by it. More and more people are searching for general health-related information in the search engines which can be either media-driven or disease-driven. A general assumption is that the more the volume of data, the better the prediction results will be. In the wake of COVID-19, the spreading of misinformation on social media and other digital platforms is as much a threat to global public health as the virus itself. Less volume of right data can give better results than a large volume of erroneous data. But for those who fear the survival of mankind post-COVID-19, this is not the first of its kind. A few of them are The Black Death in 1347, from which the origin of the word Quarantine took place; the Great Plague in 1665, the 1918 Flu, etc.

This chapter discusses various disruptive technologies like AI, Blockchain, 3D printing, Robotics, Genomics, Distributed Power Systems, IoT, Drones, etc. and their impact during and post COVID period. AI has its applications in the COVID-19 crisis, like in detecting anomalies, diagnosis of medical imagery and symptom data, predicting a person's probability of the infection, monitoring persons who have come in contact with the infected person, deploying drones for the transportation of the materials, deploying virtual assistants, chatbots, robots for serving the infected people, tracking the economic recovery, etc. Blockchain can be used for crisis management, tracking donations, securing the medical supply chains, etc. 3D printing is used in manufacturing face shields, face masks, nasopharyngeal swabs, etc. Understanding genomics will help in identifying the various mutations of COVID-19. Due to the pandemic, most of the people are staying at home and businesses have slowed down due to lock down and hence the commercial power consumption has gone down and the residential load has increased. Hence there is a need for an alternative to distributing the power between the commercial and the residential sectors. In Figure.1, the use cases of various disruptive technologies are listed.

Figure 1. Use Cases for different disruptive technologies



This chapter also discusses how humans survive despite the spread of the coronavirus. Pandemics are new to us, but not to the human species. During this pandemic, a lot has been changed. In the healthcare sector, data from the smart devices are used to update the information about the COVID-19 cases, continuous and remote diagnostics have replaced the offline or direct visits to the hospital/doctor, people are now giving importance to their fitness through virtual yoga/fitness or gym classes, etc. In the workplace, many employees are working remotely from their houses, having online meetings, etc. Due to social distancing norms and remote working, Virtual Reality tech companies now had a chance to exhibit their value to enterprises in these pandemic days. Many schools and colleges are coming up with the infrastructure for alternatives to regular classrooms. Remote learning and online courses are supported, which is difficult to completely reverse back to normal classes or courses. Due to the uncertainty about the duration of the economic instability, many are opting for online courses. Retail shopping has gone more online due to the pandemic. Groceries, vegetables, dairy supplies, etc are the daily needs and can be ordered online now. Retailers are using Augmented Reality/Virtual Reality methods to have a physical shopping experience at home virtually to enable the customers to purchase the products and this trend seems to be continuing post-pandemic. In various sectors like Healthcare, Banking, Retail, etc., customer servicing has become challenging due to the store closures and the physical distancing norms. This has been eased up by conversational AI/Chatbots. In the Finance sector, contactless payment was an option even before the rise of COVID-19, and now it was accelerated at a faster speed. Food services such as grocery and restaurant delivery have paced up. In the home-constrained world, the demand for entertainment options such as NetFlix, Disney Plus, Disney Hotstar, Voot, Amazon Prime, etc is clinching. For any of the above-mentioned sectors, one of the main goals apart from the primary one is security. High internet usage and huge data generation have raised the importance of data privacy policies. In short, most of the offline services in the pre COVID period have moved online during the COVID period and are most likely to be continued after the pandemic also. COVID has paced up the world to become more digitized. Apart from these, tourism is the most adversely affected sector across the globe due to the pandemic. Almost 50 million jobs were lost worldwide and the tourism industry has lost around USD 22 billion.

This chapter concludes with how the virus evolves in the future and its effects on mankind. Many pandemics in history have different waves and eventually end up depending on how people acquire and retain immunity to the virus, how quickly the evolution of the virus occurs and how widely the older population acquire immunity during the pandemic. One of the essential features governing the future of the virus is our immunity to the illness. It won't be a binary switch, instead, it will be like a dimmer switch. As new variants capable of spreading faster are emerging, they question the effectiveness of the newly approved vaccines. Every time the coronavirus transmits from one person to another person, it makes tiny changes to its genetic code, but scientists have started noticing patterns in how the virus is mutating. To cope up with these mutations, every year the vaccine has to be updated as was done in the past for Flu. First, it all started in China and then spread to the entire world, which tells us humans are all related or interlinked in some way or the other, either directly or indirectly. This tells us if humanity has to flourish, everyone should cooperate, should not mess with nature, and make sure that humans don't overconsume and at the same time try to explore new things. As more schools are getting closed during the pandemic in the poorer countries, this could lead to an increase in the drop-outs from the schools, increase in child labor, increase in teen pregnancy and early/forced marriages, etc. Because of the social distancing norms due to COVID-19, many people have lost their jobs which require physical presence at the workplace, thereby worsening income inequality. The pandemic has negatively affected people's mental health. For people with genetic predisposition, COVID-19 has triggered or worsened the Obsessive-Compulsive Disorder (OCD).

Apart from all the hiccup, mankind is facing due to COVID-19, a few positive things that are worth mentioning are the improvement in the Air Quality Indices in some cities due to the lockdowns, a new healthy and hygienic lifestyle, education becoming digitized and affordable, spending more time with the family, and most important of all is the Antarctic ozone hole has closed, according to the World Meteorological Organisation (WMO), on Jan 6th, 2021.

EFFECT OF DISRUPTIVE TECHNOLOGIES

The COVID-19 pandemic has changed a lot many things all over the world. From the technological perspective, various disruptive technologies have made their impact on people's lives in many ways. Disruptive technology modifies how a thing works in a typical life. Some of the disruptive technologies of the old times include the automobile, electricity, Television, etc (Smith, 2021). Few disruptive technologies that banged during the pandemic are Blockchain, Artificial Intelligence, Robotics, 3D Printing, Genomics, Distributed power systems, Virtual/Augmented Reality, Internet of Things, etc (Strusani et al., 2020). In this section, a few disruptive technologies that are listed above and their effect on mankind will be discussed. Table1 shows the timeline of various technologies from 2020 to 2026 and beyond. Table 2 lists out various disruptive technologies and their role in COVID-19.

Table 1. Technological Timeline from 2020 to 2026 and beyond

Year	Upcoming Technology Trends
2020-21	AI-related Technologies
2022-24	Sustainable Technologies
2024-26	Hybrid Cognitive Technologies
2026 Beyond	Personalization based technologies

Table 2. Various Technologies and their role during the COVID-19 pandemic

Disruptive Technology	Role in COVID-19
Artificial Intelligence	Drug repurposing. Diagnosis of COVID-19.
Blockchain	Gives real-time information and traces disease progression.
3D Manufacturing	To manufacture personalized devices such as masks, shields, etc for healthcare professionals.
Robotics	To follow the COVID-19 norms such as social distancing and contactless services.
Genomics	Ability to identify the fast-spreading variants.
Distributed Power Systems	Ability to cope up with the energy demand patterns.
IoT	Devices can sense, record, monitor, and respond.
Drones	For Surveillance and transportation services.
Cloud Computing	Able to handle fluctuating demands.

Artificial Intelligence (AI)

Today the world's most popular buzzword is AI. This disruptive technology is being used by most of us in the world, either knowingly or unknowingly. In the wake of COVID-19, AI is showing its impact in various fields like Healthcare, Retail & Ecommerce, Education, Banking & Financial Services, Transport, Real estate, Entertainment & Gaming, etc. In the healthcare sector, AI is being used for disease diagnosis, anomaly detection, predicting a person's probability of the infection, contact tracing, drug manufacturing, clinical decision making, therapeutics, restraining the spread of misinformation, etc (Huang et al., 2021; Arora et al., 2020). To get the result of RT-PCR, it may take 4-48 hours. Before the availability of the result, the infected person might transmit to a few more people. Also, the initial false-negative cases will transmit the disease to others. AI and in particular Machine Learning and Deep Learning algorithms can be used for the early diagnosis of COVID-19 and other diseases. Various ML models have been studied and compared by researchers (Huang et al., 2021). Machine learning models are also used in predicting the number of cases that can occur and appropriate measures are to be taken to handle the situation. Anomaly detection concerning COVID-19 has 2 important challenges. The first one is handling the time series data of multiple entities and the second is the lack of proper reasoning for the cause of outliers. These are addressed by the researchers (Homayouni et al., 2021) in the extension of their work IDEAL, an LSTM (Long Short Term Network) autoencoder. They modified the data preparation phase using a two-level reshaping technique by grouping the data based on the domain-dependent grouping attributes and splitting within each group using their autocorrelation-based reshaping technique.

In the Retail sector, AI is used for product recommendations, using chatbots for customer care services, deploying AI virtual assistants, product life-cycle management, merchandising and assortment, etc. Chatbots use ML and Natural Language Processing (NLP) techniques to deliver human-like conversation experiences. AI virtual assistant is a program that takes voice commands and performs tasks such as text reading, placing calls by finding the numbers, emailing schedules and meeting reminders, etc. These are all done using NLP techniques. (Ostapchenya, 2021) discusses the applications of AI in banking. AI is used in launching chatbots (eg, Bank of America, Australian Commonwealth Bank), mobile apps (eg, Royal Bank of Canada included Siri in its iOS app), data collection and analysis, risk management (can anticipate the risk involved such as customer insolvency) and data security (Macie, by Amazon).

Due to the pandemic, classroom education has moved into a virtual world of remote education. Apart from academics, other activities like music, dance, keyboard, drawing, painting, abacus, etc are taught online nowadays. Various software like Baltik, SmartNotebook, ALF, Hot Potatoes, etc is available to use during online teaching (Strbo, 2020). Secure online exams are replacing traditional offline exams. Facial scans are used instead of traditional ID cards for the students for attendance, in the library, in the canteen, etc (Dukadinovska, 2020). Personalized learning is possible through AI as each teacher cannot have a 1:1 online session for all the students in the class. But the main downside of this technology in the education sector is that the children will get addicted to the gadgets. Also, children should get knowledge about malware, viruses, etc to have safe and secured access, otherwise, serious consequences have to be faced. Table3 lists a few examples of the usage of AI.

Table 3. COVID-19 Applications of AI

Application/Utility	Company	Usage
XRaySetu	ARTPARK, Niramai, IISc Bangalore.	AI-driven X-ray interpretation for doctors.
Bluedot	Govt. of Canada.	Outbreak intelligence platform.
AlphaFold	Google's DeepMind.	AI program for the protein folding problem.

Blockchain

As far as COVID-19 is concerned, the preventive measures are wearing the mask, maintaining social distance, sanitizing the hands frequently, etc. Huge amounts of data are generated every day as more and more people are getting affected and records of all those people should be stored for research purposes. This data has to be recorded in a way that is impossible to change or hack or steal the system. This task can be achieved by blockchain technology. Blockchain is the result of the brainstorming of a person or a group of people by the name Satoshi Nakamoto in 2008. The Key properties of blockchain technology are Security, traceability, and transparency (Wang et al., 2021). In the beginning, it was only used for cryptocurrency. Later it has its applications in various domains like healthcare, supply chain and logistics, e-voting, advertising, real estate, solid waste management, Agriculture, IoT, etc (Daley, 2021; Gupta et al., 2020). Let's discuss the basics of blockchain, its scope in the COVID-19 outbreak (Gupta et al., 2020), and then see how it is being used in deploying drones (Ricci, 2021), contact tracing, and vaccination (Alameda, 2020), etc.

A Blockchain is a digital immutable ledger of transactions that is distributed across a network. It can be either public or private. In a public blockchain, anyone can join or leave. For example, Bitcoin and Ethereum. A private blockchain belongs to a specific person or an organization and an example of it is Hyperledger Fabric. All the transactions will be verified by all the involved nodes/ participants and this process of verification is called mining and all the participants involved in the mining are called the miners. There will be a consensus algorithm that is to be agreed upon by all the miners in the blockchain. This includes the decision of whether to include a set of transactions or not.

The researchers (Kalla et al., 2021) explained the scope of blockchain in the wake of COVID-19 which includes "contact-tracing, disaster relief and insurance, patient information sharing, Immigration and Emigration procedures, distribution of funding and charity, supply chain management, automated surveillance and contactless delivery, food distribution, e-government, manufacturing management, fake infodemic and so on".

The researchers (Ricci et al., 2021) discussed how blockchain technology can be useful in reducing COVID-19 from further spreading. Contact Tracing means to spot-out those persons who are in contact with the COVID patients. Manual contact tracing is very slow and requires manpower, which is not an advisable option during the pandemic as it spreads at a much faster rate. The other technologies that are used for contact tracing include Proximity-based Contact Tracing, which uses Bluetooth Low Energy Technology, Location-based contact tracing which uses GPS, and Mobile operator-based Contact tracing which uses the mobile operator's infrastructure. Blockchain technology when combined with each of the above contact tracing technologies will enhance the efficacy.

Immunity certificates and vaccination certificates are issued by the government to the COVID-19 recovered individuals and the individuals who took the vaccination respectively. The need for these certificates will be shown up shortly which helps to return to the previous normal routine work culture. Using blockchain technology for the COVID-19 certifications helps in verifying the authenticity of these certificates using the zero-knowledge proof technology (Alameda, 2020) in which the information is verified without sharing the data.

Few safety measures like staying away from the hot-spot areas, staying in quarantine if any symptoms like cough, cold, headache, fever, etc are observed. Blockchain can be used to store the data of infected persons so that they cannot be hacked or destroyed. Due to the transparent nature of this technology, it can be used to raise funds for the required medical equipment. It can also be used to segregate the true and the false information regarding COVID, as the miners will be verifying all the transactions before adding them to the blockchain. Finally, blockchain reduces the risk of direct contact as all the data will be available online. Table4 lists a few examples of the usage of Blockchain.

Table 4. COVID-19 Applications of Blockchain

Application/Utility	Company	Usage
MiPasa	IBM	Open data hub for early detection of COVID-19 carriers and infection hotspots.
Coalition	Nodle	IoT Blockchain platform for contact tracing.
	Patientory	All-in-one medical record system.

3D Printing

As more and more COVID-19 cases are emerging, the need for 3D printed medical equipment/devices like the Personal Protection Equipment (PPE) kits, sample collectors, isolation wards, ventilators, safety accessories, etc is increasing. When compared with traditional manufacturing, 3D printing or additive manufacturing will be done in a shorter time with less resource requirement, which is very much needed in the present scenario. 3D printing is the process of creating a 3D image layer by layer with minimal wastage. There are 3 broad categories of technologies that can be used in additive manufacturing. These include Sintering, Melting, Stereolithography. 3D printing helps us to get complex shapes with less material. Using 3D printing, Face shields, Face masks, personalized 3D printed masks, protective eyewear, ventilators, splitters, pharyngeal swabs, isolation chambers, hand-free accessories like door openers, button pushers, etc can be prepared. As all these are used in large numbers, they need to be disposed of in a healthy way such that they will not pollute the environment. Even though the above-mentioned products can be produced using traditional manufacturing, it takes more time and more manpower which is not possible amid lockdowns. Table5 lists a few examples of the usage of 3D Printing.

Table 5. COVID-19 Applications of 3D Printing

Application/Utility	Company	Usage
The Radius	MakerMask	N95 filter protection; filters during both inhalation and exhalation.
Nasal Testing Swabs	Stratasys	For COVID-19 testing.
Faceshield Frame Files	Stratasys	To protect oneself from COVID-affected patients.

Robotics

Depending on the purpose for which robots are used, robotics will be either disruptive technology or non-disruptive technology (Owen-Hill, 2019). If collaborative robots are used they just improve the condition but do not change what is already there. On the other hand, if robots completely change the way something is being done, then robotics will be a disruptive technology. The basic precautions to be taken during this pandemic are the usage of facemask, frequent handwashing, and maintaining social distance. Even after taking these precautions, humans are prone to get infected by the virus. To minimize the outspread of the virus and to lessen the load on the medical staff, robots were put to use in treating the COVID patients. Robots are used to screen the COVID patients, take the swab sample, etc. All the robots will be monitored by the medical staff through the camera (Wang et al., 2021). Service robots can be used instead of nurses, receptionists, cleaning and spraying robots, etc. Robots are also deployed in monitoring the patient's physiological conditions, helping patients with cognitive challenges and disabilities, giving company to the elderly and sick people, etc (Kaiser et al., 2020). With AI-enabled Robotics, the technology becomes more disruptive as the robot itself can learn from the environment and need not wait for human instructions (Vavra, 2020). Robots and robot-assisted surgeries are used in complicated and less invasive procedures. This can reduce the patient's stay at the hospital thereby making the availability of the bed to some other needy person, which is very much beneficial during this pandemic. But there is a potential risk of aerosol disposal due to the laparoscopic and robotic surgeries, which can cause COVID-19, among other things. But with extra care, a robotic procedure can be done to minimize the contact between the medical staff and the patients. Because of the early false negatives of the COVID-19 patients, it is highly recommended that the medical staff should get in minimal direct contact with them, as it will be spread to other patients. Robotics-assisted surgeries are gaining importance due to COVID-19. Preoperative examinations are done using AI and robotics-enabled telehealth (Feizi et al., 2021). Apart from the medical field, robots are widely used in the tourism, catering, and hotel industry. Table6 lists a few examples of the usage of Robotics.

Table 6. COVID-19 Applications of Robotics

Application/Utility	Company	Usage
Autonomous Mobile Robots (AMRs)	Slovak	Contactless distribution of drugs and other materials. Able to disinfect the environment.
KUKA Robots	Caracol-AM	3D printing of protective equipment.
OnRobot VGC10 Gripper	Designed Mouldings	Produces plastic caps and seals for the packaging industry.

Genomics

Since the inception of COVID-19, it has spread to hundreds of millions of people worldwide and has reported as many as 3.3 million deaths till mid of May 2021. With the availability of the infrastructure for basic genome techniques to support pandemic responses, it has become possible to collect SARS-Cov2 genomic information. A genome contains the complete genetic information of an organism or a cell. Genomics is the study of genes, their functions, and related techniques. Genomics is used for finding the sequence of molecules that make up the DNA (Deoxyribonucleic acid) of the organism. Genome sequencing is the proper placing of DNA nucleotides or bases in a genome. Comparing different genome sequences reveals the biology of development and the evolution of various species (DNA Sequencing Factsheet, 2020). The 2 different types of genome sequencing are the Sanger method (old classical chain termination method) and High-throughput sequencing (HTS) techniques or the Next Generation Sequencing (NGS) methods. DNA binding proteins are of 2 types namely double-stranded DNA (DSB's) binding proteins and single-stranded DNA (SSB's) binding proteins (Wang et al., 2013). SSBs usage can be seen in DNA replication, recombination, and repair, etc. DSBs are used to manage gene expressions. Genomics is very much helpful in understanding the interactions between genes and the environment for the improvement of the health and prevention of diseases.

Because of HTS techniques, lots and lots of viral genomic data is being generated during the COVID-19 pandemic, and from this huge amount of data only epidemiologically relevant information is needed to be encoded (Knyazev et al., 2021). Studying SARS-CoV-2 (Severe Acute Respiratory Syndrome- Corona-Virus-2) genomes is needed to understand the dynamics of the epidemic and also to track the spreading of the various variants. After genomic analysis on the respiratory specimens collected from the initial COVID patients from Wuhan, the analyses disclosed that SARS-Cov-2 has a nucleotide identity of 80% with SARS-Cov. These studies suggested that the SARS-Cov2 virus has high sequence similarity with the viruses found in bats and hence has a zoonotic origin. As bats are not much-interacted animals, scientists suggest that there could be some intermediary chain of animals that have been contracted with the virus before it reached humans, which is still unknown. In the wake of the public health response, viral genome sequencing of SARS-Cov2 is of utmost importance. SARS-Cov2 is undergoing various mutations and among the many variants that are emerging, some are associated with more transmissibility, greater disease severity, and increased risk of mortality. But there is no evidence that such variants will reduce the vaccine's potency. Also, certain mutations are helping the virus to circumvent neutralizing the antibodies. The study and analyses of genomics of the virus with a sufficient number of samples reveal the transmission chains and also distinguish the local transmission. As different parts of the world have different genotypes of the virus, combining genomic methods with clinical and spatial data will help in identifying the viral infectivity, virulence, and death rates of the area-specific viral strains more precisely. Table7 lists a few examples of the usage of Genomics.

Table 7. COVID-19 Applications of Genomics

Application/Utility	Company	Usage
Genopo	Garvan Institute of Medical Research, Australia	Track and monitor the genome of SARS-CoV-2 within minutes.
NVIDIA Clara Parabricks	NVIDIA	Computational Genomic Software.

Distributed Power Systems

COVID-19 not only has detrimental effects on people's health but also on socio-economic activities. To reduce the transmission of the virus, many countries took measures like lockdown within the country and shutting down the national and international borders. The Healthcare sector is not the only field that is affected due to COVID-19. Some of the other fields that have a high impact due to COVID are "automobile, energy and power, agriculture, education, travel and tourism, consumer electronics, aviation, entertainment, sports, etc" (Nayak et al., 2021). In this section, the impact of the pandemic in the energy and power sector is discussed. Due to the implementation of lockdowns, most of the people are confined to houses and the power consumption in the residential areas is drastically increased whereas that in the commercial sectors is reduced to a greater extent. One positive thing is that there is a reduction in the GreenHouse Gases (GHG) emissions thereby reducing air pollution. Few issues regarding the energy and power sector are the payment defaulters, importing of spare parts, like for example India imports solar-photovoltaic cells, wind turbines, rechargeable batteries, etc from other countries, maintenance issues to be solved with least staff, making appropriate changes to the policies to ensure energy security, etc.

During the pandemic, there is a change in the electricity demand and load forecasting. A power grid system has much dependency on the nature and the irregularity of the electricity generation and the consumption rather than on the total power consumption. Understanding these demands is key in maintaining the reliable operation of the electric grid. Generally, electricity consumption follows certain patterns depending on daily and seasonal usage. For example, power consumption will be more during the summer and winter seasons due to the usage of ACs and electric heaters respectively. Various models are surveyed by the researchers (Alasali et al., 2021), that use various machine learning and deep learning algorithms to study load forecasting depending upon the patterns observed. A fall is observed in the global energy demand, fossil energy generation, nuclear energy generation (Jiang et al., 2021). The key takeaway is the preparedness of electric grids to fight against future global health crises. Table8 lists a few examples of the usage of distributed power systems.

Table 8. COVID-19 Applications of Distributed Power Systems

Application/Utility	Company	Usage
Net-zero carbon products	Rolls-Royce Power Systems	Sustainable, integrated solutions for drive-power and energy needs.
Urban Smart Energy	International Energy Agency (IEA)	Digitization to the existing infrastructure (Proposals were called for).

Internet of Things (IoT)

The Internet of Things (IoT) is nothing but a network of connected "things". These things can be a laptop, watch, mobile phone, sensors, people, etc. They can be connected in any way. In healthcare, IoT devices can be used for monitoring patients' vital signs in real-time like blood glucose, heart rate, etc. IoT devices can be used for monitoring the activities of elderly people or patients. One of the most important safety measures to be taken for the prevention of COVID-19 is social distancing. But for the COVID-affected people, close monitoring is needed so that their medical condition can be improvised. With the help of these IoT devices, COVID-affected people can receive better, accurate, and quick treatment. (Poongodi. M et al., 2021) proposed an IoT-based solution to detect COVID-19. Table9 lists a few examples of the usage of IoT.

Table 9. COVID-19 Applications of IoT

Application/Utility	Company	Usage
Sub-Zero Vaccine temperature monitoring unit	Swift Sensors	A secure wireless vaccine storage unit monitoring and alert system.
OmniConnect	OmniFlow	Cloud-based software for IoT, to monitor the devices connected.
OmniFlow Breathing Therapy Biofeedback system	ACP	Provides the inhalation and exhalation data to the doctors.

Drones

During the pandemic, it is better to have less or no contact with the COVID-infected people. For that contactless deliveries, drones are used. Drones are very much helpful in collecting lab samples, delivering medical supplies, aerial spraying of disinfectant liquids in public places, surveillance of public places, etc. Blockchain enables drones to share information in a decentralized manner. In that way, multiple drones can work collaboratively. The researchers (Alsamhi et al., 2021) proposed an E2E (end-to-end) multi-drone system with 3 layers in which in the first layer the quarantine people order food or medical supplies through the smart cards, which are passed onto the blockchain in the second layer. The request will be passed onto the third layer, the donate layer, to prepare the goods.

Many countries are using drones for minimal contact or contactless assistance to the COVID-affected people. Drones help a lot in curbing the further spread of the virus and also by helping the COVID-affected people (UNICEF, 2020). Drones can be used for taking the lab samples and delivering the medical supplies, aerial spraying to disinfect the contaminated areas, monitoring and guiding during the lockdown and quarantine periods. Drones when combined with AI can monitor and record information on the ground. Table10 lists a few examples of the usage of drones.

Table 10. COVID-19 Applications of Drones

Application/Utility	Company	Usage
Drone	Throttle Aerospace Systems	For Below the Visual Line Of Sight operations.
SmartSkies	ANRA Technologies	Integration of drone service providers.
Drone-delivery network	Matternet, SkyGo, Abu Dhabi Dept. Of Health.	For the transport of medical goods.

Cloud Computing

Cloud computing is nothing but providing computing services to the users over the internet as per their requirements. There is no need to purchase dedicated resources for their requirements. It is like procuring or hiring the resources as and when needed and releasing them after their use. Its benefits like the cost, speed, security, reliability, etc had driven the healthcare sector towards cloud computing. (Singh, V.K et al., 2021) proposed a deep learning model based on the MobileNet V2 model to make mobile and edge devices compatible. Table11 lists a few examples of the usage of Cloud Computing.

Table 11. COVID-19 Applications of Cloud Computing

Application/Utility	Company	Usage
DingTalk's International Medical Expert Communication Platform	Alibaba Cloud	Provides free communication to medical workers.
Rapid Response Virtual Agent Program	Google Cloud	Contact Centre AI.
v-safe	Oracle	To report the side effects due to the vaccine.

SUSTAINABILITY OF THE HUMAN RACE DURING THE PANDEMIC

As and when the bomb of the COVID-19 pandemic exploded, all the countries implemented national and international restrictions. Lockdowns and curfews are implemented, national and international borders are closed, etc. A lot many aspects are changing in life, workplace, social relations, etc. With great uncertainty about the evolution of the virus and life after the pandemic, being optimistic about the future and helping one another only can help us in coming out of this pandemic.

The first and foremost directly affected sector due to the pandemic is the healthcare sector. The effect is on both the COVID patients and the non-COVID patients. As the virus is spreading rapidly in almost all the countries in the world, with a few exceptions of island countries, people who are getting infected by the virus are large in numbers. To protect themselves from the virus, the new routine for people worldwide is to wear a mask, maintain social distance, frequent hand washing, etc. Many lost their loved ones, near and dear due to COVID-19. As more and more COVID cases are being registered and needed admissions in hospitals and also due to the risk of contamination of the virus, the non-COVID patients with other comorbidities are getting delayed treatment for their illnesses, due to which their illnesses are getting worsened, which is very risky for certain diseases like cancer, kidney dialysis, etc. Also, children will have ill effects on their physical and mental health as they are spending their time mostly indoors without physical exercise and eating junk food. Also as there is no scope of physical interaction among their peers, they are getting depressed, irritated, etc.

Scientists and researchers all over the world are working individually and also collaboratively to fight against the virus and come up with new inventions, discoveries, and plans to lessen the impact of the virus. Efforts of such works are the vaccination, developing cost-effective oxygen concentrators and ventilators, etc. Countries are helping one another to assist themselves against the battle with COVID-19. On the contrary, many sectors are affected due to COVID. Sectors that are badly affected among the others are healthcare, business, education, entertainment, tourism, sports, etc.

Due to lockdown, all the schools and colleges are shut and few schools/colleges managed to bring their students back to classes through online mode. Before the pandemic normal offline mode of education is now moving towards the new normal online mode. Many National and International conferences are being conducted online thereby allowing many enthusiastic people to participate, which otherwise is not possible. As per the famous saying "Necessity is the Mother of Invention", many students are exploring new ways to learn and upgrade themselves efficiently. People living in poor countries cannot afford this digital transformation and hence the students are suffering a lot. Nearly 10 million children in 40 countries will never return to school. COVID pandemic made us focus on certain aspects in the work-life, which need limelight, like the support of the employers for the employees physical and emotional prosperity, leadership and company's culture, work relationships with your teammates, flexibility in the work and workplace, reduction of unnecessary bureaucracy, inter-company cooperation, etc (Brower, 2020).

Due to the strict restrictions to curb the spreading of the virus many people are not able to get their required daily essentials directly. Due to COVID, the businesses have moved online, thereby allowing the customers to choose and purchase the products online and also pay them online. To provide a better visual experience to their customers the e-commerce vendors are using Virtual Reality/ Augmented Reality techniques. They are also using Artificial Intelligence and machine learning techniques to suggest products to their customers based on their previous choices and/or the patterns in the purchases. International business is halted due to which, in some countries, getting spares is not possible. Many migrants have lost their jobs and are forced to move to their home countries.

Few indirectly affected sectors due to COVID are Finance and Banking, Entertainment, Tourism, etc. Due to lockdowns, small and medium-sized companies suffered a lot. There is a shortage of consumer durables as they are mostly imported. Real estate came to a standstill due to the non-availability of raw material and manpower. Movie theatres, live concerts, etc were closed or canceled for an unspecified time. Most of the people are going for alternatives like Internet Streaming or OTT (On The Top) namely NetFlix, Amazon Prime, Hotstar, Zee5, Aha, Voot, etc. As more and more sectors are moving their operations through online mode, cyber security breaches are increasing. As the travel and aviation sector has a direct impact due to COVID, the tourism sector is affected indirectly as international borders are closed temporarily. Most of the people will be planning for a vacation as and when the restrictions are removed. Closely monitoring the frequent searches and preparing for their best is what the tourism industry can do at the moment.

COVID hurts the economies of the countries. Because of this, in certain countries like the Democratic Republic of Congo, children are forced to work on farms, in mines, etc. The fate of girls is much worse in some countries like Vietnam and the Ivory Coast. They are getting married at an early stage for the reason that one member will be lessened to get fed from the family. Also, the teenage pregnancy percent has risen due to rapes done by relatives or neighbors during quarantine at home. Also, not all countries will have proper internet access for online classes. Also, all parents cannot afford to buy the required gadgets to attend the online classes, or for all the children in the house. Overall the gap between the poor and the rich countries is widened due to COVID.

17 Sustainable Development Goals (SDG) were set to be achieved by 2030 to improve the lives of people all over the world. Based on the report in 2020 regarding the Sustainable Development Goals, the world is making slight progress in maternal and child health, expansion of electricity access, increase in the women's representation in government, etc (United Nations, 2020). But due to the pandemic, the progress of SDG is reversed. As per the rankings of June 2021, India dropped two positions and stood at 117th position.

FUTURE CHALLENGES

The people in the world are struggling due to the pandemic for more than one and a half years. The virus is continuing to spread at a gradual pace; having lockdowns now and then is the new ordinary. An endorsed antibody gives 6 months of security, yet global arrangement making has eased back its appropriation. An expected 250 million individuals have been infected around the world, and 4 million are dead. These figures explain how the COVID-19 pandemic outplayed humans. Throughout the planet, epidemiologists are striving hard to find out different ways by which mankind can get ready for, and possibly relieve, the spread and effect of the virus SARS-CoV-2, which causes COVID-19. Despite the conjectures and timetables shift, modelers concur on two things: COVID-19 will be staying for a long period, and the future relies on so many questions, including whether individuals develop the herd-immunity to the virus, regardless of the irregular spread of the virus, and — maybe in particular — the policies of different governments. Plenty of spots are opening, and a ton of spots aren't. Nobody is yet realizing what will happen. It mostly depends upon how people will start again to mingle with one another leaving the social distancing norms and what sort of counteraction will be done. Previous models and proof from fruitful lockdowns recommend that behavioral changes can reduce the spread of COVID-19 taking it for granted that most individuals will follow. But it might not be the actual situation.

The pandemic isn't working out similarly from one spot to another. Nations, for example, China, New Zealand, and Rwanda are now reporting a low degree of cases — after lockdowns of different durations — and are relaxing the restrictions while looking for outbursts. Somewhere else, for example, in the United States and Brazil, cases are rising quickly after the lockdowns are lifted or never actuated from one side of the country to the other.

The last gathering has modelers extremely stressed. In South Africa, which currently positions fifth on the planet for complete COVID-19 cases, a consortium of modelers estimates that the nation can anticipate a top in August or September, with around 1,000,000 dynamic cases, and aggregately upwards of 13 million suggestive cases by early November 2020. "As far as emergency clinic assets, we're now breaking limits in certain spaces, so I think our most ideal situation is not a decent one", says Juliet Pulliam, overseer of the South African Center for Epidemiological Modeling and Analysis at Stellenbosch University.

Be that as it may, easing the lockdowns will be joyful. Previous experiences show that individuals' social behavioral changes are continuing post severe lockdown, helping in hindering the tide of diseases. Nobody can estimate the change in the conduct of the individuals regarding veils, hand washing, and social separation. It's nothing similar to it used to be, says Samir Bhatt, an irresistible sickness disease transmission expert at Imperial College London and a co-creator of the examination.

Researchers in virus areas of interest are concentrating on exactly how accommodating the pandemic practices are. At Anhembi Morumbi University in São Paulo, Brazil, computational researcher Osmar Pinto Neto, and partners checked with 250,000 numerical models of social-separating systems depicted as consistent, discontinuous or 'venturing down' — with limitations decreased in phases — close by conduct mediations, for example, put on masks, and sanitize the hands. The group presumed that assuming 50–65% of individuals are mindful openly, venturing down friendly removing measures like clockwork could assist with forestalling further contamination tops in a span of coming two years. People have to change their way of communication with others. Generally speaking, it's uplifting news that even without testing or an immunization, practices can have a critical effect in transmitting the infection, he adds.

Irresistible sickness modeler Jorge Velasco-Hernández at the National Autonomous University of Mexico in Juriquilla and associates additionally inspected the compromise among lockdowns and individual security. They found that if 70% of Mexico's populace was dedicated to individual measures, for example, hand washing and cover wearing after deliberate lockdowns that started in late March, at that point the country's outbreak would decrease after topping in late May or early June. Be that as it may, the public authority lifted lockdown measures in June and, as opposed to falling, the high number of week-by-week COVID-19 passes leveled. Velasco-Hernández's group believes that two public occasions went about as super spreading occasions, causing high disease rates just before the public authority lifted limitations. On the off chance that immunity to the virus endures not exactly a year, for instance, like other human coronaviruses available for use, there could be yearly floods in COVID-19 diseases through to 2025 and past.

In locales where COVID-19 is by all accounts on the decay, scientists argue that the ideal methodology is cautious reconnaissance by testing and separating new infections and following their interactions. This is happening in Hong Kong, for example. “We are testing, mentioning objective facts and changing gradually”, says Wu. He anticipates that the methodology forestalls an immense re-emergence of diseases — except if the uplifting of the restrictions on the air traffic brings in new international cases. But precisely what amount of contact following and separation is needed to effectively control an outbreak? An investigation by the Center for the Mathematical Modeling of Infectious Diseases COVID-19 Working Group at the LSHTM mimicked new episodes of changing infectiousness, beginning from smaller to a larger number of presented cases. The group inferred that contact following should be fast and broad — following 80% of contacts inside a couple of days — to manage an outbreak. The gathering is currently evaluating the adequacy of advanced contact following and how long it’s feasible to keep uncovered people isolated, says co-creator Eggo. It is critical to find a balance between what is a methodology that individuals will endure, and what procedure will contain an outbreak. Tracing 80% of contacts could be close to difficult to accomplish in areas wrestling with a huge number of new diseases in seven days — and more terrible, even the most noteworthy case checks are probably going to be disparaging. As a result, there’s a greater risk of disease than individuals realize, says John Sterman, co-creator of the test and overseer of the MIT System Dynamics Group. It is clear since summer doesn’t consistently eradicate the virus, yet hotter climate may make it simpler to manage in mild areas. Experts believe that transmission will likely expand in the second half of 2020 in areas where the weather will become colder. Yet, experts have little idea how long SARS-CoV-2 immunity endures. Killing antibodies were reported to last for up to 40 days from the start of contamination in one study of recovering patients; several studies suggest that immunizer levels decrease after weeks or months. If COVID-19 follows the path of SARS, antibodies could persist at a significant level for a very long time, with a lethargic decay lasting more than 2–3 years. In any event, neutralizer production isn’t the sole sort of virus-resistant protection; memory B and T cells also guard against future infections, though little is known about their role in SARS-CoV-2 infection. According to Michael Osterholm, director of the University of Minnesota’s Center for Infectious Disease Research and Policy (CIDRAP), analysts should track a huge number of people for a long time to get a sensible answer on immunity. Nobody has any other option than to wait. “If contaminations keep on rising quickly without an antibody or enduring immunity, we will see a customary, broad course of the virus”, says Grad. “Around there, the virus would become endemic”, says Pulliam. That’s real. And it isn’t incredible: jungle fever, a preventable and treatable infection, slaughters more than 400,000 individuals every year. These most pessimistic scenario situations are going on in numerous nations with preventable illnesses, causing colossal misfortunes of life as of now, says Bhatt. Individuals can become reinfected and yearly outbreaks could occur if the virus activates transitory immunity, as it does with two other human coronaviruses, OC43 and HKU1, which have immunity that lasts around 40 weeks. However, because this pandemic has not yet stayed clear of pandemic influenza, these figures are only estimations, according to Osterholm. The world is experiencing a coronavirus pandemic unlike any other. One possibility is that SARS-CoV-2 immunity is long-lasting. Even if no vaccination is available, it is possible that after a global breakout, the virus may consume itself and vanish by 2021. Nonetheless, assuming modest protection lasting two years, it may appear as though the virus has vanished, but the Harvard group discovered that it could resurface as late as 2024.

That conjecture, notwithstanding, doesn't consider the improvement of compelling antibodies. It's far-fetched that there won't ever be an immunization, given the sheer measure of exertion and cash filling the field and the way that a few up-and-comers are as of now being tried in people, says Velasco-Hernández. The World Health Organization records 26 COVID-19 immunizations as of now in human preliminaries, with 12 of them in stage II preliminaries and six in stage III. Indeed, even an antibody giving deficient security would help by decreasing the seriousness of the illness and forestalling hospitalization. In any case, it will require a very long time to make and disperse an effective antibody.

COVID-19 did not similarly affect the whole world. Densely populated districts disproportionally will have a hike in cases in later phases of the pandemic. A numerical model from the age groups under study, using data from six nations and distributed in June 2020, proposes that the disease will be ineffective in youngsters and people below 20 years of age, which constitute the majority of the more established grown-ups.

Practically speaking, there is one thing that every nation, city, and local area affected by the pandemic has in common. "There is such a lot that we stop pondering about the virus", says Pulliam. Till any healthier information is acquired, a ton of vulnerability is going to exist.

CONCLUSION

Many lost their near and dear ones due to this pandemic worldwide. The long-term effects of COVID-affected patients can only be observed in the future in the post-pandemic time. But many COVID recovered patients are facing health problems such as drowsiness, brain fog, headache, anosmia, tastelessness, arthralgia, depression or anxiety, and many more (Centres for Disease Control and Prevention, 2021). Another serious health issue that the recovering or recovered COVID patients in India are getting is Mucormycosis, also called the black fungus. It's a very rare and life-threatening infection generally found in soil, plants, nose, and mucus of healthy people (Biswas, 2021). It is believed that this infection is being triggered in the COVID patients due to the use of steroids for saving the terminally ill COVID patients. Antifungal intravenous injection to be given daily for 8 weeks is the only treatment for mucormycosis. In the late diagnosis, patients may lose one or both the eyes, and in rare cases may need to get the jaw removed to stop spreading the infection to the brain. The black fungus normally won't spread from person to person.

During the pandemic, many precautions are to be taken by the people like the usage of masks, PPE kits, face shields, disposable storage, etc to protect themselves from the virus. This leads to an increase in the usage of plastics which is harmful to the environment. Before the pandemic, many initiatives were taken by the government and other organizations to create awareness among people about the harmful effects of the usage of plastics. Many countries have banned the usage of plastics. But now the situation is reversed. For safety and hygienic purposes, plastic dependency is a must. Plastic waste generation is increasing due to which the environment is getting polluted. This plastic usage may change people's behavior. Social responsibility, corporate action, and government policy are crucial for a healthy and hygienic environment (Vanapalli, 2021).

The uncertainty will continue for the business sector post-COVID. Businesses are driven by political, technological, and societal risks (Klint, 2021). From the political perspective, governments are aiming at self-sufficiency and self-sustaining economies. Policies made for national security to be given utmost priority. From the technological perspective, businesses have become more disruptive and digitized. As most businesses are moving to the digital mode, cyber-attacks are also increasing at an alarming pace. Due to this sudden shift, there could be unplanned financial and ethical risks. Also, the crime rates have been reduced in most countries. But these figures only reflect the reported crime. Mostly, Aviation and tourism industries will be the first to be back to the normal post COVID. Let us not lose hope and strive for a COVID-free future at the earliest.

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KEY TERMS AND DEFINITIONS

3D Printing: Three-dimensional objects will be created layer by layer using computers with fewer resources and minimal or no wastage. Also known as additive manufacturing. This disruptive technology changed the traditional manufacturing industry.

Artificial Intelligence: AI is nothing but making computers think on their own, using previous knowledge or learning from the environment. AI covers a wide range of sub-topics like machine learning and deep learning. It includes many other branches like evolutionary computation, fuzzy systems, machine learning, deep learning, computer vision, natural language processing, etc.

Blockchain: Blockchain is nothing but a way to store data in a decentralized manner. The term decentralization means without any central authority. In a blockchain, data is stored in groups called blocks. Whenever new information is obtained, it will be linked to the unceasing chain.

Disruptive Technology: A disruptive technology modifies how anything works in a typical life. The activity or task will be so much dependent on the technology that will be changing the way we do things.

Genomics: The study of genes, their functions, and other related techniques are called genomics. How the nucleotides or the bases will be sequenced and form new combinations will be studied in genomics. A genome is the order of A's (Adenine), G's (Guanine), T's (Thymine), and C's (Cytosine). It is a long string of letters in a strange language and is similar to decoding.

Robotics: The science of making robots to do different types of work is called robotics. This technology can be either disruptive or non-disruptive.

Sustainable Development Goals: In short SDGs. These goals were set by the United Nations in 2015 to make the earth a better place of living for mankind by curbing poverty and protecting the planet.

Chapter 18
Beyond the Pandemic:
Recovery, Resilience, and Adaptation

Chabi Gupta
Christ University, India

S. Pramila
Christ University, India

ABSTRACT

Scientists predicted many years ago that a contemporary society would develop that would be more organised around and influenced by new characteristics of heinous danger. The global economy is recovering; multinational, big, and small companies are rebounding; workspaces are revitalising; and governments and society all over the globe are waking up. With reduced oil prices and low financing rates across the globe, India has a lot of possibilities to connect to global markets and achieve rising development. There are many opportunities to attain self-sufficiency via the careful application of a culture of make in India, as well as dependable innovation, continuous economic, infrastructural, and technological upgrades. A post-pandemic world offers a once-in-a-lifetime chance to review policies, refocus objectives, and reimagine institutions.

INTRODUCTION

As the world habituates itself with the ‘new normal’, we want to generate the necessary momentum and propel an equitable and sustainable growth for India. For this a thought process in this direction is necessary, cohorts of likeminded researchers can do an extensive research in this area and come up with game changing solutions that are lasting and long term sustainable. A situation beyond pandemic can now be comprehended and the initial scare and uncertainty has been substituted with growing enthusiasm and an ever-increasing wish to return back to the world we were comfortable with in operating.

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Before Covid-19, only few SMEs and MSME's had any experience with a worldwide pandemic. Even in the best of times, the business environment is unpredictable and turbulent, but entrepreneurs have traditionally learned to handle and adapt to these natural fluctuations thanks to their drive and enthusiasm. This epidemic, on the other hand, revealed fundamental flaws in the foundations of many companies of all sizes, exposing their inherent susceptibility to a massive shift like Covid-19.

Most of these flaws would have gone undetected in a regular corporate setting, but Covid's stress test revealed them for everyone to see. So, what comes next? Do they quit up and change careers, or do they persevere and make a greater and stronger comeback? As a result, it's critical to understand that predicting how long the uncertainty will continue is almost impossible, and that things may never be the same again. People will reconsider how they conduct business as a result of the severity of disruptions to companies, customers, and governments. There's no need to panic, but you should be prepared for the worst. Going digital is one such long-term strategy for companies to rethink their potentials, recovers, and adapt.

GOING DIGITAL

There's even more incentive to seek for new methods and means to stay in business for the long haul, particularly for SME's and MSME's. Although companies are learning to innovate and adapt to changing external environments on a daily basis, pandemics such as Covid-19 and unexpected difficulties have a negative effect on their operations. This epidemic necessitated immediate changes in workplaces and corporate practises. Firms had been talking about digitization for a long time, but this time they were expected to put it into action right once, and at a rapid pace. Fortunately, thanks to technology advancements, working from home is no longer difficult. Zoom, Skype, Google Meet, and WebEx are among the tools we use to make our lives simpler. Many groups have benefited from these apps during the COVID-19 issue. The aim today is to embrace technology in order to recover fast and efficiently. The pandemic has made it more important than ever for businesses to embrace digital business models, and only cloud platforms can offer the agility, scalability, and creativity that this transformation requires. If you want to get the most out of the cloud, your IT staff has to become more nimble, if it isn't already. Moving development teams to agile product models is just part of the solution. Agile IT also entails making your IT infrastructure and operations more agile by converting infrastructure and security teams from reactive to proactive models that can be consumed by service companies and developers. If businesses are to succeed in the digital next normal, senior management must ensure that their management teams understand the particular ways that turning digital may boost revenue growth and profitability, as well as how IT teams can assist and capture value for the company by working closely together.

According to the McKenzie study, nearly 70% of CEOs from Austria, Germany, and Switzerland indicated the epidemic is likely to hasten the speed of their digital transformation. The acceleration is already seen across industries and regions. Consider how Asian banks have seamlessly transitioned their physical channels to the internet. How healthcare providers, insurers, and merchants have embraced telehealth, self-service claims assessment, and contactless purchasing and delivery. All of these shifts highlight the need of becoming digital in order to adapt to the new normal. The sudden transition to virtual operations and interactions, both inside and outside of business organisations, also offers a chance to accelerate the speed of learning about and adopting technology with which the company may have just started to explore. There is a quicker pace than ever before for the need to become digital, and there is little time to experiment, which is now a need as well as an expectation.

Customers nowadays demand relevant information related to what they're doing at any time, anywhere, and in the format and device of their choice. In theory, an organization's strategy is dictated by the "voice of the consumer." And, in order to stay up with this new breed of "always-connected," "well-informed," "forever anticipating," "digitally aware" consumer, companies must embrace technology in order to provide an unparalleled customer experience. The aim is for companies to strive harder than ever before for 'customer pleasure' rather than simple contentment. According to an MIT research, businesses that embrace digital transformation are 26% more lucrative than their competitors! Businesses and governments need a strategy that not only identifies which new technologies should be used, but also safeguards against digital disruption. That is why, before attempting to harness the ever-increasing potential of digital transformation, companies must first understand their fundamental systems and processes in order to discover possibilities.

Using e-commerce platforms, companies of any size, including small businesses, may readily access regional, national, and worldwide markets in a cost-effective manner, both for purchasing and selling goods. This applies to both merchants and manufacturers, who are increasingly adopting direct-to-consumer business strategies. The need of the hour is to transition from offline to online business models, particularly for SME and MSME companies, since many of them rely on their businesses for survival. As more companies continue to use remote work, they must guarantee that their infrastructure and information technology systems are set up to allow workers, customers, and partners to do so safely. We will see more remote access and work once the epidemic is over.

DIVERSIFY PRODUCTS AND SUPPLY CHAINS

Focusing on a single product, service, or market is a typical situation, particularly for SMEs. This is similar to a one-legged stool, and it puts a lot of strain on any company. There is now a need to investigate what alternative markets (client types or regions) might be pursued, as well as what additional goods or services current consumers could need. Diversified goods would enhance company profitability while also providing protection in the event of a product failure.

As a result of trade shocks and the COVID-19 epidemic, economies are reducing their global interconnectedness and focusing on their own nations and neighbours. Improving durability would continue to be expensive, complex, and time-consuming, and there would be no one answer that would work for all sectors. When deciding on the optimal diversification strategy for their network, supply chain executives must examine the following six factors. (Global Supply Chain Diversification for Resilience) 2 September 2020, Gartner Sarah Hippold is a contributor.

According to a recent global survey, following the pandemic, both millennial and Gen Z consumers will make a special effort to support companies—particularly smaller local sellers—and will not hesitate to reject firms whose claimed and practised values do not match with their own. (Deloitte Global Millennial Survey 2020, Deloitte Global Millennial Survey 2020, Deloitte Global Millennial Survey 2020, Deloitte Global Millennial Survey 2020, Deloitte Furthermore, 74 percent of manufacturers anticipated that reporting on and governance (ESG) goals would become normal practise within a year, according to a 2020 study done by the Manufacturer's Alliance for Productivity and Innovation. (Beckoff and Ruiz, n.d.) Organizations' ability to show proof of commitment to these commitments may become a requirement. This would reorganise and emphasise the need for transparency, as well as redefine what trust and supply chain sustainability imply. (Observing the horizon) Getting today's supply networks ready to flourish in the face of unpredictability December 11th, 2020 Bergstrom, Jason E. Gallagher, Patrick R. Stewart, Ian A.)Manufacturers that pursued a diversified approach were seen as being in a much stronger place to offset the impact of the pandemic, taking advantage of the potential not just to improve production volume but also to aid in the fight against the epidemic. The pandemic would have a extended-term effect on the developed industry. It has shown that companies must improve their agility, responsiveness, and durability immediately. The current problem presents an incentive to learn, evolve, and reshape production in order to make it as diverse as possible in the future. (The Diversification Crisis in Manufacturing November 12, 2020 Claudia Jarrett United States Country Manager, EU Automation)

While a big, multinational company force has the financial means to spend in a diverse network, essential suppliers may not. Leaders in the supply chain should reach into their own capacities and see how their suppliers are harmed by the present situation and unable to sustain a diversification approach. Consider taking supportive acts, slowing down, or seeking out more competent mates if this is the case.

The economic volatility of the pandemic has revealed a number of supply chain flaws, throwing doubt on modernity. Managers all around the planet should use the present disaster to take a spanking new look at their supply chains, evaluate their flaws, and then obtain measures to strengthen their resilience. They can't and shouldn't totally abandon globalisation; if they do, others—companies that don't abandon globalization—will happily and easily fill the vacuum. Instead, CEOs should concentrate on methods to get better their companies and gain a spirited edge. It's time to choose a fresh strategy that's suitable for the realities of the new era—one that takes use of global talents while simultaneously improving flexibility and decreased the risk of disruption. (Global Supply Chains in the Post-Epidemic Era.) Companies must improve the resilience of their networks. Here's how to do it. Robert and Jane Cizik are played by Willy C. Shih. The following is an excerpt from the Harvard Business Review Magazine edition. 2020 (September–October)

ECONOMIC TRANSFORMATION

India's challenges at this critical juncture in global relations, as well as a strategy for the country to recover from the existing crisis (recovery), put in in potential institutions and systems (resilience), and thrive in the next 10 years in a globe that is unlikely to mirror the past ten (adaptation).

- India must prioritise the following to solve the deeply entrenched problems in its economy:
- improving its laws and institutions that regulate company bankruptcy procedures;
- establishing an appropriate medium-term fiscal plan, thus strengthening economic management and adaptability in the prospect years; and
- Boosting personal investment by bettering state-capital dealings and reducing contractual requirements. To ensure stronger respect for and implementation of digital transformation, increase procedural accountability and efficient dispute redressed mechanisms.

If India is to take advantage of the opportunities that exist outside its boundaries, it will need to undergo significant economic reform. As a result, India's focus on long-standing economic growth and constancy will provide it more clout when it comes to exploring new geostrategic prospects, such as worldwide technological standards. It will also give the nation with the resources to spend in the military's desperately required strategic modernization. We will carry on to engage with and consult the government, the corporate sector, and other expert on a variety of issues across three main linked areas: political economy, technology, and overseas policy, as part of our research-driven journey. (Carnegie endowment for international peace working paper September 2020 recovery, resilience, and adaptation: India from 2020 to 2030 Rajesh bansal, anirudh burman, rudra chaudhuri,tarunima prabhakar, srinath raghavan, and suyash rai)

Larger economic themes like "needed labour," "local production and markets," "community-level sharing networks," and "low-carbon, sustainable commodities sourcing" have all been emphasised as a result of the COVID-19 experience. Economic transformation routes must be discussed in order to rethink the economy's "value" and "meaning" (Mazzucato, 2018). Is 'growth' the only goal, or do other ideals like equality and sustainability also play a part in human happiness? The centre on social reproduction implies a focus on "life-making" rather than "profit-making" (Jaffe, 2020), underscoring the conflicts between concern and capital (Fraser, 2016). Instead of stimulus post that restore the status quo of a high-carbon economy as assessed by limited measures of GDP growth, a variety of alternatives are proposed (D'Alessandro et al., 2020). This raises the issue of how societally imposed "limits" in social and economic life are negotiated (Kallis, 2019), and how social floors to protect the poor – such as Universal Basic Income – may be coupled with methods that guarantee economies operate within "planetary bounds." As a consequence, rather than extraction and expansion, the ideas of collaboration, regeneration, and circularity now characterise economic progress (Raworth, 2017). ('Post-Pandemic Transformations: How and Why COVID-19 requires us to Rethink Development,' World Development 138, doi:10.1016/j.worlddev.2020.10523)

Our economic framework must evolve beyond a concentration on efficient markets and anti cyclical measures. Macroeconomic policy must include employment and climate goals in addition to concentrating on how to reduce susceptibility to external shocks. Governments should prioritise industrial policies to create jobs, as well as invest in skills development, trade-related infrastructure, and digitalization – including bringing the digitally excluded online. Fiscal and monetary policies should be used to expand the supply of global and national public goods. Trade and industrial policies must also be seen as supplements to classic macroeconomic policy tools such as fiscal and monetary policy. WTO obligations and Regional Trade Agreements might be utilised to alter economies, such as digitalization and e-commerce. Government regulation of the financial sector should prioritise shared prosperity above short-term profits. (www.odi.org/60 Publication date: March 2021)

RECOVERY AND BUILDING RESILIENCE

The production sector recognises resilience as a disaster management tool/strategy for company stability and flexibility in the face of all types of risks during normal disasters and tragedies. In addition, business pliability is related to an organization's capacity to respond to changing circumstances and the environment in order to mitigate the effect of an event (Supardi, Kudus, Hadi, & Indonesia, 2020). Resilience plans must include coordination, a variety of crisis management methods, strong linkages (among all stakeholders), a comprehensive network, a knowledge of risks and possibilities, and quick and scalable action (Alves, Lok, Luo, & Hao, 2020; Fitriasari, 2020). According to the research, resilience may be proactive, absorptive/adaptive, reactive, or dynamic (Supardi et al., 2020).

According to a resilient mentality, the infinite diversity of future dangers cannot be properly anticipated and quantified, nor can their belongings be completely understood. Adopting such a plan requires rethinking our objectives, especially the importance of efficiency and optimization. Attempting to optimise one component of a complex system may lead to the system being unstable as a whole, according to the field of systems engineering. This can be seen in global supply chains, which are without a doubt one of the most efficient elements of the global economy. The French Economy Minister, Bruno Le Maire, believes that there will be a before and after Covid-19 for the whole economic system: “We need to consider all the implications of this epidemic on the way globalisation is organised, especially value chains” (Le Maire, 2020). When shocks like Covid-19 throw your well-oiled routine off, just-in-time may need to be supplemented with a dash of just-in-case.

27 million people saw Bill Gates warn in 2015 that “we are not equipped for the next breakout” and suggest creating an army of experts from many fields to cope with whatever disaster or illness occurred, but “nobody in power received the message,” he observed in 2020. We are presently experiencing a systemic upheaval, as prophesied during the NAEC Group debate on Averting Systemic Collapse in September 2019, which said that “a new crisis may emerge suddenly, from many different sources, and with potentially catastrophic consequences.” It’s difficult to predict where the next crisis will occur due to the high uncertainty associated with complex systems, but it doesn’t stop us from learning from the past in order to build a systemic response for the future. We learned from Covid-19 that crises do not repeat themselves. Because previous corona virus crises, such as SARS, were controlled, some people were optimistic about our capacity to contain any future disaster. (How to cope with Covid-19 and future shocks using a systemic resilience strategy) 28 April 2020: New Approaches to Economic Challenges (NAEC)

The pandemic has emphasised not just the interdependence of sectors, institutions, and nations, but also the reality that relying too much on the capability of a single sector or stakeholder to absorb and recover from a crisis is inadequate. Tailoring effective reaction tactics requires the collaboration of several overlapping players. To that aim, polycentric resilience governance provides high levels of overlap and redundancy, which are critical for co-producing decentralised recovery and adaptation initiatives depending on local needs and capacities. Covid-19 is only one example of the present global risk environment. The abuse of global commons such as biodiversity, clean water and air, as well as a lack of global and national disaster planning and response ability, raises the chances of future catastrophic occurrences. This necessitates not just the resilience of the government and the corporate sector, but also the resilience of society as a whole. (Global Dev GDN blog Building resilience in the time of Covid-19 and beyond19 Oct 20 Posted by Christine, Debora Irene, Thinyane, Mamello)

Addressing broad challenges like as climate risk, cyber assaults, and global supply chain disruption may seem daunting, particularly in the midst of a pandemic, but a data-driven strategy may aid decision-making and provide clarity and direction. It’s easy to become sidetracked by COVID-19’s disruption, but genuine resilience necessitates thinking beyond short-term recovery to minimise a slew of linked hazards. Risk managers can limit the long-term financial effects of a data breach by tackling it in the same manner that they tackle environmental catastrophes. The first stage is to determine the potential for immediate effect - what exactly may be disrupted, and what exactly may be the consequences? From here, measures may be made to target any existing exposures. (Beyond the Pandemic: How to Build Resilience for 3 Key Business Risks By: FM Global | December 15, 2020)

"NEW NORMAL" TO A "NEW FUTURE"

To avoid human-to-human transmission of COVID-19, government compliance and private-sector cooperation are required. To prevent infection, Western Pacific nations have adopted mask-wearing, physical isolation, teleworking, and hand hygiene as standard practises. The challenge now is to integrate these new habits into our everyday lives. One important takeaway from this pandemic is that authorities' clear, caring, inclusive, and consistent communication builds public trust in the government's response, which leads to a better understanding of individual responsibility and, as a result, a greater willingness to adopt infection prevention practises as part of "the new normal." Including these activities in our "new normal" may be a stepping stone to a "new future," with benefits that go well beyond the COVID-19 response.

Recognizing that the virus will be there for a long time, governments should take use of this opportunity to invest in health systems that will benefit all people in the future, as well as prepare for future public health disasters. These investments may include:

1. Using COVID-19 improvements to surveillance, lab, risk communications, and other core capabilities; and
2. Leveraging COVID-19 advancements to surveillance, lab, risk communications, and other core capabilities.
3. Using information technology to detect gaps and allocate resources to future health requirements such as genetic sequencing and contact tracking;
4. Using COVID-19 breakthroughs to speed up recovery and solve other urgent health issues; and
5. Improving health services and reducing health inequality via multi-sector cooperation.

We're starting to see a way to re-establish health, the economy, and society all at once. Long-term planning and investments will help us build more resilient communities and contribute to our common goal of making the Region the healthiest and safest it can be. (From the "new normal" to a "new future": A Long-Term COVID-19 Response) Takeshi Kasai is a Japanese actor. Open to the public Volume 4, 100043, November 1, 2020) (Published: October 9, 2020 volume 4, 100043, November 1, 2020) (Published: October 09, 2020 volume 4, 100043

Individuals, businesses, and society may begin to look forward to shaping their futures rather than just surviving the present in the year 2021, provided no unexpected catastrophes strike. The next normal will be unique. It will not mean a return to the state of affairs in 2019. Future generations will certainly dispute the pre-COVID-19 and post-COVID-19 eras, just as the terms "pre-war" and "post-war" are often used to describe the twentieth century. The COVID-19 outbreak has been a financial and human catastrophe, and it is far from over. With vaccines becoming more widely accessible, it is possible to be cautiously optimistic that the new normal may emerge this year or next. And we believe that normality can be enhanced in certain ways. With strong leadership from both business and governments, the trends we described—in productivity, green growth, medical innovation, and resiliency—could provide a long-term foundation. (The New Normal Is Here: Trends That Will Define 2021—and Beyond | Article) (The New Normal Is Here: Trends That Will Define 2021—and Beyond January 4, 2021 | Article)

To follow are some leadership principles.

The pandemic has plunged the world into chaos. It may be impossible to predict what will happen in the next month, much alone the next year. What should you do now? We believe that a few guiding principles may help leaders through the pandemic and beyond:

- Plan for the worst-case scenario. Unforeseen events should no longer be ignored; they should be included into your strategic planning process.
- Perform a scan—and then wait. Huge shifts in public health outcomes, economic recovery, market sentiment, political stability, public policy responses, and other variables are likely. Monitor and scan the scenario at all times, looking for crucial information and tipping points for your company.
- Be flexible and quick to change. The goal is to cultivate flexibility so that you can respond quickly when the opportunity presents itself. Changes brought on by the crisis, whether it's a move from physical to virtual or the creation of more flexible supply chains, should make this simpler. These adjustments will not only help you get through the crisis, but they may also provide you more flexibility to move quickly in the world beyond it. (There's a new normal—and new opportunities—beyond covid-19.) Leaders must envision the unimaginable in order to create a better post-pandemic society. Here's how to get started. EY is an accounting firm. 30th of June, 2020 Technology Policy Review at MIT)

When pandemics strike, essential institutions such as health systems and medical treatments, economic life, socioeconomic class structures and racial relations, fundamental institutional arrangements, communities, and everyday family life are all disrupted. Many individuals believe the COVID-19 pandemic will have similar effects, according to a recent poll of experts in technology, communications, and social change conducted by Pew Research Center and Elon University's envisioning the Internet Center. As greater inequality, more authoritarianism, and widespread misinformation emerge as a result of the COVID-19 pandemic, a majority of experts think that significant societal change will make life worse for the majority of people. Others, however, believe that in a tele-everything future, where companies, health care, and social activities improve, life will be better. (Pew Research Center, February 18, 2021) Experts predict that in 2025, the 'new normal' will be much more tech-driven, posing more significant difficulties. Janna Anderson, Lee Rainie, and Emily A. VogelsCOVID-19, as stressed by the World Health Assembly last month, is a global catastrophe that needs ongoing worldwide cooperation and response. UHC2030 - the global movement to improve health systems for universal coverage – will play an essential role in bringing partners together to develop a shared vision for resilient health systems and priority actions. The new UHC2030 discussion paper on UHC and crises analyses the implications of COVID-19 for health systems and identifies important areas where we can work together. Its key findings are as follows:

1. The new normal for UHC involves a stronger focus on health-related common goods.

COVID-19 confirms prior findings that robust health systems centred on primary health care are the bedrock of health security and UHC. National strategies promoting UHC have sometimes overlooked prevention, promotion, and emergency preparation. There is a compelling argument for governments to see these public health initiatives as the first step toward UHC and a basic obligation.

2. Increase and improve health-care investment — for both health and economic reasons.

As a result of the crisis, countries are experiencing economic downturns. However, the epidemic provides strong reasons to prioritise health expenditures now: the expenses are minor in comparison to the economic implications of inaction. Policies on health finance should emphasise public funding for health and reduce financial obstacles to care.

3. Take advantage of chances for change: they may enhance both health security and UHC.

The pandemic has shown that robust health systems based on primary health care are required for both health security and UHC. The situation emphasises the need of global collaboration in solving objectives such as health personnel shortages and providing equal access to innovative diagnostics, medications, and vaccinations. Positive innovations generated during the pandemic – in service delivery models, information technologies, product development, funding, governance, and working methods – will help to progress on both health security and UHC if they are maintained.

4. Movements at the local and global levels to achieve common health objectives

As part of the response to the epidemic, governments must collaborate closely with local populations; this is also a critical lesson from the 2014-15 Ebola epidemics. Governments must make space for communities to actively engage in designing more equitable health systems if people are to be better protected in the future. Strong civil society voices are critical in advocating for health-care systems that safeguard everyone.

CONCLUSION

The worldwide pandemic of COVID-19 represents a substantial threat to our civilization, providing special challenges for the organisations and its systems in which they work. The ability to retain the healthcare personnel is critical to an efficient response and the ability to eventually put the epidemic to an end. Assessing and managing risk during COVID-19 by actions that improve the "essential aspects" is preferable. Interventions must include activities for people (and their families), organisations, and leaders to enable a successful "whole-of-healthcare" approach. Borrowing and altering existing practises from other high-risk occupations designed to improve functioning and maximise survival in long-term crisis circumstances may benefit health systems. The crisis has generated requests to investigate the psychological risk factors connected with the disaster's immediate effect and aftermath in occupational settings, as well as how organisations might assist recovery and flourishing resilience trajectories. This research draws on an extensive corpus of crisis resilience research as well as economic stability of pandemic-related stresses and protective variables to advocate a reframing and resourcing approach to catastrophe resilience building.

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Chapter 19
Artificial Intelligence in Healthcare: Case Studies

Gayatri Doctor
https://orcid.org/0000-0001-8568-0938
CEPT University, India

Mayuri Varkey
CEPT University, India

ABSTRACT

Artificial intelligence simply means machine learning that can sense, reason, act, and adapt based on experience with the goal of contributing to the economic growth of the country and contributing to the betterment of people's standards of living. The main aim of artificial intelligence in healthcare is to make machines more useful in solving ambiguous healthcare challenges, and by using the latest technology, it is possible to interpret data accurately and rapidly. It helps in the early detection of many chronic diseases like Alzheimer's, diabetes, cardiovascular diseases, and several types of cancers like breast cancer, colon cancer, etc., which simultaneously reduces the financial burden and severity of the disease. The key areas where AI can be applied medically include disease detection and treatment, patient connection and engagement, and managerial and security activities. The research has been aimed at a study of AI systems in the healthcare sector in India. The methodology used here consisted of a systematic literature review followed by live, on field interviews.

INTRODUCTION

Artificial intelligence is perhaps the most baffling subject in this digital age despite being around for quite a long while. The theme is ambiguous and immeasurable - from machines equipped for analysis to look through extensive calculations dating back years. Artificial intelligence has made immense progress in the past 10 years – more than it has made in its 60 years of existence and is now no longer a concept of

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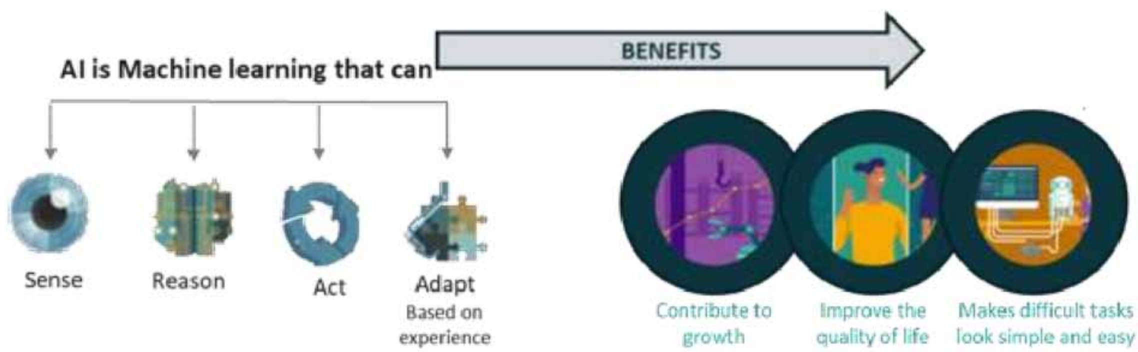
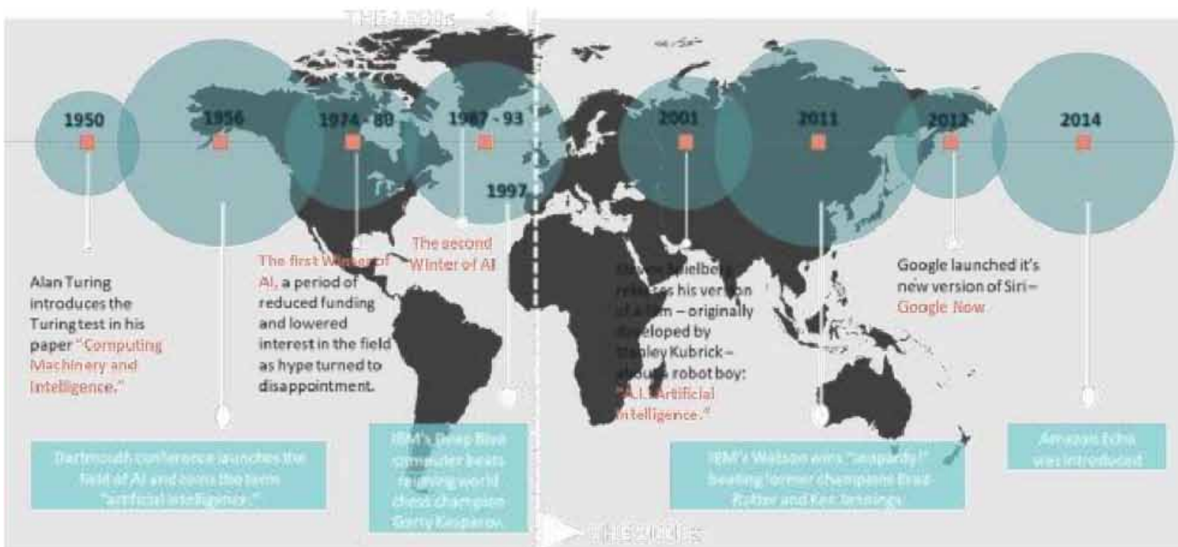
the future but something we live and breathe alongside. In the field of AI, assumptions consistently beat reality. AI is a section of technical science that centers around making smart, techno-friendly machines and devices. The reason for the multi-dimensions of AI is to attempt to imitate human awareness, cognition and perform undertakings like a human. Calculations and coordinating the factual investigation into a comprehensive format are part of the principal advances of AI. Rationally, practically and simply stating, it implies the unique capacity of a machine or program to think and learn. (Figure 1) By and large, it showcases a machine's ability to imitate human awareness and behavior patterns. Artificial intelligence has become a critical segment to boost innovation in the business arena. Artificial intelligence has undergone three phases since its commencement in the 1950s through to the 1970S where it faced its dark periods, and then rose back in 1980 - 2000 which was the beginning of the AI time, and is now a profound learning period looking back.

Figure 1. Understanding Artificial Intelligence and its benefits



Self-sustaining robots living in our midst is no more an aspect of sci-fi and fiction but rather is reality; vast leaps of progress in the field of artificial intelligence have entitled systems and devices to analyze immense amounts of data in a short period along with accurate processing abilities. AI, one of the branches of information and technology has been used for more than 60 years. Though the term 'artificial intelligence' was confounded in 1956, it is only over the last 5 - 10 years that AI has emerged as a widespread information technology feature and, with the use of superior algorithms and computing power, AI is remodeling the functional, operational, and strategic panorama of diverse multinational enterprises as well as revamping public domains. A subfield of big data technology - artificial intelligence equips computers and machines to inspect data based on inputs and experience history so that humans can take on the responsibility of decision-making accurately. AI algorithms are programmed to take action frequently and mainly use real-time information. According to the Father of AI - John McCarthy, "Artificial Intelligence is the science and engineering of making intelligent machines, including intelligent computer programs". Artificial Intelligence is simply machine learning that can sense, reason, act and adapt based on experience with the main aims of contributing to the capital and economic growth of the country and improving the quality of people's lives. AI means "computers, robots or other technology that can accomplish human tasks as well as learn and complete tasks that humans may not be able to do". From the 1950s all through to the 21st century this subject has seen many high periods (frequently known as AI spring), and low phases (frequently known as AI winter) (Figure 2) along with the drop in investments, ‘Hype’ and the eventual necessity to face ‘reality was an elemental part of AI’s progress. Many experts connected and involved in AI over the years consider ‘this time to be far different. (Tate, 2014)

Figure 2. Global Milestones Crossed in the journey of AI



AI-based tools are increasingly absorbing cognitive abilities that were believed to be unique to humans, and their superiority in number processing, image recognition, language processing, etc. is evident in natural language processing, support systems for decision making, disease diagnosis, navigation. and in many other areas that directly impact people’s lives. The success in compactness and high-speed computing on modern devices is a boon and catalyst for artificial intelligence technology. Predictive searches in browsers, spam filters, predictive taps on cell phones, and message suggestions on social media platforms use AI in the background which many users are unaware of. However, unlike other technological revolutions humanity has experienced in the past, the disruption this technology is creating will be reflected in all aspects of human life and, if one does not adapt to it, could very easily lead to disaster and isolation. The popularization of AI-based technology needs to be done with caution, as the behavior of machines that have achieved a human level of autonomy and self-awareness is unpredictable. However, if used wisely, AI could be a good friend of humanity and help us achieve goals that seem impossible with the skills that humans currently possess alone, which are not possible with traditional tools and techniques. Because of the advances being made, AI is all set to revolutionize health, education, transportation, commerce, etc. Research in machine learning, speech recognition, natural language computer processing, and image processing is expected to have even more computing power and application of AI in the years to come. (Artificial Intelligence and India)

The surges of the revolutionizing AI insurgency spreading worldwide have not left India unimpacted. In a nation like India, with varied cultures and different financial foundations, it is imperative to zero in on any developing innovation and technology that would boost the country’s development. The Indian

Government is additionally mindful of the effect these arising AI innovations could have on the citizens and has dispatched numerous platforms to avail all AI-related benefits while staying away from the science-society struggle. Programs such as, 'Digital India' and 'Skill India', started by the Government of India focus on inculcating and imbibing new abilities amongst the adolescent and assisting them to adapt to the requests of AI-based innovations. In February 2018, the Ministry of Information Technology set up four boards of trustees on AI for Citizen-Centric Services; Data Platforms; Skilling, Reskilling, Research, and Development; Legal Regulatory and Cybersecurity. NITI Aayog (2018) has stated that Agriculture, Transportation, Infrastructure, Education, and Healthcare are the five areas that can profit with AI and has likewise set up a Center of Research Excellence (CORE) to pursue cutting edge research in AI. (Aayog, 2018)

Numerous specialists accept that the use and growth of AI-based applications can assist our country to decrease the rural-urban gap and imbalance present in key aspects of literacy, health facilities, etc. Based on the current situation in India, especially after the pandemic, the healthcare expenses are progressively getting high, and the number

of doctors being low is a constant challenge, especially in rural areas. In many towns of India, there is a major requirement for improved medical support. Improvement of AI-based tech, enhancing and availing medical facilities to the youth and senior citizens of rural India could ensure millions get access to the latest health facilities and thus improve their health. This can be possible only if the rural hospitals get a workforce influx. Currently, the accessibility of medical professionals in the rural areas of India is one-fourth of that in the cities and districts. The accessibility of specialists and attendants in India is not exactly up to the WHO rules. Through AI intermediation in medical services, there can be a tremendous improvement in giving medical care to an enormous rural populace. (Thomas, 2020)

BACKGROUND

Artificial Intelligence in India

Even though it's been around in some structure or other for more than sixty years, the most recent decade has seen the fast development of Artificial Intelligence (AI) universally through innovative breakthroughs in the field. The outcome is that AI has become a vital part of one's regular day-to-day existence. Artificial intelligence-powered devices and machines can reason, comprehend, and collaborate. In simple terms, Artificial Intelligence is a machine that can detect, reason, act, and adjust depending on past events. Simultaneously it adds to the economic growth and development of the country while catering to improving the personal satisfaction and living standards of the citizens.

In India, organizations like Swiggy and Zomato, which have invested vigorously in AI over the recent years, have seen the force of innovation to both maintain and increment development which has thus controlled the conversation towards AI's latent capacity. As per a new report, AI can add US$957 billion (15% of current gross worth added) to India's economy by 2035. It's nothing unexpected at that point, that the public authority has presented strong, multi-pronged activities to expand work efficiency and advancement with the end goal of driving development. However, notwithstanding positioning high as far as the quantity of AI new companies, India lingers behind other G20 countries, specifically the United States and China, in advancement and tech improvement in the field. By and by, a distribution of $480 million in Budget 2018 for exploration, preparing and abilities improving in mechanical technology, advanced assembling, information knowledge, and AI underlines the Indian government's obligation to budding innovations that are viewed as key to boosting monetary and social turn of events. The declaration of a public program this year will see the foundation of a center for AI research further showcases the country's assurance to winning in this field. Strategy producers have likewise assembled a guide for arising innovations and set up a team. (Faggella, 2019)

Delving deeper into understanding the vast concept of AI, how it functions, and what makes it unique: AI has reasoning and understanding abilities because of its graphic processing unit, its advanced algorithms, its program interface, and the internet of things which enables it to behave in particular ways. This vast concept encompasses six fields of cognitive computing, cognitive vision, machine learning, natural language processing, deep learning, and neural networks that all contribute immensely to powering AI. Some of the features of AI are its ability to eliminate tedious tasks, easy data analysis, its imitation of human thinking, its futuristic approach, how it helps in predicting natural disasters, and its facial recognition capacity.

The extent of AI in India is immense. Artificial intelligence innovation in India can make the country a worldwide pioneer in man-made consciousness. One can discover successful uses of AI innovation in India in pretty much every area – farming, medical services, training, framework, transportation, retail, producing, and so forth.

As per a 2018 paper by NITI Aayog, the research organization of India, AI can add USD 1 trillion to the Indian economy by 2035. The paper expresses that AI innovation in India has the potential "to beat the actual limits of capital and work, and open up new wellsprings of significant worth and development." How? Artificial intelligence innovation in India can robotize both intricate and everyday errands that can bring about ideal usage of human resources by empowering them to pack their endeavors in where they add the most benefits thus, improving their general productivity. (Aayog, 2018)

Of the multitude of various regions where the extent of AI in India is promising, there are a couple of areas where the effect of AI in India is expected to yield significant advantages. Education, health, Agriculture, Infrastructure being a few under concentration in the country. In the following chapter, we have focused on various use cases of AI in the healthcare sector.

Artificial Intelligence in the Healthcare Sector

To say that the part of Artificial Intelligence in Healthcare is fascinating would be putting it mildly. With its immense disparities in the medical services field, the glaring absence of highly qualified medical care consultants and development, and a dearth of government funding, our country hold a huge scope of developing an intricately planned versatile healthcare dimension for the citizens. However, with a population of over 1 billion individuals, this task becomes difficult; this is where the role of AI will help ease our burden and create a digitally functional healthcare system connecting various aspects of the healthcare domain on one platform. In contrast to the world, India faces numerous issues in enlarging the medical field. Issues incorporated are the lack of clinical specialists, deficient framework and inadequate government venture, high-therapy costs, powerless specialist patient proportion, late analysis, overscheduled specialists, affliction ignorance, and such. Nevertheless, in an Indian medical care market that is helpful for computerized changes, the occasions are changing as the public authority is showing energy for advancement and supportable undertakings. Tech appropriation, by and large, is moderate, and the Indian government and private players have a lot of preparation to cover on the off chance that we are to find their Western and European partners. AI increase is occurring across clinical exploration, medical clinic tasks, and mechanical medical procedures.

Health sector figureheads face crushing notes of the increasingly critical issues ranging over quality, expenses, and revenue. These people are turning to AI to support decision-making and believe that this technology will deliver accurate insights and reduce the scope for errors. These efforts may enable us to incorporate artificial intelligence to help better human decisions accuracy. Many a time these attempts have been far from successful and leading companies struggle to integrate AI within their current framework. Developing nations like India may face a tough time developing AI-based healthcare solutions owing to the lack of AI experts, skilled personnel, high investment costs, and the nonavailability of required equipment. Nonetheless, these countries also have the following advantages:

- An immense hub of upcoming talent: Upcoming nations hold vast potential for future data analysts, scientists, researchers, and developers.
- Availability and accessibility of vast amounts of medical data: Data is of utmost necessity for AI-powered devices and in countries like India, there is an abundance of data that healthcare-related AI systems can use.

Talking about the challenges and constraints of AI in the medical dimension:

It is seen that AI has a varied number of systems in the health sector, and constantly grows with each technological advancement. But this sector also holds some drawbacks which hinder AI from being merged with the present healthcare structure. These barriers are:

1) Security

In the healthcare industry, privacy and data security is a critical factor and hospitals as-well-as healthcare companies should take utmost care and preventive measures to ensure that the patient information is kept confidential. Business concerns about the possibility of data breaches are reducing the adoption of health technologies. Therefore, advances in artificial intelligence in cybersecurity also play a role in the healthcare sector.

This is one of the main areas healthcare companies invest in as it can more securely ensure privacy and reduce data breaches.

2) Privacy

In healthcare systems, artificial intelligence systems must comply with the patient data laws of organizations that govern and comply with certain rules and regulations. For example, many jurisdictions do not allow data sharing between multiple companies unless requested by the patient. These rules can slow the adoption of AI in healthcare.

3) Reliability on AI Models

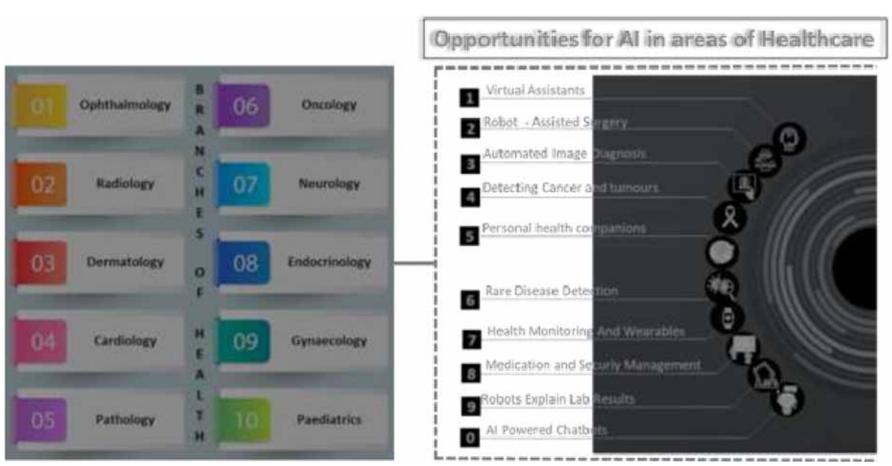
Most AI models get more complicated to produce better results. This complexity makes AI work in a “black box” that makes it more difficult to understand how the model works. Healthcare workers need to understand how and why AI is created with specific outcomes to act accordingly. A lack of justification poses reliability problems for both healthcare companies and patients. Explainable AI solutions (XAI) how they come to specific solutions. A detailed and explainable guide to AI (XAI) to learn more about this area Rigorous testing procedures to avoid diagnostic errors. If AI devices can provide accurate diagnoses, then there is a possibility that they will make mistakes too, making companies reluctant to use AI in the Introducing Healthcare Diagnostic AI tools are not widely used today as they also require FDA (Food and Drug Administration) approval. However, this is an expensive and time-consuming process that can take years. Additionally, some of the previous applications that received FDA approval have shown no significant benefit.

On the other hand, the key benefits of using and implementing AI are:

1. High level and quality of patient care: Early detection and accurate treatment is the key to AI providing the best patient care and solutions.
2. Data-run decision-making process: With machine learning algorithms, AI can document and provide more information about a patient's condition and help clinicians make better data-driven decisions by providing a better picture.
3. Save time and money on administrative tasks: AI is equipped to take on administrative tasks such as patient registration, patient data entry, and doctor planning for appointment requests.

With AI as an assistant, it liberates medics to give time and energy towards recommending the correct counteractant to patients, rather than considering and diagnosing side effects. During seasons of weariness, specialists accidentally administer basic boundaries or data about the patient. Artificial intelligence steps in to check the essential variables of patients and their illnesses. Despite having to overcome various hurdles to integrate AI with the health systems, there is a vast scope in innovating AI-based medical tools and new startups in this dimension. These are the steps that are now shaping and customizing the health management to reduce the errors in inpatient data privacy and ease the doctor-patient transparency to create a dynamic environment for the welfare of the patients. AI in Healthcare can reduce expenses, administer data with precision and be a patient benefitting-oriented platform. (Parry & Aneja, 2020)

Figure 3. Classification for areas of opportunity of AI in the Healthcare Sector



Areas of Artificial Intelligence in Healthcare (Figure 3) that used the most AI-based: (Murali & Sivakumaran, 2018)

1. Making medical care supply effective and gainful.
2. Giving an undeniably more smoothed out and hearty experience to inpatients and outpatients.
3. Making back-end measures compelling and coordinated

Healthcare is said to be one of the primary and topmost sectors which will incorporate AI. The rapidly growing AI healthcare market gives a big boost to this notion as well. Considering the current pandemic and the increasing demand for medical staff and doctors, the growth of the health sector and its integration with artificial intelligence has become a need of the hour as artificial intelligence can play a key role in bridging the gap of demand.

CASE STUDIES OF AI IN HEALTHCARE

Figure 4. Beam Technology for remote proctoring

Virtual Assistants for Patients and Remote Proctoring

The vital driver for receiving virtual nursing partners has been the lack of clinical work that frequently prompts

tension on the accessible medical services laborers. A remote helper fueled by AI can upgrade the correspondence between the doctor and patient while prompting a better patient experience and decreasing the doctor's burnout.

Figure 5. The DaVinci Robot used in surgeries

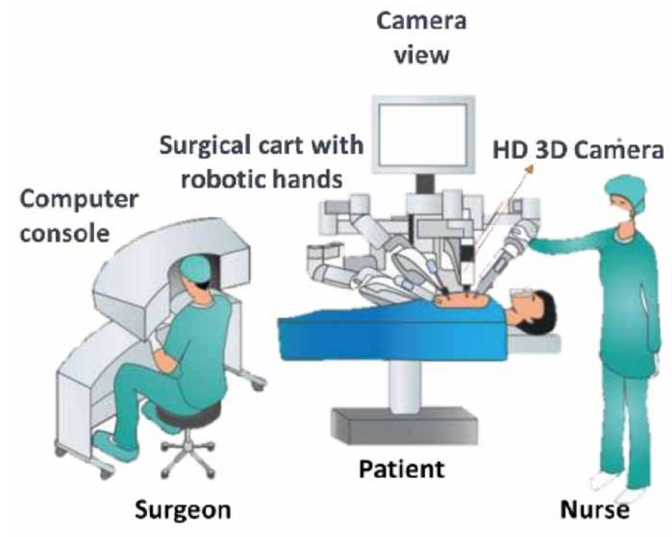


Figure 6. The AI-powered qXR technology

Live Case Study: Virtual Health Powered Tech – DRBOT for Telehealth

Inspired by Innovation and Remote Patient Care

DrBot Virtual Health, LLC is an innovative company that provides customized telehealth solutions and remote patient monitoring services for healthcare providers and their patients using an advanced robot-based telepresence platform along with state-of-the-art patient monitoring devices to monitor their health condition remotely. Providing healthcare professionals & patients with state-of-the-art telehealth solutions for virtual visits and remote patient monitoring. Their mission is to provide high-quality customized telehealth solutions for their clients by using advanced telepresence and remote monitoring technologies for secure, efficient, and cost-effective care for their patients to build healthy communities. The unique feature of services provided by DrBot Virtual Health is the use of an advanced robot-based telepresence technology called Beam® (Figure 4) giving a clinician or health provider the ability to get a comprehensive 360-degree view of their remote patient's physical condition in real-time through two wide-angle HDR cameras for provider and a high-resolution LCD screen for the patient. It provides virtual visits and remote patient monitoring through this tech. Though one may not always get to choose a doctor of their choice, this tech is private, efficient, and time-saving.

AI-Powered Chatbots

Chatbots fueled by AI can improve things greatly in medical care. Artificial intelligence-controlled bots can help doctors in medical decisions through a progression of inquiries where clients select their answers from a predefined set of decisions and are then suggested a strategy likewise. Information from the executive's frameworks will turn into a basic piece of chatbots for AI where the basic inquiries and answers would be collected for the duration of the existence of an answer, supporting the learning cycle of the chatbot.

Case Study: Querent Powered App – Practo (Practo App)

Practo aims at integrating various sections of the health sector ecosystem and connects them all. Their moderation team takes AI and algorithms help to ensure that only first-hand and useful experiences make it onto the platform. The patient feedback filtration procedure and verification are also done by AI-powered algorithms.

Robot-Assisted Surgery

Microsurgical techniques in the medical services space require exactness and precision. Robots fueled with AI are helping doctors to help lessen varieties that could influence patient wellbeing and recuperation in the more extended term. Robot-supported strategies can make up for the distinctions in the abilities of doctors in instances of new or troublesome medical procedures, which frequently lead to suggestions for the wellbeing of the patient, or expenses of the method.

Live Case Study: Intuitive Surgical Powered – Da Vinci Robot

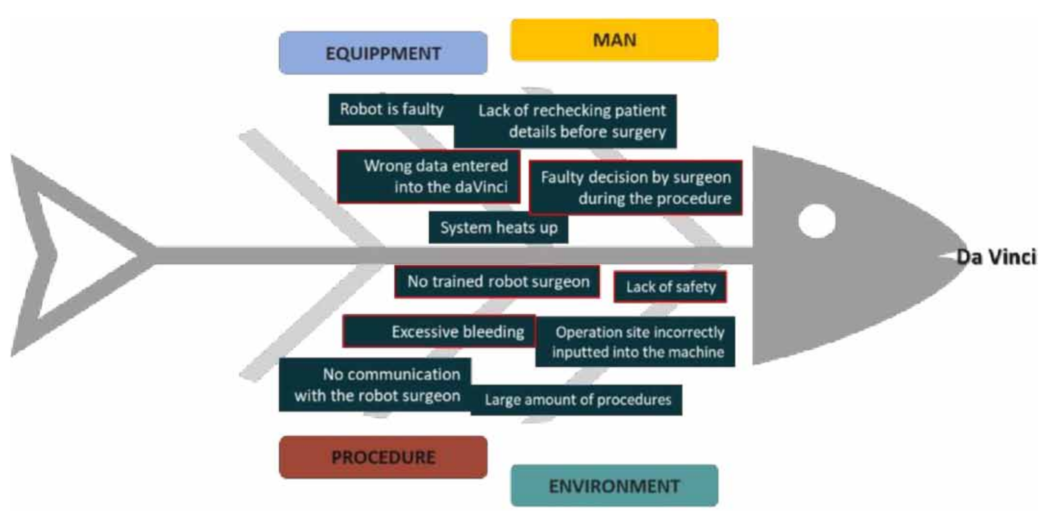
Looking at a very interesting case study about the Da Vinci robot which was created by the company Intuitive Surgical for minimum invasive surgery. The Da Vinci robot costs 25 crores and requires 70-75 lacs for annual maintenance. For any patient using this technology, we will have to pay 1-2 lakh extra. It is mainly used in Cancer, brain, spine, and knee surgeries. In Ahmedabad 4 hospitals are currently using this robot namely Sterling, Zydus, HCG, and Parekh hospital. Educated people are more willing to use and have the resources to afford it. A downside of the robot surgeries is that the Mediclaim refund will not be granted for the extra robot charges. Talking more about the creator Intuitive Surgical is a one of its kind company approved to produce and sell AI agents according to US legal laws and standards. These robots have a counter on them and will be useful for up to 10 major surgeries after which one will have to buy them again. The Da Vinci can move in 7 different ways, turn 360 degrees, and has 4 arms - 3 instruments and 1 camera (Figure 5) While talking to a doctor who is not only an oncologist but also a certified robot surgeon; a comparison of the present technology being used i.e. the laparoscopy instrument and the incoming technology i.e. the robot was done from which several differences were observed:

1. Laparoscopy offers only a 2D image from the camera and cannot move 360 degrees while Robot gives a 3D high definition image on the screen during the operation and can rotate 360 degrees
2. Doctors are trained since medical studies to use this device. Almost all surgeons are capable to use it whereas the training process is rigorous and requires 3-4 animal sacrifices per person. Very few doctors are certified
3. Touch, feel, and sensation is there with the patient while operating as compared to Lack of touch, feel, and sensation while using robots which makes doctors rely on vision alone
4. There is no issue in patient acceptance of this technology whereas only educated and wealthy patients are easily motivated to undergo robot-assisted surgery compared to uneducated ones.

The DaVinci ensures that the patient has minimum invasion, less trauma, and a short hospital stay. Similarly, it assures precision and accuracy in results for the doctors. On the other hand, the disadvantages of – inflammation, burns, tears, increased heat of the machine, wrong data entry and excessive bleeding are drastic.

A root cause analysis (Figure 6) done with the help of the fishbone diagram based on discussion with doctors and patients based on the issues of the DaVinci states that lack of training, safety, excessive bleeding, surgeon's faulty data entry can prove to be fatal for the patient which is why the barrier of cultural acceptance and adoption of AI in healthcare remains.

Figure 7. Root Cause Analysis (Fishbone Diagram) on the DaVinci Robot



Automated Image Diagnosis with AI

Clinical picture analysis is another AI use case in medical services. Quite possibly the main issue that clinical specialists face is filtering through the volume of data accessible to them, on account of EMRs and EHRs. This information likewise incorporates imaging information separated from strategy reports, pathology reports, downloaded information, and so on, Later on, patients will send considerably more information through their far-off entryways, including pictures of the injury site to check if there is a requirement for an in-person registration after a mending period.

Live Case Study: Qure.ai Powered Tech – qXR for TB and Covid

Qure.ai was founded in Mumbai, 2016. Our mission is to use artificial intelligence to make healthcare more accessible and affordable. In the past four years, qure.ai has standardized AI across all its platforms with high accuracy rates. Their qXR technology helps detects abnormalities through chest X-rays, (Figure 7) after which it recognizes and isolated those twenty-nine common abnormalities. It also can detect tuberculosis in its screens, and thus is used in public health camps mainly in rural India. The qXR technology has been fed over 1 million curated X-ray and radiology reports, making it hardware-agnostic and robust to variations in X-ray quality. It is now being used to screen and detect the novel covid virus. Apart from the occasional internet connectivity issue in remote areas they have deployed their easy-to-use qXR tech globally and surpassed their company goals to make healthcare more accessible and affordable for the public.

Oncology – Detecting Cancer with AI

Specialists are utilizing profound figuring out how to prepare machines to recognize malignant tissues with a precision practically identical to a prepared physicist. Profound learning holds exceptional worth in distinguishing malignancy as it can help accomplish higher symptomatic precision in contrast with area specialists.

Live Case Study: Niramai Powered Tech – Thermalytix

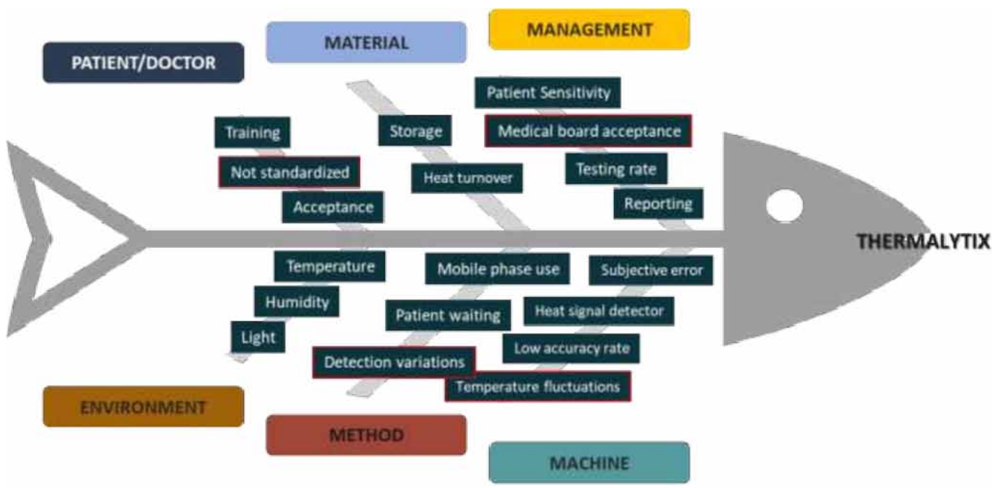
Talking about the company NIRAMAI Health Analytix which is a Bangalore-based deep-tech start-up addressing critical healthcare problems through automated solutions. They developed the breast cancer detection technology Thermalytix that is a system and method for detecting cancerous tissue and tumorous breast tissue from a thermal image. It works based on body temperature to detect the highest heat signals in the chest area. It has an accuracy rate of 74% and each system costs 3 to 4 lacs. Privacy and non-invasiveness are its prime benefits. Currently, this technology is not recognized or authorized by the medical board of India due to its constant fluctuations in heat signals and its high maintenance. However, it can and is being used in medical camps conducted in rural areas.

A root cause analysis (Figure 8) done with the help of the fishbone diagram on the various issues of the Thermalytix technology shows that medical and legal standardization, patient acceptance, tech accuracy, and temperature fluctuations are the key reasons behind the non - recognition of the technology.

Rare Diseases Detection with AI

Uncommon illnesses present difficulties for AI. While their recognition is one of them, we likewise need to guarantee our medical care frameworks are not slanted towards recognizing uncommon infections when the determination could be an ordinary thing. Through a progression of neural organizations, AI is helping medical services suppliers accomplish this equilibrium. Facial acknowledgment programming is joined with AI to distinguish designs in looks that point us towards the chance of an uncommon illness. Face2gene is a hereditary inquiry and reference application for doctors. In this arrangement, AI looks over the picture information of a patient's face and spots indications of hereditary issues, for example, Down's Syndrome.

Figure 8. Root Cause Analysis (Fishbone Diagram) on the Thermalytix technology



Case Study on FNDA Powered – Face2gene (FDNA Telehealth)

Building AI-based Phenotyping Technologies - FNDAs roots stem from facial recognition but the future lies in the phenotype, and as a leader, in AI they aim to provide innovative, impactful solutions. FDNA Telehealth helps patients with rare genetic diseases gets faster and more accurate genetic analysis. Since 2011, FDNA continues to aid clinicians, researchers, and genetic testing labs in finding answers and treatments for hundreds of millions of patients globally living with a genetic or rare disease.

Live Case Study: Invento Robotics Powered – Mitra robot for Covid

The Mitra robot uses facial recognition to identify patients, occupy and keep them engaged until the doctors are made aware of their presence. Mitra robot is equipped with automation and can decrease operational costs and enhance the patient experience. (Mitra Robot)

Mitra's (Figure 9) abilities help the doctor to understand the patients better which is more beneficial for the patients themselves. An upgraded patient experience leads to satisfaction and doctor goodwill which is best for the growth of the medical field. Unlike the medical staff, the Mitra can keep track of the patients spread over the hospital and provide them real-time services without the risk of getting infected. Ironically, robots are helping bring back humanity to a point where humans are lost in the pandemic crisis.

Figure 9. The Mitra Robot and the Karmi Bot

Key Characteristics of the Mitra Robot

Facial Recognition

Easily recognizes visitors, points out age, gender, emotional level, and much more with its computer vision.

Engaging Conversations

Involves customers with its conversation engine, which recognizes the speech input of the user and provides appropriate information with its (NLP) natural language processing content.

Autonomous Navigation

Mitra can move autonomously and with an accuracy of one centimeter to open a range of location services.

Live Case Study: Asimov Robotics Powered – KARMIBOT for Covid

ASIMOV Robotics has come up with a newly designed robotic platform, KARMI-Bot to support the health workers from getting infected inside the quarantine zone. Being used in Kochi; KARMI-Bot is very practical and capable of autonomously navigating inside the isolation ward to transport and delivering food and medical provisions to the patients admitted. The robot can occupy patients as well as start a video conference between doctor/nurse and patients from any secluded area. The robot is also equipped to disinfect items used by the patients while leaving the ward back to the home station so that the nurses are spared any risks of contact. (Figure 9)

KARMI-Bot Features

- Autonomous dispensing of food and medical supplies inside the isolation ward.
- Cost-effective and lightweight. Easy to handle, you can transport it in a hatchback.
- Heavy payload up to 20 Kgs.
- Quick transportation up to 1 m/Sec.
- Autonomous and remote control.
- Video streaming and video conferencing.
- Detachable container with UV self-disinfection facility of used items between visits
- Disinfection with electrostatic sprays
- Self-Charging

Other Uses of AI in healthcare are: (Mishra, Takke, Auti, Suryavanshi, & Oza, 2017)

AI in Pathology

Pathology worries with the finding of infections dependent on the examination of organic liquids like blood and pee. AI in medical services can help improve the endeavors in pathology generally left to pathologists regularly need to assess numerous pictures to arrive at a determination in the wake of discovering any hint of anomalies. With assistance from AI and profound learning, pathologists' endeavors can be smoothed out, and the exactness in dynamic can be improved.

Robots for Explaining Lab Results

In 2017, Scanadu created doc.ai. The application removes one errand from specialists and doles out it to the AI – the work of deciphering lab results. The stage works with normal language preparing to chat with the patients employing a versatile application and discloses their lab results to them in a manner they can comprehend. The innovation is controlled by AI and eases specialists from their not-so-main thing from the medical care measure, permitting them to zero in on the more basic viewpoints.

Medication Management with AI

The AiCure application created by The National Institutes of Health helps screen drugs by a patient. With a maxim of "Smart Observation. Health Care.", the application empowers independent affirmation that a patient is routinely devouring the recommended medicine. A cell phone webcam is coordinated with AI to oversee drugs for the patient.

Furthermore, the powers of artificial intelligence can be leveraged for:

- Goodwill management, promotion, and marketing - Designing an optimal marketing strategy for the
  hospital-based on user perception and targeted audience section.
- Cost and risk – Set a standardized rate for treatment and services based on competitors as well as market conditions.
- Market research and knowledge - Prepare hospital with AI for competition.

- Operations – AI automation would help hospitals automate regular front and back-office operations like reporting.
- Patient/user service chatbots – This allows the patients to ask queries about bill payment issues, booking appointments, or medication refunds.
- Fraud scam detection – Sometimes patients might state false claims. AI-powered fraud detection systems will assist hospital managers to pinpoint these fraudsters.

1. Health Monitoring with AI and Wearables

Wellbeing observing is now a far and wide use of AI in Healthcare. Wearable wellbeing trackers, for example, those offered by Apple, Fitbit, and Garmin screen movement and pulses. These wearables are then in a situation to send the entirety of the information forward to an AI framework, acquiring more experiences and data about the ideal action prerequisite of an individual.

2. Research

Research and development can leverage the powers of artificial intelligence for the following:

- Drug discovery- Discover new drugs based on previous data petters with the help of AI.
- DNA and Gene analysis - Understand genes and their components as well as foresee the impact of gene alterations.
- Machine - drug comparative effectiveness studies

There are endless possibilities for the uses and needs of AI in healthcare to be listed and identified by experts in one place. In India, the enormous scope of AI execution is on the iron block through new businesses and tech firms. Google and Microsoft are working with clinics to incorporate AI. Tech. Behemoths and life science players are additionally, flushing out AI-based stages, cell phone applications, and chatbots for the clinical business. New businesses are teaming up with clinics for early recognition, repeat, and treatment. Simulated intelligence is changing determination and medicines across chemical imbalance, cardiology, ophthalmology, dementia, nervous system science, oncology, pathology, radiology, gynecology, pediatrics, in addition to the mental universe of bipolar problems, Post-Traumatic Stress Disorder (PTSD), and schizophrenia. Different factors, for example, enormous scope datasets of a gigantic populace, hyperconnectivity, and digitalization present the right climate for AI pilot tasks to extend and thrive. (Murali & Sivakumaran, 2018)

In the intricate universe of medical care, Artificial Intelligence can help practitioners faster to come too early conclusions with the help of information investigation and recognize hereditary data to incline somebody to a specific illness. Saving seconds could mean saving lives in the medical services space and that is the motivation behind why artificial intelligence holds such importance for patients and doctors equally.

FUTURE RESEARCH DIRECTIONS

Artificial intelligence is practically taking over all businesses across the globe. Today, interests in AI and Big Data Analysis are pouring in as these advancements can bring monstrous technological changes. Alongside others, medical care specifically, is seeing an enormous change as AI-sponsored information has empowered the field to streamline and mechanize its cycles.

Since the pandemic, AI in medical services is assuming a game-evolving part; in this area, AI implies performing digital errands using complex calculations that are explicitly intended for the reason. This can be used by specialists, analysts, and researchers to audit, propose, and decipher answers for clinical issues in the present age. For example, in the wake of the pandemic, the patient lab-test information across the globe was digitized and worked together. Simulated intelligence is likewise assuming a significant part in learning designs, anticipating effect, and treatment in explicit areas. Such pointers assist the administrations with making remedial moves before the circumstance turns more awful. Furthermore, AI is empowering research labs to break down the information and think of discoveries in spaces of infection indications, in this manner offering plausible arrangements.

The more normal use of AI and ML in medical care is exactness medication. This implies that it predicts what treatment is well on the way to prevail on a specific patient, given the different properties of the particular patient. The more unpredictable way that AI and ML are being utilized is to foresee results. For example, it very well may be utilized to perceive sores through x-beam pictures. This applies to situations where certain information can't be seen by the natural eye. Further, AI and Deep Learning are likewise being utilized for voice and discourse acknowledgment in Natural Language Processing (NLP). Here, the use of NLP incorporates getting, creating, and order of exploration and documentation. Furthermore, it can likewise be utilized to plan reports, dissect clinical notes, decipher patient associations, and offer human-like conversational arrangements.

Along these lines, AI is by and large broadly sent in different portions. These progressive arrangements are only the aftereffect of starting to expose what's underneath. One can't start to envision the profundity of the marvel that AI is probably going to make in the impending years. It has effectively begun changing the substance of the instruction and medical services ventures to improve things. Subsequently, it wouldn't be a jump to say that the AI insurgency is occurring at a quick speed.

As AI discovers its way into everything from our cell phones to the inventory network, applications in medical services fall into three general groupings: (Srivastava, 2018)

1. Patient-arranged AI
2. Clinician-arranged AI
3. Managerial and operational-situated AI

The fate of AI in medical services could incorporate undertakings that range from easy to complex—everything from picking up the telephone to clinical record audit, populace wellbeing moving and examination, helpful medication, and gadget configuration, perusing radiology pictures, making clinical determinations and therapy designs, and in any event, conversing with patients. The fate of AI-based knowledge in medical services presents benefits of having the power of artificial reasoning, natural language processing (NLP), and machine learning (ML) in the tools and devices that will be used for healthcare thus, rendering ease in the medical procedures for doctors and patients both. This research project and knowledge have provided a glimpse at how the fate of AI in medical services may unfurl as these advancements are set to sway the health sector over the upcoming decade.

CONCLUSION

Artificial Intelligence is a rapidly growing emerging technology that is predicted to influence us, humans, extraordinarily. For it to non-controversially merge within our society, it requires the coordination of scientists, philanthropists, investors, industrialists, and policy-makers along with a clear understanding of the user perception and response to the tech, and the mindset of the public to accept it. The current project research gives insights into a few opportunities and uses of AI across the various dimension of the health sector in India. There is no doubt that our country is a ‘cultural mosaic’ where expectations, values, adoption, acceptance of the citizens vary especially when it comes to any science and technology interventions. Thus, it is important to conduct more studies focused on the socio-economic and cultural groups in India to understand their perceptions and general attitude towards AI-based tools and devices, which can then be taken up to function as the pointer for this emerging industry and its policymakers to speed up a conflict-free integration of AI-based technology into India. (Challenges of Artificial Intelligence, 2018)

To have a smooth execution of AI advances in India and refrain from a science-society struggle, it is essential to comprehend the outlook of the individuals from different layers of the general public. It is fundamental to come out with compelling methodologies for making individuals mindfully aware of the advantages of the arising AI innovations and wipe out any feelings of trepidation by reporting: (Monitoring, evaluation, and review of national health strategies) the nature of the information individuals have on different AI innovations, their demeanor and assumption from such AI advances and the dread and threats associated with respective AI-based techies. Besides, this is fundamental for the Government and administration to set up the laws and guidelines without causing animosity in the public before the advent of AI begins affecting society. The impact of the disruption of AI is anticipated to be interlaced across all sectors in the industry and the citizens of the nation all in all. Any disregard of this knowledge could cause an AI-Society struggle resulting in individuals’ dissent and prevent our country’s monetary development. (Faggella, 2019)

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Chapter 20
Case Study on State-of-the-Art Wellness and Health Tracker Devices

Sonali Vyas
https://orcid.org/0000-0003-2348-3394
University of Petroleum and Energy Studies, Dehradun, India

Shaurya Gupta
University of Petroleum and Energy Studies, Dehradun, India

ABSTRACT

In today's world, the concept of smart health is attaining acceptance in the field of medical sciences which is based completely on the concept of IoT. IoT devices are responsible for collecting and analyzing voluminous data, which involves monitoring the health status of various patients, which would enhance the clinical support system and provisions of monitoring and controlling patients with the help of sensors and medical devices equipped with IoT unit. With the aid of various architectural constituents, interactive communication between the medical spaces and remote users, health or wellness systems are being developed in such a manner that they collect data from varied monitoring devices. Then the data being collected is processed, and then a personalized scheme for an individual or patient is suggested for his wellness goal, like walking ten thousand steps would help him lower his blood pressure. This chapter provides an understanding and discusses various environmental considerations like humidity, air temperature, and the forecast provided by the organisation's system.

INTRODUCTION

In today's scenario healthcare in addition to wellness activities are considered must for a healthier and improved living and this is implemented with the help of health management implementation in terms of smart devices and services. Specifically, Japan was the only country in 2005 with its aged person rate at 20% and it will surge to about 40% in 2055 (Ikeda et al., 2011). The problematic condition is about the

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illness rates because of routine ailment like hypertension besides diabetes mellitus. Diabetes complicates illness whereas hypertension is linked with cardiovascular events and are responsible for decreasing the Quality-of-Life (QoL). To encounter all these illnesses our routine depends on various factors like diet, sleep, exercise in addition to dynamic keys like blood pressure measure before and after exercise. Healthcare and wellness data, which is collected by varied sensor, based Internet of Things (IOT) devices and they are amassed in a database, which can be studied in terms of lifestyle diseases or illness generated due to sedentary lifestyle. It might initiate a novel and smart incorporation of smart devices and services. The solutions proposed will be quite valuable and custom-made. Even though people are being more and more health conscious nowadays but still there a stigma allied with mental health and wellness with respect to nutrition in addition to workplace ethics (Clement et al., 2015). Social interaction is one of the features which improves physical and mental well-being of a person (Mirowsky et al., 2013) besides in cases of traumatic events (Collins et al., 2003), (Einarsen et al., 2015), (Berry et al., 2010). Due to increased levels of anxiety which is prompted by substantial assignments in association with substandard working conditions which is responsible for deteriorating a person's psychological well-being. Scholars in specific, always remain at a very high risk of undergoing any mental health issues because of the abrupt variations in their everyday routine besides having unpredictable assignments and general expectations of their parents or teachers. Numerous student associations focus and promote on mental well-being of students along with assisting in providing varied tools to the administration. Facilities or tasks like online self-assessment tests besides individual psychotherapy are made available to students with the ultimate objective of recognizing persons who are at risk of mental ailment or need certain kind of help to manage with present circumstances. There are varied wellness tools which are responsible for addressing a person's health on a weekly basis apart from some tools which address wellness on a day-to-day basis. With the help of developing technologies with mobile sensors in addition to smartphone technologies, wellness can be monitored as well as managed on a day-to-day basis. With the rapid development in Internet of Things (IoT), applications are supporting extremely short power communication protocols in addition to energy competent sensors, that too within a cost competent sensor development kit. Low cost, precise compact sensor nodes are positioned for months without a need of any upkeep cost, whereas regular smartphones act as the receiver.

BACKGROUND

By a period of time due to numerous recent developments in varied technology besides data communication, sufficient types of fitness and well-being nursing systems are developed in previous time span (Patel et al., 2012), (Baig et al., 2013), (Banaee et al., 2010), (Kahaman et al., 2019), (Majumder et al., 2017). Some of the contemporary educations inculcated chronic illnesses of patients (Kakria et al., 2015), (Eternadi et al., 2015), (Sabesan et al., 2015) therapy involving rehabilitation (Sung et al., 2005), (Sardini et al., 2014), (Xu et al., 2016), cardiac illness (Sapno et al., 2016), (Megalingam et al., 2015), (Lan et al., 2012), (Melillo et al., 2015), (Doty et al., 2015), and universal wellness (Ghayvat et al., 2015), (Forkan et al., 2016), (Arshad et al., 2016), (Lim et al., 2017). Modern investigation study in terms of healthiness nursing structure which is broadly classified in two categories. First category comprises of hardware progress and development being easy-to-use dependable wearable sensors devices plus central consumption system; though the other one is concentrated especially on information investigation on data which has been collected from varied health care resources. In current time, exploration tendencies are transferred from hardware progress besides extent legitimacy in terms of application level and institution-centered support structures to patient-centric arrangement (Chawla et al., 2013). Though, broader reception in terms of prevailing structures in case of incessant observing which has certain limits:

- Data dispensation plus investigation and all are carried out offline.
- Maximum of the contemporary structures emphasis on the usage of smart device besides providing prompt solo constraint measurement dimension.

Custom-made well-being nursing system involves data mining, decision support system, besides context-aware system which is needed to enable analysis, cure, besides carefulness which is completely centered on any person's hereditary routine apart from that they permit persons to monitor their vital signs very closely and if there's a change in those signs by large margin, they can alert medicinal employees as it may be an indication of a lethal possibility of as symptom. The contemporary reading in (Herland et al., 2014), (Zhang et al., 2012), (Thommandrum et al., 2013), (Chitra et al., 2013), (Mythili et al., 2013) suggest employment of custom-made welfare nursing structure, with the help data mining tools which are operational in providing resolutions in competent healthcare amenities. Furthermore, an integrated system can be used to incorporate healthiness nursing dimensions via dissimilar sources and with assistance of smart devices which act as a quite beneficial tool in terms of generating well-being consciousness amongst the people in addition to aged homebased nursing (Meharia et al., 2016), (Rebolledo et al., 2015), (Chen et al., 2011), (Naddeo et al., 2017). Assimilated usage of data from numerous sources of information stands very beneficial in terms of procurement of supplementary consistent info rather than discrete dimension attained from a solo kind of sources. Therefore, it is quite important to record activity and keep a log of repetitive scrutiny data for on-time deterrence, therapy of any kind of illness. Various pharmaceutical companies are focussing more and more on health management and targeting the population having sedentary regime by introducing health supplements besides an assortment of health and wellness devices for varied age groups and they claim to have assured enactment against certain lifestyle diseases. With due course of time mobile health services has seen major innovative developments in monitoring and diagnosing patient's illness along with therapy and medication suggestion remotely. Even speedy developments in the field of information besides sensor technology have led to improvement of tools and methods for personalised health monitoring of patients or individuals. The apps or smart wearable bands of various companies keep a steady track of steps walked by an individual, keeps a count of calorie consumed in a day, measurement of heart rate and blood pressure. In case of patients this kind of wearable devices or trackers helps in implementation of one station-based monitoring by doctors or nurses and which in turn aids in detecting the physiological changes of patients.

IOT ARCHITECTURE IN SMART HEALTHCARE

During contemporary time, IOT has found its application in varied healthcare amenities especially applications involving universal hardware device units, which are able to interconnect with the help of Wireless Sensor Network (WSN). Applications of IOT especially in terms of healthcare are increasing gradually in homebased healthcare besides infirmary administration. Smart wellbeing specifies the involvement of healthiness with the help of IT gears in addition to medic patient message exchange procedures. Growth of hardware devices like smartphones plus their incorporation with numerous kinds of sensors has provided significant development in terms of smart itinerant wellbeing. World Health Organization (WHO) has demarcated the word "public health" as "carefulness plus medicinal repetition which is reinforced with the help of mobile hardware devices, like smartphones, patient nursing hardware device units, and custom-made digital aids besides other wireless device units". The utmost acknowledged advantage is unquestionably the aptitude in being associated to our healthcare specialists, at any point of time and immaterial of the distance. These kind of health solutions involves secure transmission of bodily motion signals which is gathered with the help of dissimilar wearable sensor devices, to various healthcare institutes. It ensures newer modes of communication amongst patient and doctors, apart from that it offers custom-made healing and relaxing treatment suggestions to patients. Authors in (Ahmadi et al., 2017) presented a review which regulates varied IoT styles in healthcare segment apart from that responding to several queries involving varied IoT application architecture in terms of healthcare plus the necessity of indispensable constituents of IoT architecture when healthcare is taken into consideration and the prevailing exploration is focused in the direction of incorporation of smart health tools in case of illness like cancer apart from some lifestyle generated diseases like obesity, diabetes, etc. Numerous efforts were directed in nursing patient disorders at their homes, which includes fall detection of bedsores seizures, and rehabilitation homes. Home-based nursing is amongst one of the useful applications of WSN (Kharel et al., 2019), wherein varied sensors identify common people activity. It plays a quite protruding part infirmaries and super speciality hospitals, which is implemented by intelligent processes and devices, which are communicating amongst themselves (Din et al., 2019). IoT plays a very significant role in supporting to infirmaries transportation and logistics structures, alternative circumstances, post-discharge patient care and their conforming medication including their distant nursing (Hamidi et al., 2019). Cloud computing stands as the backbone technology for IOT implementation in smart healthcare. Authors in (Sung et al., 2013) anticipated cloud centered architecture design which identifies the difficulties besides readmissions which is cantered on patient dynamic info. In (Vargheese et al., 2014) a regular biological sign recognition system in terms of blood pressure, oxygen consumption, besides body temperature, is taken as an input in Cloud-based architecture providing excessive convenience, suppleness provided security of data besides power intake needs to be taken care of. In (Sarma et al., 2019), authors recommend perceptive power administration regulator enhanced with adaptive energy convertible practice in order to control power ingestion which is solely based on energy status of battery (De Ridder et al., 2017a) along with it assesses the power ingestion in Wireless Body Area Network (WBAN) for ECG sign monitoring. Benefits and shortcomings of IoT applications in smart health are discussed in Table 1.

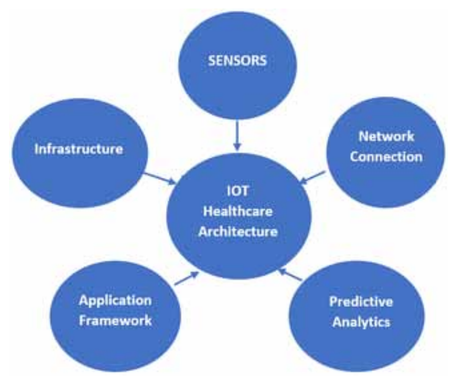
Table 1. IoT Applications in Smart Health: Methodology, Advantages and Disadvantages

Methodology	Advantages	Disadvantages
Well-being Monitoring via WSN and Cloud Computing	Cost effective ubiquitous monitoring technique	WSN node deployment is tougher than wired node installation
Health Monitoring via Wireless Body Area Sensor Network (WBASN)	Addendum of new sensor is quite easy	Sensors must be lightweight and easy configurable
IoT enabled smart device implementation	Real time access of data apart from intelligent data integration	Continuous upgradation of hardware device units is required

Source: (Ahad et al., 2020)

Self-powered IoT nodes are now a crucial part of investigation in IoT sphere because of energy gathering procedures (Ray et al., 2018a). It upsurges the energy effectiveness with the help of augmenting the accessible energy to get consumed throughout data broadcast. Additional method which is projected for prolonging epoch of IoT aided units involves the usage of lightweight protocols (Khan et al., 2021), which are responsible in communicating amongst source and sink node involving the usage of least number of transitional device units which helps in lessening the power ingestion. Architectural design, which is being discussed in figure 1, discusses about the prevailing systems supporting the concept of smart health, which is quite capable in analysis of massive capacities of varied experimental data, which is personalized in terms of varied contexts besides many health application situations instead of focussing on a single health issue (Ahad et al., 2020). Furthermore, it encourages smart health nursing besides decision-based support systems.

Figure 1. IOT in Smart Healthcare (Comito et al., 2014)



IoT-cantered design aims at collection besides analysing massive capacities of varied medical information for the purpose of advancing and automatizing healthiness (Savaridass et al., 2021) and observing in addition to medical decision support system like illness diagnosis at a very early stage (Strobel et al., 2020). The clinical data which is generated which is produced during the process is devised by varied disseminated bases, which includes info involving microelectronic healthiness histories, research laboratory test data, signs of illness of patients of varied age, electrocardiography (ECG) outcomes (Hussan et al., 2021). The demographics is used in identification of alike patients, health records or medical imageries, besides data being sourced from wearable device units (Muneer et al., 2020), (Bedon-Molina et al., 2020). Mobile device units, wearable devices in addition to sensors forms the essential components of the architecture which are in turn connected to cloud. Figure 2 expresses the varied constituents of architecture besides interactions amongst them. Cloud-centered base permits the essential association amongst patients, medics in addition to other fitness specialists who are being continuously aided by smart medical amenities. A patient, is linked with numerous mobile device units like smart phones, watches, glasses, wearable devices and sensors which includes EEG, ECG, EMG sensors apart from blood and motion sensors which are capable of interacting amongst themselves via ad-hoc connections like Wi-Fi, Bluetooth (De Ridder et al., 2017b). Data communication takes place amongst nodes in order to update the biological standing or for a calculation demand in order to analyse varied medical data. Info dispensation is disseminated over numerous autonomous device units. Massive volume of information is placed together then for the purpose of analysis which is either done locally or remotely on cloud which is further obtainable for several, geologically disseminated healthcare infirmaries which thereby aids in the process of detection of illness or disease (Ray et al., 2018b).

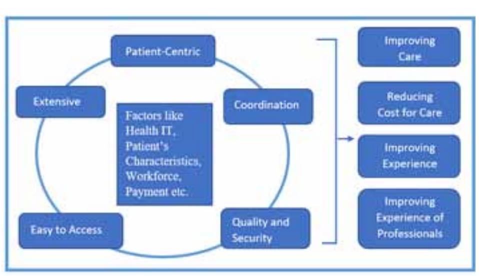
For the purpose of supporting medical practitioner besides healthcare benefactors in decision making the following phases are suggested:

- **Knowledge Attainment**: A dominion information is created with the help of dissimilar bases like expert heuristics, strategies, printed exploration besides prevailing systems.
- **Knowledge Demonstrating**: Assimilated knowledge is transmuted to a prescribed illustration. Considering the scenario of healthiness information investigation in cloud settings, dissimilar machine learning practices are applied. These set of certain procedures may be alienated in groups based on cataloguing, cluster analysis, association rule mining, time series analysis, and anomaly detection.
- **Rule Generation**: Knowledge is transmuted from prescribed depiction to computer executable layout.
- **Implementation***:* It includes development of a separate executable setting for the purpose of execution of generated knowledge in aiding out recommendations. Natural language Processing, predictive analytics are used for the purpose of improving effectiveness of resolution making procedures.
- **Evaluation***:* Accurateness of system is estimated on real or existing patient information which always corresponds to a particular medicinal field.

Depending on the application circumstances plus devices nominal characteristics like computing capability, existing memory the above steps are carried out locally on patient's mobile device units and partly on cloud. The concerned architecture is used in distant observing of biological standing in patients' status which requires constant attention, besides the architecture is quite useful in regions where healthiness providers and services are not accessible in the vicinity. It also licenses patients whom can be identified besides being hypothetically cured distantly by medics, fitness specialists. Architecture is being discussed in figure 2 having subsequent features like:

- Provisioning in terms of frequent user movement besides the use of moveable device unit's, wearable device units in addition to intellectual terminal device units.

Figure 2. Home and Medical care: Blend of Business and Technology (Nakajima et al., 2014)



- Enables admittance of information dynamically which reduces the need of interaction with patients directly.
- Analyses of vast capacities of varied medical data which will suffice to knowledge attainment methods.
- With the help of influential computation besides analysis competences of cloud computing, it delivers more precise, real-time wellbeing amenities to users.
- Guarantees energy effectiveness, by efficient energy consumption and distribution amongst accessible devices units associated to patients.

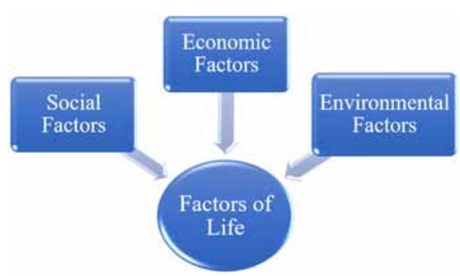
HOMEBASED MEDICINAL NURSING

It's important to measure the blood pressure daily at home which is quite necessary for the study or monitoring of medical professional. In response to this clarification, the home-measured blood pressure is specified in the guidelines for the diagnosis and treatment of hypertension (Shimamoto et al., 2014). By this discussion, we are able to reach the target, along with the rate, blood pressure, which should be evaluated and treated, both in the home or in infirmary and it may be a part of complementary medical exam involving a short period of time. These recordings would help us in maintaining an overall healthy lifestyle. The measured indicators can be helpful, both in the medicinal field and in the case of self-care-management.

THREE FACTORS OF LIFESTYLE

It is well known, there are three lifestyle factors as shown in figure.3, like diet and nutrition, sleep and rest, daily activity and training sessions. This has to be one of the important cause-effect relationships between the habits, way of life, and of the vital signals for measuring blood pressure, blood glucose, and adipose tissue.

Figure 3. The Three Factors of Lifestyle (Nakajima et al., 2014)



The sensory information is used in order to establish cause-effect relationships, which can be used to avert illness and improvise human health. One of the most important indicators of overall health is the blood pressure. It is closely related to cardiovascular events, as it was, the body was crippled by a heart attack, and heart failure. It is easy to measure, both at home and in the health care system. Some useful indicators related to life-style are weight, activity, body mass, and sleep status. The weight can be used as a substitute for the quality of the benchmarks in the amount of weight in one's life which is being shown in figure 4. The active monitoring measures such as intensity and amount of physical activity, and other day-to-day life activities. The sleep monitor will measure the quality and quantity of sleep. The multi-dimensional time series data related to blood pressure, body weight, and the sleep mode can be assembled in the sensor unit. The cause-effect which is obtained from the data, will provide important insights for the analysis and prediction related to specific health conditions.

Figure 4. The Parameters of Quality of Life (Nakajima et al., 2014)

MEASURING VISCERAL FAT

Visceral fat accumulation in the abdominal cavity, has been known to be closely associated with lifestyle-related diseases, and metabolic syndrome. The cross-sectional area, with the help of x-ray computed tomography (CT) or magnetic resonance imaging (MRI) is vital in the field of medicine, in order to measure visceral adipose tissue. Though, X-Ray exposure is caused by CT scan and complicated to use and expensive. Compared with the above problems, it is very important to have non-infringement, low action, and easy-to-use and low-cost medical instrument. In addition, these device benefits, but in the x-ray effect, can be used later to measure the reduction of visceral fat for the treatment of the metabolic syndrome, and obesity. In order to gain visceral fat in all of the other formulations of the human abdominal cavity, the two types of bioelectrical impedances is known as the Dual Impedance of the (DIS) is used in (Shiga et al., 2009), (Yoneda et al., 2008). Of the style, the electrodes are placed in the back of both hands, and legs and the surface area of the abdomen impedance is measured through the electrodes. An electric current is passed between the electrodes on the back side. Though the resistance can be measured by means of electrodes placed on the arms, legs, and stomach. The power is transmitted from the hands and the feet.

ACTIVE MASS METER

The loss or destruction of the metabolic syndrome, is the most important problem these days. The Japanese Government and the Ministry of Health, Labour and Social Welfare issued guidelines on the criteria for the indicators of physical activity and exercise in 2006, (Nakajima et al., 2011). In accordance with the principle of activity and exercise, which are discussed as below:

- **Physical Activity**: Activities consuming more energy.
- **Workout**: Physical activity that is planned and calculated and improves physical strength.
- **Daily Exercises**: Physical activity including professional activity.

Table 2. Workouts and Daily Activities

Time	Activity	Day-to-day exercises
25-20 minutes	Muscle training or playing Volleyball	Walk
15 minutes	Brisk-walking, Golf playing	Cycling, playing
10 minutes	Aerobics or jogging	Climbing stairs (up and down)
8 minutes	Swim or running	Lifting heavy objects

Source: (Nakajima et al., 2014)

Active mass meter was designed to calculate physical activities (Oshima et al., 2010). The step count is a well-known, but they tend to lower the estimate during daily chores like laundry, dishwashing, house cleaning, etc. which is being discussed in table 2. Active mass of the meter using the three-dimension accelerometers with evaluation of the algorithms, in order to assess the attitudes and behaviours of people associated with different tasks at different times (Comito et al., 2020).

CONCLUSION AND FUTURE WORK

The chapter suggests that to deal with the health and care of the device for the connection, and the cyclical development of the services. Examples of smart devices and services, which includes equipment for the measurement of visceral fat, the active mass, with the aid of web services. These devices and services provide features that are a part of the solution for difficult life in areas of health and well-being. It is necessary to improve on social innovation in terms of the socially predictable needs. Bioelectrical resistance study, and cause-and-result of the investigation, the analysis is carried out in order to tackle the amount of visceral fat. Active mass meter is easily serviceable with a low penetration rate. Lastly, the measures can be utilised in terms of attainment of quality of life at users end. As far as future work is considered, the cost of health and fitness tracker devices can be optimised in a monetary vertical so that more of the population can have access to it and use it for their improvement in quality of life.

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Chapter 21
AI Technology in Lifestyle Monitoring:
Futuristic View – AI Technology and IoT

S. S. Aravinth
Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Gopi Arepalli
Koneru Lakshmaiah Education Foundation, Vaddeswaram, India

Sakthivel P.
Knowledge Institute of Technology, India

Viknesh D. Kumar
SNS College of Technology, India

Senthil J. Kumar
Sona College of Technology, India

ABSTRACT

Artificial intelligence-assisted technologies are playing a crucial role in the lifestyle monitoring cycle. AI-enabled advancements, devices, products, and clothes are giving a clear picture of the enormous usage of smart applications. These predominantly used solicitations are classifying emails, monitoring health-related issues with smart wearable devices, self-driving cars and unmanned vehicles, faster communications, and web searches. These AI-enabled services are being rendered into industries and home automation initiatives. Also, AI-powered healthcare services and devices are getting few attractions in recent days. In this chapter, a few of the usages of AI technologies in healthcare are discussed, and some proposed ideas are presented. In this chapter, the detailed study and implementation are discussed. This chapter also focuses on revealing some useful information about applying AI-enabled services in the home automation category.

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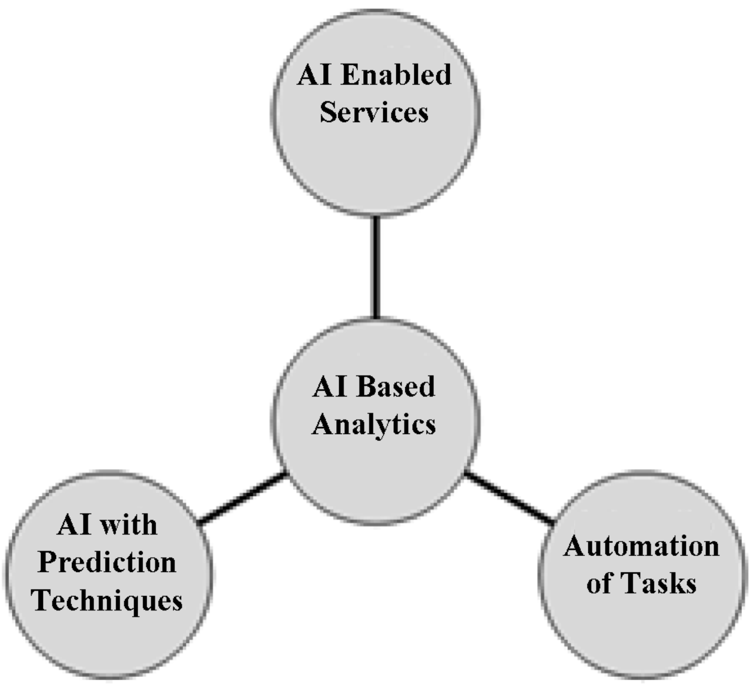
INTRODUCTION

Artificial intelligence is a broad section of computer science and applications. It is the process of making the machines think and act like a human being and also considered as the process of simulating the tasks and workloads concerning living beings (Yasaswini, 2018). AI has given raise to various applications by creating cognitive and intelligent machines which are trying to reduce the iterative and heavy computational intelligence tasks. These applications are employed in various fields such as gaming, arts, manufacturing industries and so on(Vickranth et al., 2019).

Figure 1. AI is Everywhere

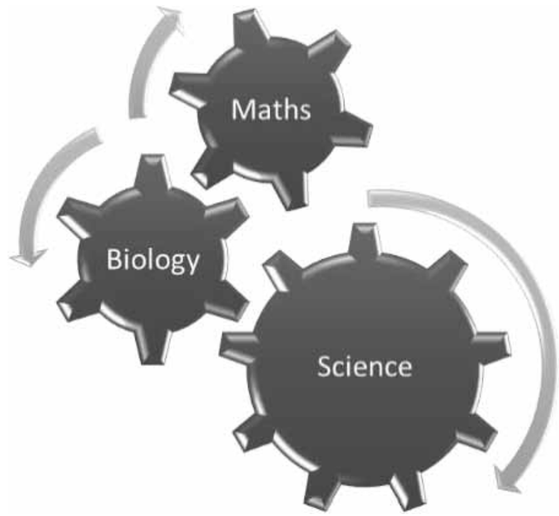


The above fig 1., clearly explains the applications and services in all the business domains. With the help of predictive analytics techniques, the future sales, products and Return on Investment of any business is sensed earlier. Using AI, the learning skills, problem-solving skills and reasoning skills are applied to machines or objects (Sailaja & Madhu Kanth, 2020). The algorithms and instructions are being programmed to create AI intelligent agents to solve real-world problems.

1. COMPOSITION OF AI

This AI technology is the composition of factors such as sociology, computer science, psychology, biology, neuron science and maths (Singh & Singh, 2015). These factors are really helping to get the improved results in AI related algorithms. The below diagram 2. is narrating the importance of factors for consideration of AI based decision making process.

Figure 2. Factors of AI



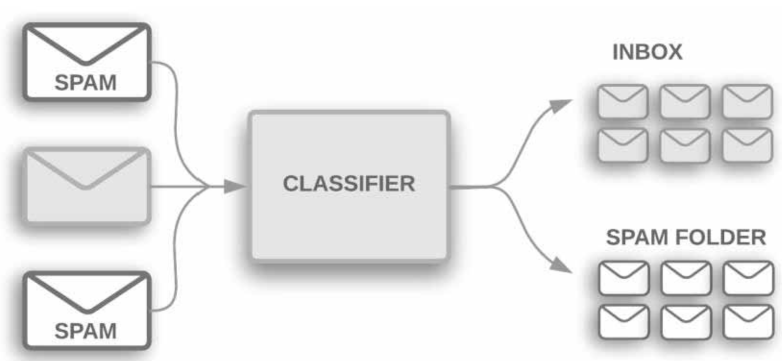
2. AI IN EMAIL CLASSIFICATION

Email communication is used for sharing the information's, advertisements and confidential information's of any businesses. If any service provider wants to send the offer details about products, the recipients will discard those mails into spam folders (Saikumar et al., 2020).

Consider the bank application scenario, enormous of customer data have been stored and accessed often. It is considered as a tedious task to do. So AI based auto scheduled mails are sent with regular intervals (Sarat Kumar et al., 2019).

Classifying those mails are considered one of the challenge in banking sectors. Hence, the AI based classification algorithms are applied to predict and segregate these mails efficiently (Anguraj et al., 2021).

Figure 3. Email Classification using AI Algorithms



Supervised algorithms are applied to deal with the labelled data with features attributes (Zhang, 2021). Such as regression analysis, decision tree classifier, random forest, support vector machine and logistic regression are being used widely. If the dataset has the two variables, then regression techniques are applied to extract the relationship between response variable and predictor variable. The below table 1. gives the report of spam classification results.

Table 1. Spam classification results

S.No	Number of Mails Received	Interval	Iteration Applied	Spam Mails	Non Spam Mails	Accuracy %
1.	850	Jan 2021	23	250	600	98%
2.	725	Feb 2021	35	125	600	92%
3.	650	Mar 2021	45	500	150	98%
4.	600	Apr 2021	25	450	150	96%

3. AI BASED DATA CENTRIC CLINICAL SYSTEM

After the advent of digital assistants such as mobile apps and digital medical guides, the huge amount of digital medical patient's records is accessed to produce the quick results (Kumar et al., 2021). Through these techniques, the medical care takers are able to make the impact on few deadly diseases such as cancer, tumour and covid-19.

The wearable devices are predominantly used as medical assistants in the digitally surrounded world (Sai et al., 2019).

The following fig 5. shows the launch of wearable and health care devices in the global market. Few devices and usages are given in the following table 2.

Figure 4. Smart Health Apps

Figure 5. Wearable Devices

Figure 6. Smart Devices in the Global Market

Table 2. The various usage of Wearable Technology

S.No	Name of Devices	Usages
1.	Smart Glass	To tag the objects
2.	Waistband	Motion Capturing
3.	Smart Watch	WWW
4.	Smart Clothes	Monitoring the Body Temperature

4. AI BASED SELF DRIVING CARS

The automobile industries and vehicle manufacturing industries are trying to make use of the innovation in all their respective products (Mu & Wang, 2020). The autonomous vehicles and self-driving cars are gaining the attention to achieve the technology based outcome in terms of vehicle industries (Anilkumar et al., 2019).

The following industries are launched the smart transport vehicles as per the following figure 7.

5. AI BASED FASTER COMMUNICATIONS

Lifi is a protocol which provides the faster communications between the API's and connected devices (Kaleem & Khan, 2020). This Lifi technology drives the AI application towards the fast exchange of services to the real time networked entities. The following are the list of advantages of using the Lifi with AI technologies (Sahiti et al., 2019).

1. Higher degree of data transmission
2. Low power consumption
3. Low cost of ownership
4. Easy deployment
5. Enhanced security

The Lifi technology also has few enhanced metrics with respect to Wifi. Those are coverage distance, interference, multi-mode operation and privacy.

6. AI BASED WEB SEARCH

Web search gives the massive amount of the web information to the user based on the keyword. The search engine throws plenty of gathered information within a few seconds. With the role of search engine crawler and bots, the communication exchange between the web pages are enhanced as a faster (Susmitha & Seshi Reddy, 2017).

The working of search engine has the following steps

1. User search with the keyword & Initiating the crawlers
2. Indexing with the servers
3. Fetching the information from server
4. Throwing the results to user by search engine

From the above figure 8 & 9, it is clearly concluded that, the AI enabled bots and crawlers are playing an important role in fetching and retrieving the fast information to the search engines and users (Weibin et al., 2019).

Figure 7. Workflow of Various practising industries

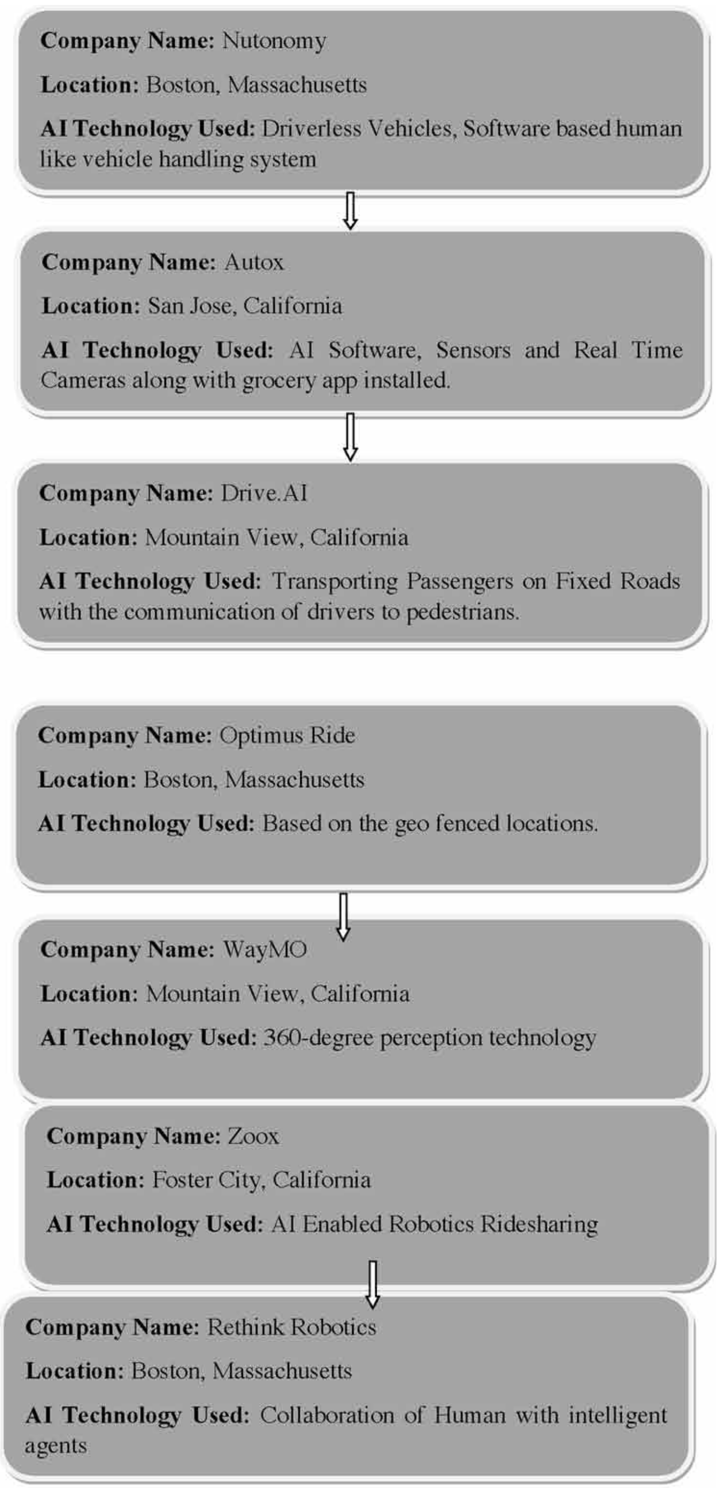


Table 3. Usage of Lifi in various Domains

S.No	Name of the Domain	Scenario
1.	Transportation	Vehicle to Vehicle Communication (V2V)
2.	Augmented and Virtual Reality	Marketing Products Experiences
3.	Industry 4.0	Fast Communication
4.	Smart Home	Secured Home Smart Home

Figure 8. Google Engine

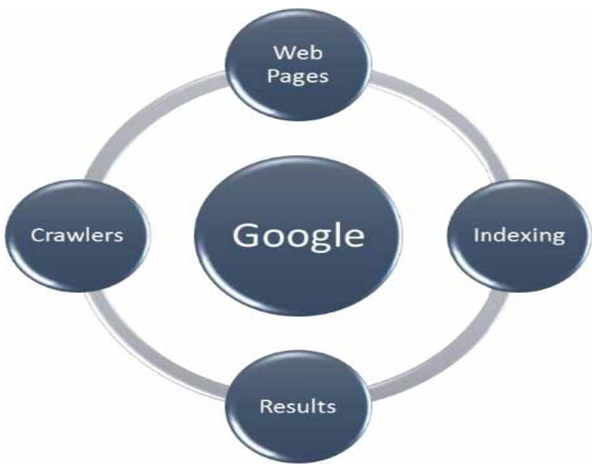
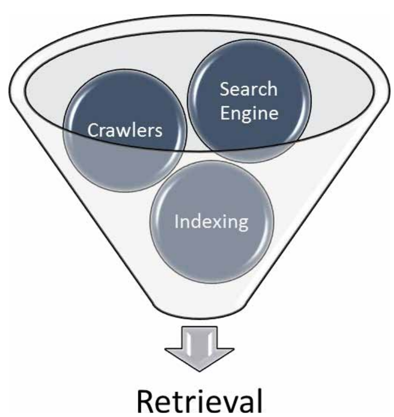


Figure 9. Information Retrieval



The website is organized and developed based on the search engine optimization techniques. These techniques are divided into two types such as on page optimization and off page optimization techniques. Here, in on page, the website pages, structure, links, tags and keywords length are optimized. Based on these factors, the website is placed in the search engine rankings (Flaih et al., 2019).

Whereas, in off page optimization techniques, the process of driving the heavy traffic to website is considered from the outside world. For that, the link building techniques and back link creation are entertained as shown in the table 4.

Figure 10. AI Based On Page Optimization Techniques

Table 4. Website Optimization Techniques

S.No	Search Engine Rank	Techniques Used	Duration
1	2	On Page	2 months
2	3	Off Page	6 months
3	1	On & Off page	12 months

7. AI BASED INDUSTRY AUTOMATION

AI technologies are providing the precise solutions for computationally heavy tasks that carried out by industries. With the help of robotics process automation software, the repeated tasks are executed by in a smart way. To reduce the extensive manpower in performing heavy computation, these robot-bots are being used in an effective manner (Rusia et al., 2021).

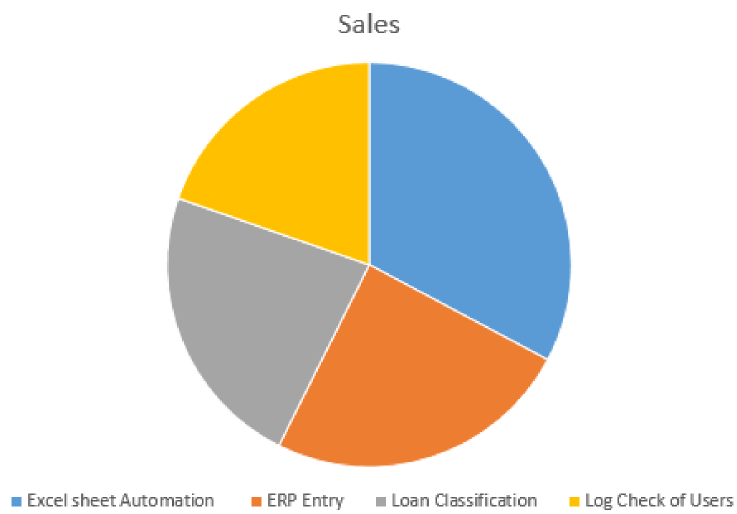
The RPA software are used in the following domains (Hemapriya et al., 2017)

1. Education
2. Food Services
3. Construction Engineering
4. Retail Service
5. E Commerce
6. Banking and Financial Services
7. Healthcare and Agriculture
8. Transportation
9. Manufacturing
10. Public services

The following table narrates the usage of RPA in various domains in terms of performing multiple tasks without the intervention of human beings.

Figure 11. Facts and Figures of RPA Workloads

	Sales
Excel sheet Automation	200
ERP Entry	150
Loan Classification	140
Log Check of Users	120



The above fig 11. Gives the clarity of RPA based workloads automation in industries. Various tasks are carried out with the use of RPA software UiPath and Automation Everywhere. Those tasks are Excel Sheet Preparation, ERP data entry.

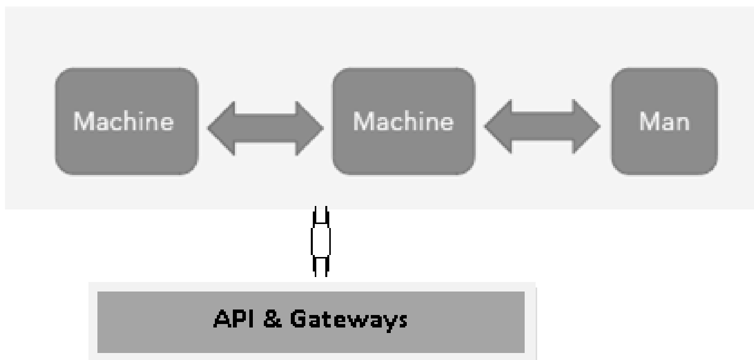
8. AI BASED SMART HOME AUTOMATION

Artificial intelligence creates the integrated solutions to everyday activities to improve the life easier (Meng & Kim, 2011). The voice based google assistants and agents are being used in everyday life to communicate with the family members such google assistant, siri and alexa. Those smart devices are used for solving the problems, creating calendar's and schedules, used for playing the songs and giving the instant replies the users (Hosea et al., 2011).

All the electronic equipment's are embedded with sensor devices and communication gateways. So that the object to object information exchange is carried with the higher degree of efficiency (Khurana et al., 2019).

IoT based smart technologies are offering the great services to all physically available devices. Through that the devices are connected with each other to provide the ample communications (Krey, 2020).

Figure 12. IoT Communication



This above fig 12. is the basic concept of using IoT devices in the home automation landscape. IoT devices produce the machine to machine and machine to man communications to achieve the prompt and faster information exchange.

AI & IoT enabled techniques are being used globally to attain the smart integration of connected devices. The following are the applications of IoT technologies.

1. IoT enabled smart home appliances
2. IoT assisted vehicle transport system
3. Agriculture automation using IoT sensor devices
4. Vehicle tracking and positioning system
5. IoT based healthcare monitoring system
6. IoT in construction technologies

9. CONCLUSION

This book chapter aims to provide the basic idea of Artificial intelligence and IoT based technologies in digital world. These technologies are being incorporated in various industries and domains to provide the better experience with digitally assisted devices (Porkodi & Bhuvaneswari, 2014).

Further to this view, some results are being carried out while implementing these technologies with some use cases. The results are in turn to the enhancement of prompt decision making process (Dudhe et al., 2017).

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About the Contributors

Sailesh Iyer has a Ph.D. (Computer Science) and currently serving as a Professor and Dean, CSE/IT Department, Rai School of Engineering, Rai University, Ahmedabad. He has more than 23 years of experience in Academics, Industry and Corporate Training out of which 18 years are in core Academics. He is presently guiding 8 Research Scholars. In addition to Patents, he is involved as an Editor for Book projects with IGI Global (USA), River Publishers (Denmark), Taylor and Francis (UK) and Bentham Science (UAE). A hardcore Academician and Administrator, he has excelled in Corporate Training, Delivered Expert Talk in various AICTE sponsored STTP's, ATAL FDP's, Reputed Universities, Government organized Workshops, Orientation and Refresher Courses organized by HRDC, Gujarat University. Research Contribution include reputed Publications, Track Chair and TPC Member for various reputed International and National Conferences, Reviewer of International Journals like Multimedia Tools and Applications (Springer), Journal of Computer Science (Scopus Indexed), International Journal of Big Data Analytics in Healthcare (IGI Global), Journal of Renewable Energy and Environment and Editor in various Journals. Expert Talk on Research based topics in various Universities and Conferences in addition to guiding Research Scholars as Supervisor. He has also been invited as a Judge for various events, Examiner for Reputed Universities, is a Computer Society of India Lifetime Member and was serving as Managing Committee (MC) Member, CSI Ahmedabad Chapter from 2018-2020. Research interest areas include Computer Vision and Image Processing, Cyber Security, Data Mining and Analytics, Artificial Intelligence, Machine Learning, Blockchain.

Arti Jain is working as Assistant Professor (Sr. Grade), CSE, Jaypee Institute of Information Technology, Noida, India. She is has academic experience of more than 19 years. She has done her undergraduate in Mathematics (1998) from Delhi University; MCA (2002) from Panjab University; M.S. (2009) from BITS Pilani; and Ph.D. in Computer Science & Engineering (2019) from JIIT Noida. She is a member of IEEE, INSTICC, IAENG, SAFAS, IFERP, and TERA. She is an editorial board member of Journal of Technological Advancements (JTA), IGI Global; American Journal of Neural Networks and Applications, SciencePG; International Journal of Innovations in Engineering & Technology (IJIET), and International Journal of Information Technology and Web Engineering (IJITWE), IGI Global. She has been an international advisory committee member of the International Conference on Recent Trends in Multi-Disciplinary Research (ICRTMDR) during 2020-2021, Maldives; International Conference on Applied Sciences, Engineering, Technology and Management (ICASETM-2020), Dubai, UAE. She is an advisory member of the ATAL advisory committee, Atal Tinkering Lab, Jaypee Public School (JPS), Noida. She is a reviewer of reputed and peer-reviewed International Journals such as World Scientific, Taylor & Francis, IGI Global, Wiley, TISA, Inderscience, GRD, Premier, and has also Guest-Edited various Special Issues. She is a TPC member and reviewer of several International Conferences and has also conducted Special Sessions. She has Chaired Sessions in International Conferences such as 2021 FTSE, ICICC, and many more. She has been the invited speaker for various workshops, seminars, and conferences such as 2021 Workshop on Computer Methods in Medicine & Health Care, Transdisciplinary Information Sciences Conferences (China); 2nd International Webinar on Big Data Analytics and Data Science, Coalesce Research Group (USA); National Workshop on Soft Computing and Language Processing. She has also been the key resource person for prestigious FDPs such as Deep Learning for Natural Language Processing, Applications of Machine Learning, and International Knowledge Development Program by Special Minds, to name a selected few. She has participated in around 80 specialized short-term courses. She has more than 20 research papers in peer-reviewed international journals, book chapters, and international conferences. She has supervised MTech thesis in the area of social media analytics, and around 100 BTech projects. Currently, she is supervising her Ph.D. candidates in the area of social networks and deep learning. Her research interest includes Natural Language Processing, Machine Learning, Data Science, Deep Learning, Social Media Analysis, Soft Computing, Big Data, and Data Mining.

John Wang is a professor in the Department of Information & Operations Management at Montclair State University, USA. Having received a scholarship award, he came to the USA and completed his PhD in operations research from Temple University. Due to his extraordinary contributions beyond a tenured full professor, Dr. Wang has been honored with a special range adjustment in 2006. He has published over 100 refereed papers and seven books. He has also developed several computer software programs based on his research findings. He is the Editor-in-Chief of International Journal of Applied Management Science, International Journal of Operations Research and Information Systems, and International Journal of Information Systems and Supply Chain Management. He is the Editor of Data Warehousing and Mining: Concepts, Methodologies, Tools, and Applications (six-volume) and the Editor of the Encyclopedia of Data Warehousing and Mining, 1st (two-volume) and 2nd (four-volume). His long-term research goal is on the synergy of operations research, data mining and cybernetics.

* * *

Sanketkumar Jagdishbhai Ahir received his M.Sc. in Microbiology from Sardar Patel University, Vallabh Vidhyanagar in 2020. He is currently working as a teaching assistant at Rai University, Ahmedabad. His research area includes healthcare, medical microbiology and environmental issues.

Sandhya Avasthi is an Assistant Professor in the computer science and Engineering Department of ABES Engineering College, India. She is currently pursuing a Ph.D. in information technology from AIIT, Amity University Noida. Her research interests include natural language processing, information extraction, information retrieval, data science, and business intelligence. She has considerable teaching experience and is the author of many published research papers in machine learning techniques.

P.G. Sunanda Bhagavathy is currently working in Karunya Institute of Technology and Sciences, Coimbatore as Professor & Head of the Department of Criminology . She has done her PG in Criminology and the Doctorate was `Access to Justice – Victims of acquitted murder cases of three districts of Kanyakumari, Tirunelveli and Thoothukud’. In the present capacity, she teaches Police Administration, Penology, Victimology, Forensic Science Practical, Contemporary forms of crimes, Private detection and Investigation, Juvenile justice and more. Before she could take up this Job, she was serving as a Police officer in Tamil Nadu Police and retired as Additional Superintendent of Police. While serving, she has served in various capacity like, officer in the Police security and Anti-hijacking in the International Airport, Chennai, Special Branch CID officer, All women Police Stations, Police training college as Vice principal, Additional SP in Q Branch CID and so on. She has authored seven articles in Police Journal and International journals besides partaking in two book chapters. She is interested in victim assistance and social service.

Ayan Chatterjee is currently working as Assistant Professor in School of HealthCare of Rishihood University, Haryana, India. He has published 75 full length research papers; among them 32 as first author in Peer Reviewed Journals (International and National), Conference Proceedings and as Book Chapters and also presented papers in International and National Conferences held at IIT Bombay, IIT Guwahati, ISI Kolkata, ISI Giridih, Jadavpur University, University of Calcutta, Vidyasagar University, IISWBM (Kolkata), NIT Jalandhar, Aligarh Muslim University, University of North Bengal, College of Engineering Trivandrum, Brainware University, Diamond Harbour Women's University (Through Webinar), University of Gour Banga (Through Webinar). He received Springer Sponsored Young Researcher Award for presentation of Papers at the 16th International Conference on Humanizing Work and Work Environment (HWWE 2018), Trivandrum, India. Also received Young Scientist Best Oral Presentation award for the presentation of paper at the 2nd International conference on Environmental, Agricultural, Chemical and Biological Sciences (ICEACBS 2021). He also served as Honorary Member- Editorial Board and Reviewer of different International and National peer reviewed Journals.

Gayatri Doctor is an Associate Professor and the Program Chair for the Master's in Urban Management Program. She has over 20 years of experience in the IT industry and academics. She is currently engaged in the field of Urban Management from a technology perspective. She teaches studios and courses in Urban Governance and Management, Service Operations Management, E-governance, and Future Cities and Technology. Her interests include data-driven governance; open data; smart cities; emerging technologies & their applications in the urban realm and future cities.

Michael Onyema Edeh is currently the Head of Department, Mathematics and Computer Science, Coal City University, Nigeria. He is also the Director of ICT at Coal City University, Nigeria. He has taught computer Science courses to both postgraduate and undergraduate students in several tertiary institutions, including Southwestern University; Coal City University; Gregory University Uturu (Enugu Study Centre); Nnamdi Azikiwe University; Pogil College of Health Technology; and Federal Science and Technical College, all in Nigeria. He has also acted as guest Speaker for many institutions, including GD Goenka University, India; Dumlak Engineering College, India; International Centre for Diplomacy, and Caritas university. He was recently appointed Overseas Mentor at Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India. Michael has interest in Cybersecurity, Mobile computing, Education, Machine Learning and learning technologies. He is is also open to opportunities, collaboration and learning.

Ani Ukamaka Eucharia is a lecturer in the department of Computer Science, Coal City University, Nigeria. She obtained her masters degree in Computer Science at University of Nigeria Nsukka (2016). She is currently a doctorate student at Ebonyi State University, Nigeria. She teaches Computer Science courses to undergraduate students. Her research interest includes ICT application and data mining.

Jyotsna Garikipati did B.Tech from V.R Siddhartha Engineering College from the department of Information Technology, Vijayawada, Andhra Pradesh in the year 2006. Then she did M.Tech from Andhra University, Visakhapatnam, Andhra Pradesh from the Department of Computer Science in the year 2008. Later, she worked as a Software Engineer for Aricent Technology Holdings for 2 years. Due to her passion towards research, she is writing papers for various journals/ books.

Shaurya Gupta is currently working in the capacity of Assistant Professor with the University of Petroleum and Energy Studies, Dehradun, Uttarakhand, India. Prior to this, he has worked with Amity University, Rajasthan, India in the same capacity. He has completed his PhD (IT) from Amity University, Rajasthan. He has done M.Tech (CS) from Jagannath University Jaipur and has over 11 years of experience in Teaching, Administration, Liaison & Coordination, Student Management and Research & Analysis. He has published various research papers in reputed research journals and attended many National and International conferences. His areas of interest are Delay Tolerant Network, Wireless Sensor Network, Ad Hoc Network, IoT and Machine Learning. Apart from research, he is involved in academics by means of preparing exercises, questionnaires and assignments for students at various levels and setting & marking assignments and tests, assessing students work for internally assessed components of qualifications for both UG and PG level.

Nidhi Ashokbhai Jodhwani received her M.Sc. in microbiology from Nirma University, Ahmedabad. She is currently working as an assistant professor at Rai University, Ahmedabad. She has previously worked as teaching assistant at SS Agrawal college, Navsari. She has cleared CSIR-NET LS and GSET examination in 2019. She has also cleared Gate-2021 examination. Her research interest includes healthcare, medical microbiology, immunology etc.

Aruna Kasinathan is currently working as Assistant Professor in the Department of Commerce and International Trade in Karunya Institute of Technology and Sciences, Coimbatore . She received her Ph.D. from Tiruvallur University. She completed her M. Phil., M.B.M. (Banking Management and M.Com from Alagappa University, Karaikudi, Tamil Nadu. She worked as a Dealer in Karvy Consultancy and Consultant in Anand Rathi Shares and Stock broking ltd from 2003-2009. She has 16 years of Teaching experience in various educational institution. Added to this she is a state player in long jump and won individual Champion ship at District level and University levels. Dr. Aruna Kasinathan has authored a textbook on Financial System & Digital Banking in India. Her research focuses on Banking, Stock Markets, Finance and Marketing Management. He has published 22 articles in UGC, Scopus and Web of Science journals. She is a Life Time member in SEBI and Indian Commerce Association. She teaches Banking, Investment Management, Principles of Management and HRM.

Deepa Kasthurirangan has been an alumnus of Auxilium College (Autonomous), Vellore and has served the same institution for 17 glorious years. She did her Masters in Commerce and M.Phil., Commerce in the University of Madras Ph.D. degree at Thiruvalluvar University. She has been qualified with TNSET. She had been the Dean of Arts for 5 years. During that period, digitalization of various aspects of the College had taken place and Mrs. Deepa had been an active participant in that area. She has contributed a lot for framing the syllabus for B.Com., M.Com. and M.Phil., by being a member of the Board of Studies from the department. She has headed the P.G. Department of Commerce for the past two Academic Years. Guided projects of 25 M.Com., students and dissertation of 15 M.Phil research scholars. Published around 7 papers in UGC- Care listed journals, with about 8 papers presented in conferences and published in conference proceedings.

Shankarashis Mukherjee has more than 18 years of experience in teaching in substantive posts in UGC system initially as a Lecturer, including a decade at University of Calcutta. Dr Mukherjee had served as Deputy Director (additional charge), IQAC, University of Calcutta also. Presently he leads the Department of Food and Nutrition, West Bengal State University. So far 6 candidates have been awarded PhD under his mentoring, including Co supervision. 2 more are now working as JRFs with funds from Government of India in research projects. More than 90 full length research papers, receiving reasonable citations, have been published in important peer reviewed journals and as book chapters in publications from Springer Nature, Singapore, McGraw Hill and like. Dr Mukherjee has delivered talks on invitations at important international conferences across length and breadth of the country including at IITs, central universities and other top ranked institutions and also chaired sessions at important conferences held at IIM, ISI Kolkata and IIT. He is member of ISNA council and also of Vigyan Prasar core group in Bangla.

Satyen Parikh, an academician in the field of Computer Science, has more than 22 years of experience in the higher education segment. Presently Dr. Parikh engaged in the development of the University at the different capacities of role/designations includes Executive Dean and Dean-FCA, Prof. & Head, etc. As a professor, he is guiding many students for their research work and students have been awarded Ph.D. under his guidance.

Hiral R. Patel is working as an Assistant Professor in Department of Computer Science, Ganpat University, Gujarat, India. She did her Ph.D. from Ganpat University. She completed her Ph.D. under the Faculty of Computer Applications. Her research title is “Prediction Model for Financial Products”. Her research area of interest is in Machine Learning. She is Gold Medalist in Master of Computer Science and B.C.A. from Ganpat University. She has 10 years of experience in academic. Recently, she has received “Ganpat University Presidential Award of Staff Excellence” under Research - Early Career Researcher category for the year 2019. She is awarded as “Young Scientist” in May 2017 by International Science Community Association in 3rd International Young Scientist Congress. She is recipient of “Best Conceptual Paper” in GFJMR 2012. She has published research papers in well known and globally indexed journals. She has been working with Web Application Development, Mobile Application Development, Database Management System, Data Mining and Machine Learning.

Helly Raval is working as an Artificial Intelligence and Machine Learning Engineer in an IT Company. She is pursuing her Ph.D. in Artificial Intelligence and Machine Learning Domain at Ganpat University. She has completed her Master of Computer Applications from Gujarat Technological University and Secured the first rank in University.

Akindutire Opeyemi Roselyn is a student at the Department of Statistics, Ekiti State University, Ekiti State, Nigeria.

Puja Sareen is a Doctorate in the area of Human Resource Management with 19 years of industry and academic experience. She has expertise in teaching OB/HRM subjects. She has been certified by IICA, Ministry of Corporate Affairs as a Master Trainer for their Certificate Programme in CSR. A University Topper in B.Com (H) and MBA, she has extensive experience in curriculum development. Conducting soft skills training is her forte. She has published several papers and case studies in international and national journals and conference proceedings.

Aabha Sharma is an Associate Professor, and Head of Department at School of Education, GD Goenka University, Gurgaon, India. Dr. Aabha Sharma is an expert in the area of Education, Test and Measurement, Educational Technology and Science Education. She has more than 22 years of experience in academic and academic leadership roles in various Universities and Institutes in India and Muscat (Oman). Aabha holds a PhD in Education (Educational Psychology), Masters in Education, Chemistry and Management. She has qualified National Eligibility Test (NET) in Education and awarded Junior Research Fellowship from UGC, (India). Aabha has participated and presented papers in more than 40 National/ International workshops/ conferences etc. and she has more than 22 years experience in conducting interactive sessions as Resource person and chairing National and International Seminars/ workshops/ FDP's. She is an Academic Expert (Education) for Tuning India Project with University of Deusto, Bilbao (Spain), Resource person for Developing and delivering Video content of MOOCs.

Anilkumar Suthar currently serves as Director of Degree Engineering College, more than 23 years of experience in academic, out of that 6+ years of experience in Administrative activities. Recognized Ph.D. supervisor in Gujarat Technological University (Gujarat), Pacific Paher Univ. (Rajasthan), JJTU (Rajasthan). Under my leadership and guidance team winning in Smart India Hackathon-2018 Hardware competition and started five startups under the scheme of NewGenIEDC and SSIP. Mentor of Change in AIM. Associated with various NGO for social activities.

Suman Lata Tripathi has completed her Ph.D. in the area of microelectronics and VLSI from MN-NIT, Allahabad. She did her M.Tech in Electronics Engineering from UP Technical University, Lucknow, and B.Tech in Electrical Engineering from Purvanchal University, Jaunpur. She is associated with Lovely Professional University as a Professor with more than seventeen years of experience in academics. She has published more than 55 research papers in refereed IEEE, Springer, and IOP science journals and conferences. She has organized several workshops, summer internships, and expert lectures for students. She has worked as a session chair, conference steering committee member, editorial board member, and reviewer in international/national IEEE/Springer Journal and conferences. She has received the "Research Excellence Award" in 2019 at Lovely professional university. She had received the best paper at IEEE ICICS-2018. She has edited more than 12 books/1 Book Series in different areas of Electronics and electrical engineering. She is associated with editing work with top publishers like Elsevier, CRC Taylor and Francis, Wiley-IEEE, SP Wiley, Nova Science and Apple academic press.

Sonali Vyas is serving as an academician and researcher for around a decade. Currently, she is working as Assistant Professor (Senior Scale) at the University of Petroleum and Energy Studies, Uttarakhand. She is a professional member of CSI, IEEE, ACM-India, IFERP, IAENG, ISOC, SCRS and IJERT. She has been awarded as "Best Academician of the Year Award (Female)" in "Global Education and Corporate Leadership Awards (GECL-2018)". Her research interest includes Database Virtualization, Data Mining, and Big Data Analytics. She has authored an ample number of research papers, articles and chapters in refereed journals/conference proceedings and books. She is an editor of "Pervasive Computing: A Networking Perspective and Future Directions", Springer Nature and "Smart Farming Technologies for Sustainable Agricultural Development, IGI Global". She acted as a guest editor in a special issue of "Elsevier International Journal of Computer and Electrical Engineering (CAEE)" and Machine Learning and Software Systems in "Journal of Statistics & Management Systems (JSMS)" (Thomson Reuters)". She is also a member of the Editorial Board and Reviewer Board in many referred National and International journals. She has also been a member of the Organizing Committee, National Advisory Board and Technical Program Committee at many International and National conferences. She has also Chaired Sessions in various reputed International and National Conferences.

Manas Kumar Yogi is currently working as Assistant Prof. in Department of Computer Science Engineering, Pragati Engineering College (A), Surampalem, E. G. Dist, A. P., India. He is a member of IEEE & ACM. He has published more than 98 review, research papers in reputed international journals, conferences including IETE sponsored conferences.

Index

3D Printing 274-275, 277, 280, 291, 293

A

accurate treatment 305, 311
AI Algorithm 24, 168, 177
alert system 57, 65, 68-69, 254
Arduino 254, 256, 259-263, 265-267, 272
Arduino Nano 254, 259, 261-262, 267
Artificial Intelligence (AI) 1-3, 14-15, 19-20, 26, 28-29, 34, 36-37, 39-40, 52, 73, 75-77, 81, 83-90, 109-110, 112, 115, 132, 153, 156, 158, 168, 170-171, 177, 179-184, 200, 206-212, 216-219, 274, 277-278, 286, 290-291, 293, 305-312, 316, 319-324, 339, 347-351
Artificial Intelligence Assistant (AI Assistant) 168-169, 172, 176-177, 181-182, 184
Assignment 231
Ayurveda 168-169

B

BERT 91-92, 94, 100-101, 105
Big Data 19, 24, 29, 32-34, 55, 74, 109-115, 117, 119-126, 128-130, 133-135, 200, 259, 266, 272, 306, 321, 334-335, 351
blended learning 197-198, 201
Blockchain 25, 73, 274-275, 277, 279-280, 284, 290-293
budding generation 206-207, 212, 215-217, 219
businesses 58, 208, 210, 255, 275, 286, 289-290, 294-296, 300, 320-321, 340
buying behaviour 207, 217-218

C

cancer 10, 38-39, 53, 56, 109-111, 114, 116-118, 121-136, 285, 305, 314, 316, 323, 328, 341
chatbot 30, 81, 168-174, 183-184, 314
cloud 11, 19, 29, 34, 59, 68, 71, 74, 113, 173, 200, 231-232, 239, 243, 253, 256, 259, 266, 284-285, 295, 328-331
cognition 206, 220, 306
Computer Science 35, 39, 56, 90, 107, 148, 179, 197-198, 200-205, 208-209, 252, 272, 291, 339, 350
convolutional neural network 22, 32, 35, 37, 56, 116, 136, 179-180
coronavirus 28, 32-34, 173, 189, 195, 197, 199, 205, 275-276, 288, 290, 303
COVID-19 28-37, 39, 54, 56, 74-75, 81-82, 84, 87-89, 91-92, 105-106, 169, 172-173, 175-176, 181-182, 185, 189, 196-200, 204, 274-293, 295-296, 298-304, 341
crisis 87, 173, 189, 195, 225, 275, 294, 297-299, 301-303, 317

D

Deep Learning 13, 20, 35, 37-40, 43, 53-56, 85, 89, 112-116, 133, 136, 179, 209, 278, 283-284, 293, 309, 321
defibrillator 57, 59, 63-64, 67-69, 71, 73
depression 75-77, 79-80, 88, 90, 138, 141-142, 146-147, 152, 155, 158, 171, 289
diagnosis 1-3, 8-11, 13, 15, 19, 22, 28, 34, 37, 40, 59-60, 63, 66-67, 75, 78-83, 85-86, 90, 122, 146-147, 149, 275, 278, 289, 291-292, 307, 315, 329, 331, 350
disruptive technologies 205, 274-275, 277
disruptive technology 277-278, 281, 292-293
drug discovery 52, 109-121, 124, 128-129, 131, 133, 135

E

early detection 1, 17, 23, 30, 32, 53, 305, 311
ECG 2-3, 9, 11-12, 14, 19, 24, 57, 61, 328-329, 334, 337
Edutech 197
e-learning 185, 187, 189, 195-196, 203, 268-269

Email Classification 338, 340
emerging technology 138, 183, 305, 322
Emotion Detection 91, 105, 107
exercise 3-5, 62-63, 139, 144, 153, 169, 177, 179, 181-182, 198-199, 285, 326, 333

F

faster communications and web searches 338
field interviews 305
fiscal environment 221, 223-224
fiscal policy 222-223
fiscal space 221-229
fiscal space asymmetries 221, 229
fitness 10, 12-13, 15, 19-23, 28, 31-32, 96, 144, 160-161, 254-255, 257, 271, 276, 326, 329-330, 333, 336
flexible 15, 57, 68, 200, 231, 256, 301
flipped classroom 197-205

G

gadgets 1-2, 4-5, 35, 58, 151, 206, 210-211, 218, 255, 257, 278, 286
gas sensor 254, 260
Generative Adversarial Networks 37-38, 40-42, 44, 46-47, 50, 52-56
genomics 117-118, 125, 127, 131, 135-136, 274-275, 277, 281-282, 291, 293

H

Health care Monitoring 336, 338
health insurance 18-20, 24, 26, 32-34
health monitoring 9-10, 12-14, 18, 20, 32-33, 58, 66, 73, 320, 327, 334-337
Health monitors 1
healthcare 1, 3, 9-11, 14-16, 18-24, 27-32, 34, 36-38, 43, 49-50, 52-53, 55-58, 66, 73-79, 81-90, 109, 123-124, 137-151, 157, 169-174, 176, 178, 182-184, 208, 274-276, 278-279, 282-285, 291, 293, 295, 302, 305, 308-313, 315-316, 319-330, 334, 336-338, 346, 348-349
healthcare applications 9, 14, 73, 79, 138, 146-147
heart attack 57, 59-62, 65, 68-69, 71, 73-74, 331
heart rate 3, 8-13, 16, 18-19, 21, 24, 28, 35, 57, 59, 63, 65-69, 71, 73-74, 161, 164, 177, 181, 283, 327
heat indices 160
higher education 185, 187, 189-191, 193-194, 196, 202, 219
household-based medical care 325
human-robot interaction (HRI) 137

I

immune system 4, 169, 176-177, 181-182
impact 13, 19, 22, 33, 63, 73, 76, 88, 110, 117, 120, 130, 160-161, 164-165, 170, 185, 187-188, 191, 196, 205, 207, 211, 219, 225-226, 274-275, 277-278, 283, 285-286, 290-292, 294, 297, 307, 320, 322, 334, 341, 350
innovation 58, 110, 120, 204, 292, 294, 296, 300, 306-309, 313, 319, 333, 343
Internet of Things (IoT) 19, 34, 58, 65, 73-74, 76, 89, 168, 184, 243, 256, 261, 271-273, 277, 283, 309, 326, 334-337, 349-351

K

Knowledge access 186, 191, 193-196
Knowledge acquisition 185-186, 191, 193-196, 220
Knowledge application 185-186, 191, 193-196
Knowledge evaluation 186, 190-191, 193-196
Knowledge Management 108, 185-190, 194-196
Knowledge sharing 186, 189-191, 193-196

L

Lifestyle Changes 63, 220
live case studies 305
load balancing 231-244, 246-247, 250-253
Long Short-Term Memory (LSTM) 94, 168, 179, 181, 184

M

machine learning 12, 20, 33-35, 37-40, 46, 52-56, 75-82, 84-88, 90, 107, 109, 111-114, 128, 130, 132-133, 168-170, 173, 179-180, 182, 184, 200, 209, 278, 283, 286, 293, 305-307, 309, 311, 321, 330, 334, 349
mental health 2, 4, 9, 13-14, 21, 75-79, 83-86, 88, 91-92, 102, 105, 137-138, 140-142, 144-151, 153-156, 158-159, 169, 171, 174, 183-184, 276, 285, 326, 334-336
mental health care 76, 86, 137-138, 140, 147, 150, 158, 174
ML 18, 20, 22-25, 29, 37, 76, 79-81, 86, 94, 111-112, 115, 173, 278, 321
MQ7 254

N

natural language processing 20, 40, 75, 81, 91-93, 107, 169, 171, 179, 184, 209, 278, 293, 307, 309, 318, 321, 330

P

paddy 160-161, 163-165
pandemic 8, 20, 28-29, 32, 35-36, 76, 81-83, 86, 88-89, 91-92, 96, 105, 168-169, 172, 175-176, 182, 184-186, 189, 197, 204-207, 210, 218, 220, 274-279, 281-297, 299-303, 308, 312, 317, 321
pandemic situation 82-83, 86, 168-169, 175-176, 182, 220
Persuasion 86, 220
pollution detection 254, 266

R

rare diseases 118, 305, 316
robotic technology 137, 139
Robotics 87, 137-141, 145-159, 200, 274-275, 277, 281, 290, 292-293, 317-318, 323, 346, 350

S

Satyen Parikh 169
self-driving cars 338, 343
Sensor Calibration 268
sensors 1-2, 4-12, 19-21, 23, 29, 31, 34-35, 54-55, 57, 59, 65-66, 68-69, 73-74, 177, 179, 181-182, 254, 256-258, 261, 265-266, 270-273, 283, 325-329, 333-337
smart devices 58, 275, 325-327, 333, 336, 342, 347
smart healthcare services 325
smart wearable 58, 181, 184, 327, 338
Socially Assistive Robots (SAR) 137
state budget expenses 221
state budget revenues 221
Sustainable Development Goals 274, 286, 293
SVM 18, 24, 31

T

telehealth 12, 83, 90, 173, 281, 295, 313, 317, 323
telemedicine 9-10, 75, 78-79, 81-83, 86-90, 335
text classification 30, 91, 105-106
Thermal Comfort 160, 166

V

viewership 206, 210, 212, 217-218, 220
vital signs 1-2, 7, 11, 15, 283, 327

W

wearable devices 2, 4-5, 8-10, 18-22, 24, 27-29, 31-34, 179, 184, 327, 329, 338, 341-342
wearable sensors 4, 20-21, 73, 181, 326, 334-337
wearable technology 3, 18-21, 23, 30-33, 36, 57-58, 181, 342, 349
wearables 1-3, 13, 19-35, 179, 320
well-being administration 325

Y

YouTube advertisements 206-207, 210, 212, 216-217, 220
Youtube popups 206, 215, 220