Applications of
Artificial Intelligence and Machine Learning in Healthcare

Dr. S. Balamurugan
CEng. Radhey Shyam Meena
Dr. Ramasamy V

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Dr.S.Balamurugan, CEng. Radhey Shyam Meena, Dr.Ramasamy V

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Dr S. Balamurugan, SMIEEE,
ACM Distinguished Speaker,
Director- Albert Einstein Engineering & Research Labs (AEER Labs), India
Vice Chairman-
Renewable Energy Society of India

CEng.Radhey Shyam Meena
Ministry of New & Renewable Energy (MNRE)
Government of India, New Delhi, India

Dr.Ramasamy V, PhD,
Associate Professor, Department of CSE,
Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology
(Deemed to be University),
Chennai, Tamil Nadu, India.

Applications of Artificial Intelligence and Machine Learning in Healthcare

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We are honoured to dedicate the Applications of Artificial Intelligence and Machine Learning in Healthcare book to all the authors, contributors, reviewers, and editors.

Preface

A huge amount of potential is vested in Artificial Intelligence and Machine Learning techniques to transform next-generation Healthcare applications. This book aims to cover a wide range of applications of Artificial Intelligence and Machine Learning techniques in disease diagnosis, remote patient monitoring, and assisting healthcare providers. Early detection of diseases such as cancer and tumours will highly reduce the mortality rate of the disease. Predictive modelling could help in determining the effect of the drug, on a patient building a strong clinical decision support system. The Covid-19 pandemic has led to the huge adoption of telehealth applications, which is also covered under the scope of this book.

Chapter 1 presents the comparison and role of different AI-based mental healthcare analyses. As AI using electronic health record, brain imaging, and other sensing systems can predict issues in individual and help to monitor patients' progress, helps the doctor to alter treatment if needed, and can help decrease suicidal issues. Apart from identifying the particular issue in the patient, AI can help the patient to assign the right therapist as per his/her problem. Thus the patient is been given with right therapy at right time. It can also, guide the caretaker to give medicine at a given time. Natural language processing and Machine learning can be used to find the problem in an individual along with its social media presence can be an effective tool to identify one's mental health. This information can assist the healthcare practitioner to identify a particular problem and guide for treatment. There is also a limitation to collecting data and training the AI-based system which is discussed in this chapter. Along with that the technology limitation and challenges are well described.

Chapter 2 introduces a view of IoT functionality and its application with the sensing and wireless technique for implementing the required stress monitoring system for drivers.Stress conditions experienced by the driver are a serious problem in road safety. Driver error is the most common cause of road accidents. In this chapter, skin conductance is taken for analysis of driver drowsiness fatigue, and mental stress. To minimize human error while driving, it monitors stress and fatigue by measuring physiological parameters like skin acting like a conductor gives a response also called a Galvanic skin response and the motion is continuously monitored over a while. The IoT-based sensor used in driver's health care is a novel approach from the classical ways that include visiting hospitals for clinical procedures and constant supervision of the person. It connects the health care professionals with the driver through a smart device to monitor vitals without affecting the freedom of movement of the driver. Further, the Captured data is sent to an IoT Cloud Where Machine learning algorithms were deployed for computing the percentage of alertness and stress if the stress levels go beyond the threshold levels, then an alert signal is sent to the driver from the buzzer.

Chapter 3 aims to assess the tragedy, take into account the depth of its spread, and make intelligent guesses and predictions that will help all parties take appropriate steps to stop the disease. The covid-19 pandemic disease created a great scare and massive economic, social, political, and international challenges. Many lives were lost, and the economic crisis was coupled with crippling industrial activities. Using the Covid-19 time series dataset, an analysis was conducted to reveal the confirmed, active, recovery, and death cases of Covid-19 cases in the 16 West African countries. Using three machine learning algorithms Polynomial Regression (PR), Support Vector Machine (SVM), and Neural Network (NN) the prediction had been carried out. The polynomial regression model gave the best result when considering the generated results among the three techniques employed for the study.

Chapter 4 presents an approach towards early detection of the neurological disorder called Parkinson's Disease (PD) by employing a Complementary Metal Oxide Semiconductor (CMOS) readout circuit which measures and amplifies low-level dopamine in the form of an electrical signal from the brain with help of electrodes. A neurotransmitter chemical released by neurons is one of the prime functions of Dopamine in the brain. Analog Digital Converter (ADC) is used to convert an amplified analog signal to digital information. Machine learning algorithms are used to predict the disease based on the data received from the readout circuit. Dopamine level is measured in current which ranges from pA to nA. CMOS Amplifiers are used to strengthen the acquired signal in the range of millivolts (mV) with the help of bio amplifiers. For conversion of acquired current in the range of pA to voltage with an amplitude of micro voltage (μV), a CMOS front called a Transimpedance amplifier (TIA) is employed. This chapter provides a complete design and analysis of low noise, low-power CMOS machine learning-based readout circuit for the detection and prediction of Parkinson's disease.

Chapter 5 discusses the IoT architecture which includes equipment correspondence protocols that support a layer of medical care administrations and apps that uses machine learning and artificial intelligence algorithms. Applications that include remote correspondences via IoT are profoundly inclined to security chances. The larger part of the applications currently goes remote including IoT as an innovation to convey their particular objective. IoT is considered the fate of the Web. The Web of Things is imagined to fill quickly in the field of medical care in the approaching a very long time due to the multiplication of correspondence innovation, the accessibility, combination, and use of application-coordinated gadgets and administrations. In addition, in this pandemic, the integration and competent correspondence of patient well-being watching bounds are critical. In addition, difficulties in data security, security, and incompatibility are explored. This chapter also includes some of the real-time Healthcare test cases where decisions are taken by a sample algorithm whose solution is proposed to the user. Chapter 6 aims to develop an application aligned with the objective of health professionals' advice about diet and nutrition as the main factor for a healthy lifestyle. This is providing the Filipino public with a means to monitor, assess, and visualize their health through their diet. The development of the application employed artificial intelligence through K-means clustering and Image Classification using ResNet architectures for diet and nutrition analysis, Cloud technology for storing diet records, and Augmented Reality for visualization. The development of the application yielded these results; diet analyses were done through the K-means algorithm yielded that diet of individual Filipinos can be divided into three clusters, where each posed health risks and diseases, and a ResNet-18 classifier yielded an 81% accuracy in classifying 15 different Filipino foods.

Chapter 7 contributes multiple noise filtering algorithms for accurate diagnosis, and lucid imaging details of the region of interest which are required to read the minute details of the affected organ/cell/tissue. In imaging, artifacts are a major issue in capturing the expected image and position of the organ or tissue, or cell in the human body. This chapter will provide a filtered image thereby aiding medical experts with a clear picture in diagnosing the disease from the region of interest. The boom of Artificial Intelligence is a dominant support in future medical imaging modalities as it is surpassing the critics in the current time. It can process enormous quantities of medical images with high precision and accuracy and with fine details that are invisible to the naked eye. The roaring development of Artificial Intelligence in medical imaging will provide medical experts with value-added tasks and will thereby enhance patient interaction times.

Chapter 8 presents study reviews about the dimension of big data and the significance of the Internet of Everything (IoE) in the medical field. The study highlights the IoE-based Big-data journey in Medical Industry. Because health is considered a global challenge for humankind. According to World Health Organization (WHO), constant patient monitoring is said to be the highest standard in hospitals. The developing amount of data in the healthcare industry has made predictable the big data techniques adoption in the range of enhancing the healthcare delivery quality. Big data plays a significant role in the medical industry by governing numerous amounts of data, such that the information is maintained and gathered from various platforms. These are possible by performing big data analytics to analyze and capture every piece of information, resulting patient's entire history and appropriate information at right time. The study also reviewed the application and challenges of big data in the Health care System.

Chapter 9 developed an application entitled "Nutrify" to help people diagnosed with Type 2 Diabetes (T2D) in planning their meals. The meal plan contains the calorie and macronutrient distribution. The decision-tree algorithm is responsible for the changes in the meals computed by the application, the appropriately distribute of the macronutrients, and optimizing the plan's validity. The conducted survey shows that for all the participants' responses, the respondents are very satisfied with the application having a score of 4.62. However, results from the paired t-test could not prove the effectiveness of the application in managing the user's weight due to the short period to produce statistically significant results. In conclusion, this chapter has developed an application that will generate a meal plan and create a dietary goal for the user to help the user to stay healthy and avoid their existing health conditions becoming worse.

Chapter 10 provides an outline of how the Internet of Medical Things (IoMT) operates and how it has improved the lives of many patients through the use of modern technologies. IoMT is a medical gadget that allows one to examine the patient's health status at any time and from anywhere, including body temperature, pulse rate, and hearing beats utilizing ECG sensors, temperature, pressure, and observation. IoMT assisted doctors in identifying and diagnosing COVID-19-affected patients and assisting them in providing appropriate therapy remotely using AI, telemedicine, and advanced sensor technologies. This also includes a design and overview of IoMT, as well as numerous activities in the healthcare industry, pop-up technologies, and several IoMT case studies in medical applications. It also lays out the IoMT's cybersecurity rules and indicates issues that need to be tackled in the parliamentary and community sectors.

Chapter 11 introduces a revolutionary solution through machines using mathematical algorithms entitled Artificial Intelligence (AI) to combat human setbacks in data handling. Because the evolution of lifestyle had eventually turned down the hale and health statement of humans. This led to the gradual upsurge of various diseases in humans irrespective of their age. On the other hand, numerous healthcare data generated from a wide range of medical sectors challenged the human brain. The employment of Artificial Intelligence is traced in the medicine pipeline commencing from the diagnosis of disease until treatment. AI registered its pivotal role in the clinical section by processing (diagnosis, image processing, drug discovery, digital pathology, oncology, mutation identifications) such huge data using an algorithm. One of the major subsets of AI is Machine Learning (ML), which competes with humans' cognitive skills using higher-order algorithms comprising Artificial Neural Networks (ANN). The complicated nature behind the diseases like cancer, diabetes, cardiology, and neurological and psychological disorders can also be unveiled with the assistance of AI. The processing of healthcare-related databases executed by AI provides data with high accuracy and clarity. Overall, human intelligence assesses their vast health database requirements using Artificial Intelligence.

We would like to offer our sincere thanks to all the authors for their timely support and for considering this book for publishing their quality work. We also thank all reviewers for their kind cooperation extended during the various stages of processing the manuscript. Finally, we would like to thank Technoarete publications for producing this volume.

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Ramasamy V
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About the Editors

Dr.S.Balamurugan Ph.D., SMIEEE, ACM Distinguished Speaker is the Director of Albert Einstein Engineering and Research Labs. India. He received his B.Tech., Degree from PSG College of Technology, Coimbatore, India, M.Tech., and Ph.D. Degrees from Anna University, India. He has published more than 60 books, 300 articles in international/national journals/ conferences, and 200 patents. He is also the Vice-Chairman of the Renewable Energy Society of India (RESI). He serves as a research consultant to many companies, startups, SMEs, and MSMEs. He is the series editor of several book series and serves in various editorial capacities of several international journals. He has received numerous awards for research at national and international Levels.

A few of them include:

• Rashtriya Vidhya Gourav Gold Medal Award and The Best Educationalist Award from Hon. Justice O.P Saxena, Supreme Court, New Delhi, India.

• Three Lifetime Achievement Awards

• Dr.A.P.J.Abdul Kalam Sadhbhavana Award from Hon. Balmiki Prasad Singh, Former Governor of Sikkim. India

• Jewel of India Award from Mr. Gurpreet Singh, General Secretary, India

• Star of Asia Award from Mr. Korn Debbaransi, Former Deputy Prime Minister, of Thailand

• Pride of Asia Research Excellence Award from Hon. Anant. V.Sheth, Deputy Speaker- Goa Legislative Assembly, India

• CSI Young IT Professional Award

• National CSI Youth Award

Dr. Ramasamy V received his B.E Degree from Anna University Chennai, in 2006 an M.E Software Engineering from Anna University, Tiruchirappalli in 2009, and a Doctor of Philosophy in Computer Science, from Anna University Chennai, in 2021. He is currently working as an Associate Professor in the Department of CSE at Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology (Deemed to be University), Chennai, Tamilnadu, India. His area of interest includes Mobile Cloud Computing, IoT, Data Science, Artificial Intelligence, and Machine Learning. He is the author of several scholarly research papers in national and international journals and conferences. He is the Editor in Chief for Technoarete Transactions on Advances in Computer Applications in Technology (TTACAT) journal. He is the Book Editor of a few books for Technoarete publisher. He is the Guest Editor for Innovations in Future IoT Communications in MMTC Communications - Frontiers (IEEE COMSOC). He is the Evaluation Committee Member for IFERP Innovative Project Seed Funding Scheme. He is the organizing Chair of the International Conference on Advanced Computing and Intelligent Engineering ICACIE and organizing committee member of Advanced Communications and Machine Intelligence - MICA.

Mr Radhey Shyam Meena is a power sector professional with over 8 years of techno-commercial experience. He is working in the Ministry of New & Renewable Energy (MNRE), New Delhi. He is also enrolled in the Indian Institute of Technology, Kanpur for eMasters Degree in Power Sector Regulation, Economics, and Management. Apart from this, he has completed his B.Tech. & M.Tech. from Rajasthan Technical University, Kota.

He is also an inventor/co-inventor of 25 National/International patents. Apart from these he has co-authored 6 books and have over 51 peer-reviewed journal/conference publications. He is actively engaged with a number of technical institutions like IEEE, IET CIGRE, RESI, SESI IAENG, IEI.

About the Contributors

Dr. Shivangini Saxena, Electronics & Communication Engg. Department, SAGE University, Indore, Madhya Pradesh, India

Prof. Madhvi Singh Bhanwar, Electronics & Communication Engg. Department, SAGE University, Indore, Madhya Pradesh, India

Dr. Pallavi Pahadiya, Electronics & Communication Engg. Department, SAGE University, Indore, Madhya Pradesh, India

Dr. Akhilesh Upadhyay , Dean Engineering, HOI, SIRT, SAGE University, Indore, Madhya Pradesh, India

S.M Revathi, Assistant Professor, Dept. of ECE, University College of Engineering, Arani, India

R.Srinivasan, Assistant Professor, Dept. of EEE, Annamalaiar College of Engineering, Modaiyur, India

C.R Balamurugan, Professor, Dept. of EEE, Karpagam College of Engineering, Coimbatore, India

H.Kareemullah, Assistant Professor, Dept. of EIE, B.S.Abdur Rahman Crescent Institute of Science & Technology

Michael Segun Olajide, Department of Computer Science, Adeyemi College of Education, Ondo, Nigeria

Adekola Alex Ajayi, Department of Computer Science, Adeyemi College of Education, Ondo, Nigeria

Oladoyin Anthony Abiodun, School of Computing and Communications, Lancaster University, Lancaster, United Kingdom

Oluwagboyega Peter Afolabi, Department of Computer Science, Adeyemi College of Education, Ondo, Nigeria

Jyoti M Roogi, VTU Scholar CMR Institute of Technology Bengaluru, India

Dr.Manju Devi, The Oxford College of Engineering, Bengaluru, India,

Sudhakar Hallur, Department of Electronics and Communication Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, India

Vinay Sangolli, Department of Electronics and Communication Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, India

Vishweshkumar Aithal, Department of Electronics and Communication Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, India

Dr. Shaneth C. Ambat, College of Computer Studies and Multimedia Arts, Program Director, FEU Institute of Technology

Hezekiah John V. Rizan, FEU Institute of Technology, Philippines

Rom Braveheart P. Leuterio, FEU Institute of Technology, Philippines

John Patrick G. Chua, FEU Institute of Technology, Philippines

Chrys Uoie A. Salazar, FEU Institute of Technology, Philippines

Dr. Hadji J. Tejuco, College of Computer Studies and Multimedia Arts, Faculty, FEU Institute of Technology

Anthony D. Aquino, College of Computer Studies and Multimedia Arts, Faculty, FEU Institute of Technology

Dr.S.Rajalaxmi, Associate Professor & Head, Department of Biomedical Engineering, Mahendra College of Engineering, Salem. Tamil Nadu.

Justine Rose R. Cale, FEU Institute of Technology, Student, P. Paredes St., Sampaloc, Manila

Czarina G. Castillo, BSCSSE Student, FEU Institute of Technology, P. Paredes St., Sampaloc, Manila

Oliber M. De Leon, FEU Institute of Technology, Student, P. Paredes St., Sampaloc, Manila

Royce Christian N. Esguerra, FEU Institute of Technology, Student, P. Paredes St., Sampaloc, Manila

May Florence D. San Pablo, FEU Institute of Technology, Faculty, P. Paredes St., Sampaloc, Manila

Piyush Gupta, Research Scholar, Department Of CSE, UIT RGPV Bhopal

Dr Bhupendra Verma, Department of CSE, Director UIT Bhopal

Dr Mahesh Pawar, Associate Professor, Department of IT, UIT RGPV Bhopal

Varsha Jacqulyn, Assistant Professor, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS) Chennai

Mrs. R. Thiruchelvi, IInd year student, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS)

Mrs.K. Rajakumari,Assistant Professor, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS) Chennai

Krishna Priya Kumar, Industry Academia Cell, National Institute of Food Technology, Entrepreneurship and Management- Thanjavur (NIFTEM-T), Thanjavur India.

Padmashree Baskaran, Department of Biotechnology, Rajalakshmi Engineering College, Chennai, India.

Anitha Thulasisingh, Associate Professor, Department of Biotechnology, Rajalakshmi Engineering College, Chennai, India.

Contents

Chapter - 1

Role of Artificial Intelligence in Mental Healthcare

Dr. Shivangini Saxena[1], Prof. Madhvi Singh Bhanwar[2], Dr. Pallavi Pahadiya[3], Dr. Akhilesh Upadhyay[4]

[1,2,3] Electronics & Communication Engg. Department, SAGE University, Indore, Madhya Pradesh, India
[4] Dean Engineering, HOI, SIRT, SAGE University, Indore, Madhya Pradesh, India
[1]shivanginisaxena23@gmail.com, [2]madhvisinghbhanwar@gmail.com, [3]pallavi_19_2000@yahool.com,
[4]hoi.sirt@sageuniversity.in

Abstract— Artificial Intelligence (AI) has found a lot of scope in diversified applications including health care systems. Due to the rapid increase in digitization and change in the life style lot of people are facing health care issues like mental diseases. Now the days AI is use to help health care members with its analysis like tumor, cyst, cancer, dermatology issues etc. Looking towards the increasing cases there is a urgent demand of AI in medical specially in mental health care.Many electronic systems are used for the health data analysis so the combination of AI within system can help the patients. Due to the pandemic there is increase in health issues and it has pushed the limits for increase in need of mental health care system using AI. Since AI can provide services like personalize care, remote access, guiding patient, online doctor's advice etc. AI can be used to identify the individual with high risk also it can provide intervention to treat and prevent mental illness. This work presents the comparison and role of different AI based mental healthcare analysis. As AI using electronic health record, brain imaging and other sensing system can predict the issues in individual and help to monitor patient's progress and helps the doctor to alter treatment if needed and can help in decrease in suicidal issues. Apart from indentifying the particular issue in patient AI can help the patient to assign the right therapist as per his/her problem. Thus the patient is been given with right therapy at right time. It can also, guide the care taker to give medicine at given time. Natural language processing and Machine learning can be used to find the problem in individual along with its social media presence can be an effective tool to identify once mental health. This information can assist the healthcare practitioner to identify particular problem and guide for treatment. There is also a limitation for collecting data and training the AI based system which is discussed in this work. Along with that the technology limitation and challenges are well described.

I. INTRODUCTION

In the smart world AI enters with the enormous use in many aspects in which the health care is more significant like radiology, dermatology, oncology etc., among all, the AI in mental health care became very important as it is the main part of human body. With the help of AI the ability to find the illness of a person highly increased, so that the prevention and the treatment is possible for any patient on time and it found very successful. AI use with electronic health records, sensor based monitoring systems, brain images and social media platforms to guess and group the mental illness and also the suicide factors. AI helps to diagnose the mental health status at a initial stage and also prescribed the treatment which can help the person for the proper care. It also take care the privacy of the database. This intelligent work is done by artificial intelligence [1].

1.1 Participation of Artificial Intelligence in Mental health care

There are many advantages of AI in mental health care but with this there are many challenges also in the path of implementation. The technologies are rapidly involving in the health care systems and in every up gradation of technology the concern is to improve the curable results of the patients. Among all the mental health care is very much significant and it is going digitally in Tele health services. By using the Tele health mental health is one of the most important sectors to be delivered without losing gist. The increase of digital health care demands the technology that always cagey in medical science i.e. artificial intelligence [2].

During the pandemic it was found that there is huge demand of digital mental health services specially the ages between 13 and 24 in the US to avoid the suicide each year even to avoid the suicide in every seconds [2].

1.2 *Use of AI for Healthcare support system*

Now days due to the advancement in technology Artificial Intelligence has found lot of scope in healthcare support system.AI can help in healthcare and lot of research is going on for the same to support in every medical field. Some of the field like virtual nursing, AI based medical diagnosis of disease, Analyzing medical images/data, AI assisted robotic surgery are hot area of application [3]. As shown in figure 1 AI can be used to assist the patients virtually by Tele- nursing. Bigger image/data analysis can also be done. As per the requirement of market the particular drug can be designed for particular area.

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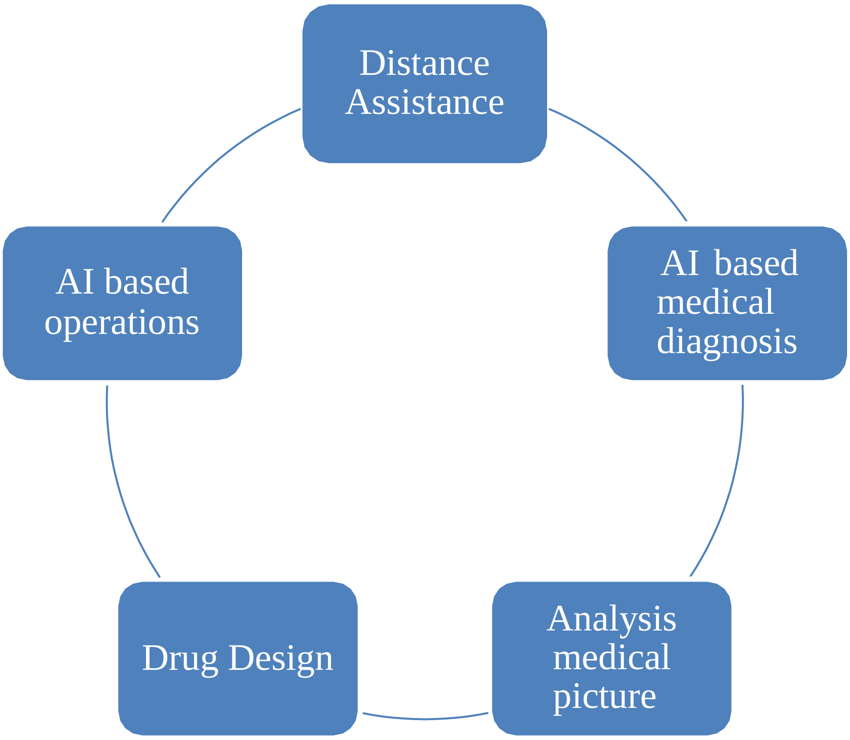

Figure 1: Use of AI in healthcare [3]

AI can help in reviewing of clinical data and images for supporting physician to judge for disease identification. It can help cardiologist, radiologist, psychiatrist, and neurologist etc. to identify essential insights so as to prioritize the critical important patients. Algorithms used in AI can analyze bigger datasets with very high speed and also it can identify and classify the patters to predict the disease. AI can help the physician to judge the disease with prior analysis of dataset being used. Thus this whole process enables the medical professionals to tract the critical information quickly which was earlier very time consuming and may lead to increase in mortality rate. AI can help in mental disease identification and supports both physician and drug maker to provide the accurate medicine. Figure 2 shows how AI can help in healthcare and mental healthcare support.

As per the figure the unstructured data from Physician/ Radiologist can be collected and store to prepare the database. This database can be analyzed with any of the supervised learning algorithms like Support Vector Machine (SVM), machine learning convolution neural networks to classify the input as per training. These data base and results can be used by new researchers to give innovative idea or new algorithms which can give better accuracy and reliability of classification. Omics data [4] and other data can be analyzed in laboratory for validation purpose and creation of new drugs for particular disease.

Patients can provide real time data to AI based system and they can be helped by providing life style changes by physician as per the analysis done by system. Thus AI can be helpful to physician, patients, laboratories, researchers and drug designer for improving drug quality and increasing accuracy [4].

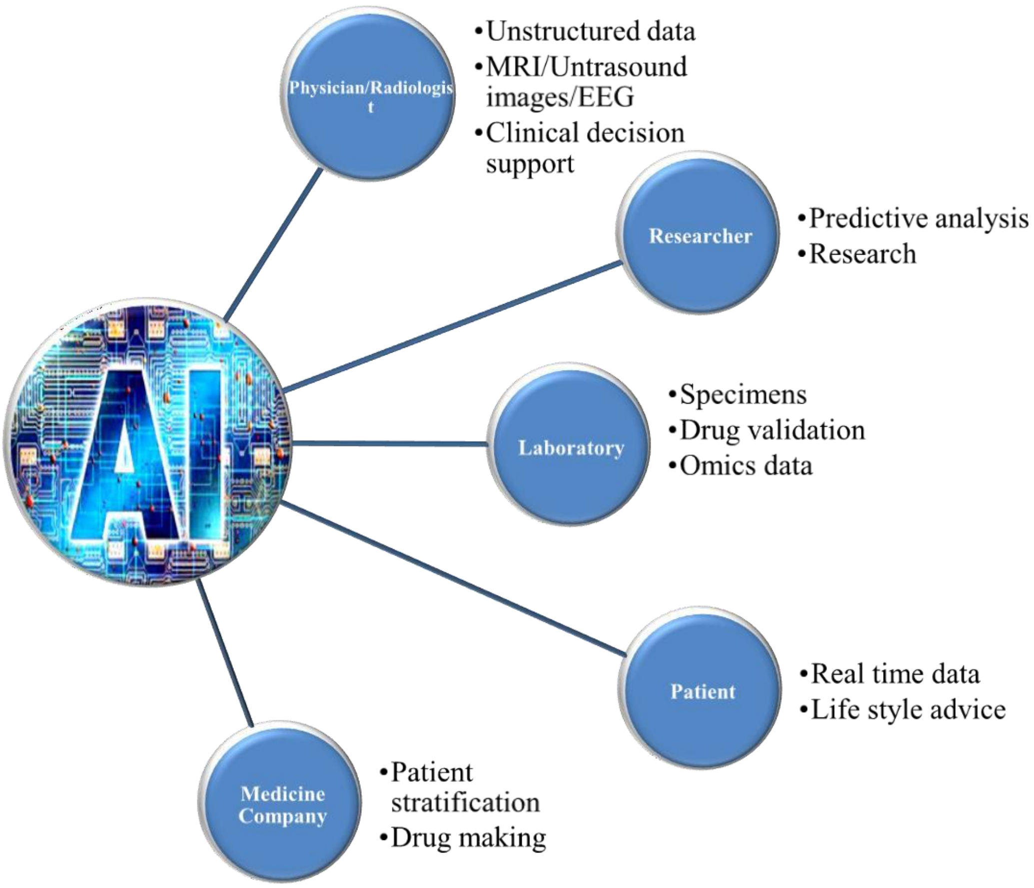

Figure 2: Use of AI in healthcare like mental health [4]

II. HOW DOES AI WORKS IN MENTAL HEALTH CARE

When we talk about the work of AI in medical area, we found that it is the technology that has ability to get the data from the enormous number of details. It is the revolution in mental health care system.

Previously there was one revolution called genetic revolution by which the mental health condition could be provided. By neuro-imaging one can identify the working of brain. These significant data can be use to take care of the patient but the problem was facing to track the data for treatment on daily basis. AI system analysis this tracked data and take action to cure the illness. In this the patient can get more attentive and personal care and the approach becomes more targeted to the illness.

As said by expert Prochaska, “Chatbots are helpful for the person to chat about the illness or any query, as this service is available for 24*7”. Also there is no cost for these services and make it more helpful. The new updated technologies also have the ability to reduce the difficulties and challenges for the groups. One of the organizations for lesbian, gay, bisexual, transgender, queer & questioning (LGBTQ) young people it has been recognized the AI very useful. AI give the

services especially for LGBTQ young people because these youth gone through the trauma of injustice in their life.

It has been observed that many difficulties are to talk about the health issues, the services available 24*7 on various platforms for the smooth conduction and conversation. The AI comes with many benefits to overcome the difficulties.AI have the intelligence potential like a human but it cannot be said that it can replace the humans but it can say that AI is there to help them, because human to human connection is very important and technology cannot do that effectively. The AI design is not to replace the counselors but it is design to help them and to support them. There are many elements on which the use of AI depends. In future AI can help on research that how mental illness are growing, spreading and how to treat it [2].

It’s very interesting the use of AI in case of mental health care. For good care of mental health disorder patients AI is playing very important role which also somehow excludes the consultation with medical practitioner. It is not like that we don’t need doctors but we can diagnose the illness with the help of AI as any doctor does. That treatment is based on data collected by the history of the patents and the questionnaire with the patients. Doctors do much analysis with their knowledge. This is not clearly said that AI can replace the need of doctors [5]. AI has the features like human person for example to listen, understand, solutions of problems. Recognition in the early stage is possible via examination of an individual face expressions, voice modulations, speech and length of the statement.

2.1 Use of AI for Mental Healthcare support system

Artificial intelligence can be effectively used to improve mental health and treating mental problem at distance. Comparing it with direct one-one contact therapy it has lot of advantage as shown in figure 3[6].

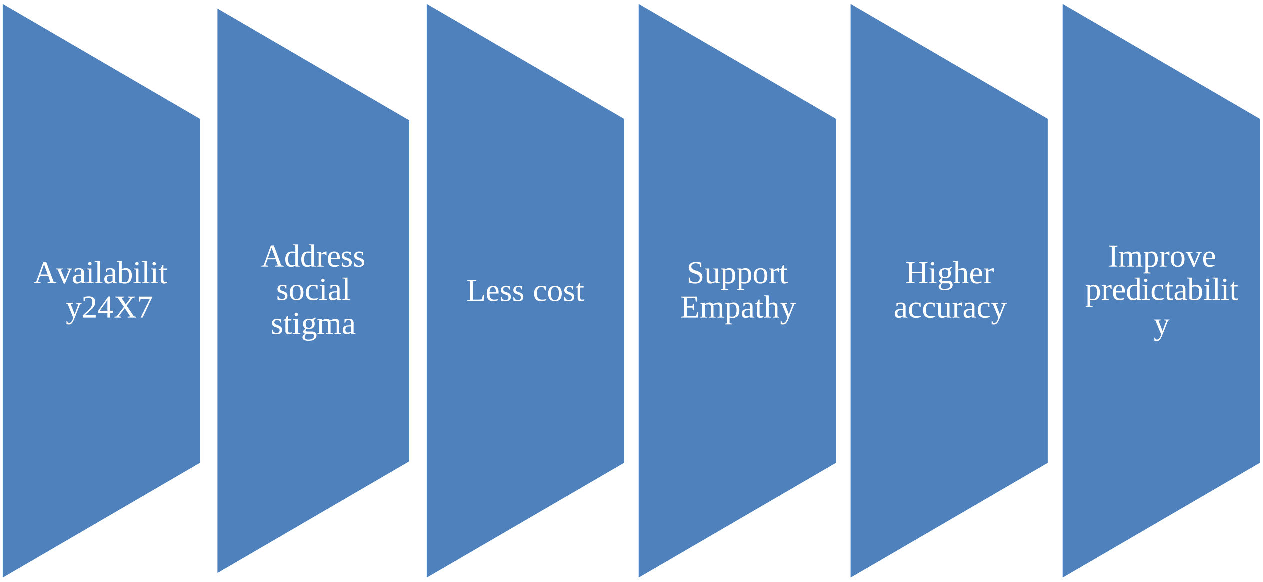

Figure 3: Advantages of AI for mental healthcare [6]

Table 1: Comparison of AI in mental healthcare and one-one consultancy

Parameter	Mental health with AI Support system	Mental health with One-one consultancy
Availability	24X7 any time any where	
Social problems	Social fear not present any one can get help with no worry of knowing socially	Social fear present people avoid due to social fear.
Predictability	Due to large database its high	Low
Cost	Less	High
Reach	Any where	Depends on physician availability
Accuracy	High	Depends on physician knowledge
Support availability	Yes	Depends on availability of counselor

2.2 AI founds nostrum in mental health

The concepts of AI in mental health care are more feasible and more attractive when some factors are accepted by the ill persons with no interference of human body [5].

III. CHARACTERISTICS OF AI

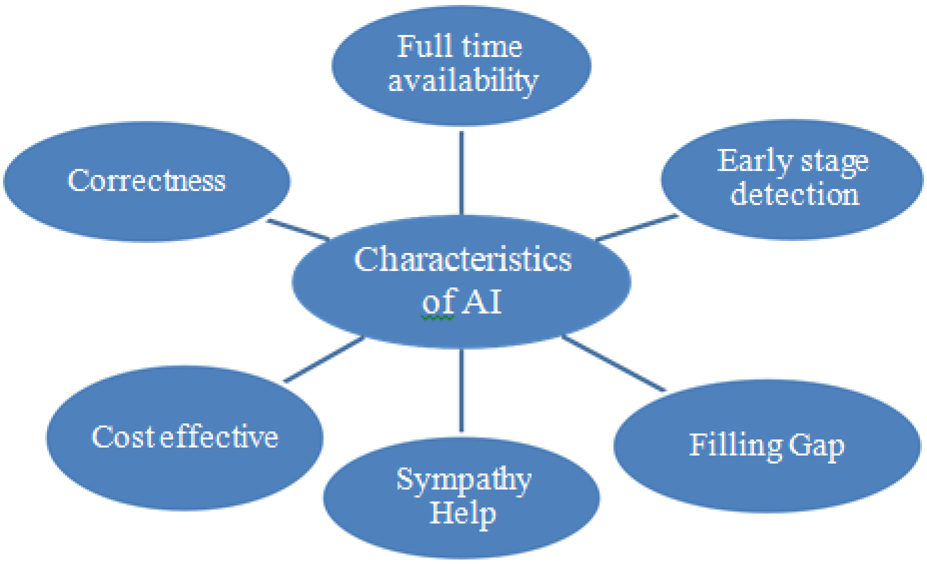

Figure 4: Characteristics of AI [5]

a) Full time availability

There are some time limitations for the doctors to consult their patients regarding illness especially in night. Apart from this AI is the best care tool which is available all the time 24 *7 especially at the time of emergency.

b) Early stage detection

AI identifies the nature of the signal of mental health illness at the early stage and prevent it from the level of increasing and give best care.

c) Correctness

AI has the ability to examine correctly the symptoms of person's disorder through the analysis of signal and data identifications.

d) Costs effective

As it is known the doctors charge the consultancy fees and follow up charges. The AI is a tool which gives the low price consultations and counseling to the many sufferers. So the cost of the treatment reduces and affordable to many people.

e) Sympathy Help

It is very uncommon to get the sympathy support from any software tool or any machine here we found that AI somehow overcome this problem by giving the support and counseling to the patients.

f) Filling Gap

AI fills the gap between the patients who is seeking for the treatments and finally the individuals get the benefits of the treatment **[5]**.

IV. DIFFERENT METHODS USED IN AI FOR CLASSIFICATION

For classification different models are available.

4.1 Machine Learning

Machine learning (ML) is one of the branches of AI along with computer science that emphasizes on the use of data as well as algorithms for improving its accuracy. Machine Learning Algorithms uses historical data to predict some condition and it is type Artificial Intelligence that enables the software application to more accurately predict the outcome. Some of the examples of machine learning are Predictive maintenance of system, detecting any fraud, filtering any spam mails, detection of malware etc. [6].

ML is normally used in any enterprise to know about behavior of customer, choice of customer to develop new product.

Normally the companies which use digital marketing also uses ML to know about choice of customer by tracking the last search and provide the customer with filtered products. Such algorithms helps customer to surf for their choice and it also benefits company too to target a group of people [7].

ML can be used in solving mental healthcare problems. Say if some customer is regularly surfing for anti depression products or methods then that customer can be provided with mental problem solutions or Tele-medicine.

Machine learning algorithm can be of different types like supervised learning, unsupervised learning, Semi-supervised learning and Reinforcement learning as shown in figure 5.

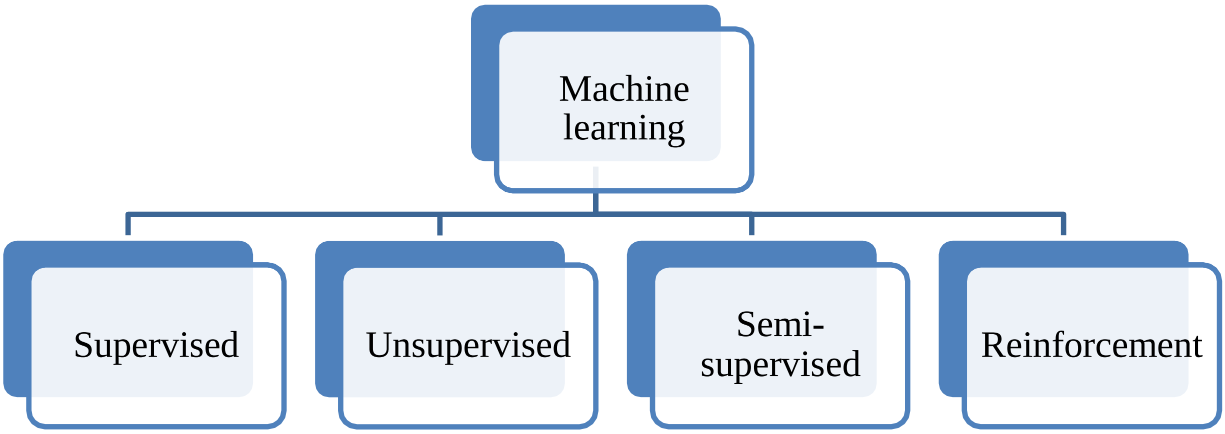

Figure 5: Types of Machine learning algorithm [7]

The type of algorithm which used unlabelled data to train is called unsupervised learning. In supervised learning for training, labeled data is used for classification. In semi supervised learning mix of both the above two is used. Researchers can use semi supervised methods also for training. Reinforcement learning is used for problem having multi step process. The algorithm is provided with fixed clues based on specific rules for which step to take. Thus algorithms decided by its own which step to take.

4.2 Artificial Neural networks

In Artificial Neural networks there are connected nodes called artificial neurons. These neurons have weights which increase or decrease depending on the signal strength. Two nodes are connected. The neurons may have threshold such that if signal is higher than threshold can only pass. ANN can be of multi layer. Signal passes from input layer to output layer by traversing intermediate layers many a times. System is trained with given data so as to produce output at final layer. The difference between output and desired output is called error; it is used to adjust the weights of neurons again. In ANN learning can be done by supervised learning, Unsupervised learning, Semi-supervised learning, Reinforcement learning and self learning. The nodes and different layer of ANN [8] are shown in figure 6

Input Layer

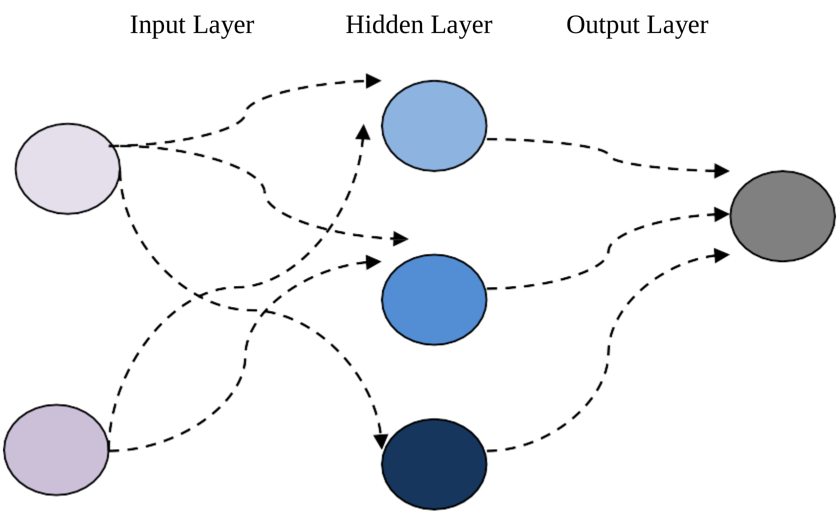

Figure 6: Artificial neural network node connection [8]

4.3 *Convolution neural network*

A simple CNN has convolution layer, pooling layer and feature extraction layer. One of the examples with two hidden layer is shown in figure 7.

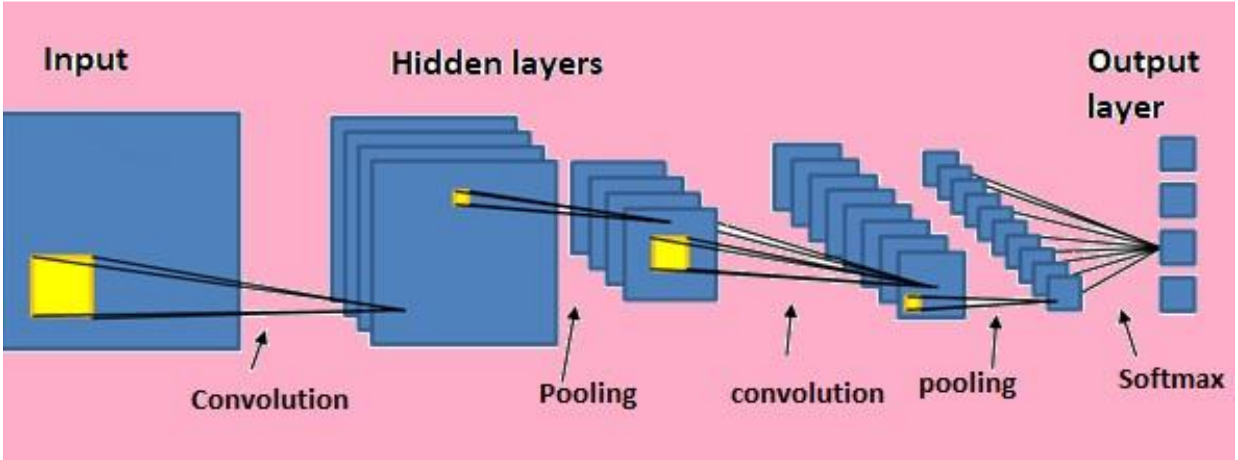

Figure 7: Convolution neural network having 2 hidden layers [4]

In convolution layer the input image is convolved with the given filter called kernel to produce intermediate output. Pooling layer is used introduce variance so that same data at any shape size can be identified. Finally feature extraction layer is present which flattens the output. Convolution neural networks are generally used to find any object, video, identification of letters etc.

V. RESEARCH IN THE FIELD OF MENTAL HEALTH CASES USING AI

AI technology performs the mental health care and takes care of different risks. This chapter provides the description of AI and the applications in medical science. How AI will work with its limitations and will be beneficial in recent research and clinical aspects. The study of AI in mental health care said that it use brain imaging data, mood rating scales electronic health records (EHR), advance monitoring systems like smart phones and any other electronic gadgets, social media platforms, depression, suicide thought and attempts, psychiatrics condition etc. On all these problems AI proved the best examples in mental health care with high accuracies. However caution and precaution is very important to avoid the discrepancies and there is many things required to do in AI work so that AI can meet the work of mental health care and medical issues [9].

5.1 *During COVID-19 the role of Artificial Intelligence in Mental Healthcare*

This is world known scenario that during COVID – 19 people suffers from mental health issues. There was lot of mental pressure that raised the mental health suffering. During this time there were scant of the treatment for mental health in almost every country. Then the Artificial Intelligence made the important role in some urban countries and helped to come out from the mental health sufferings. Identification and awareness became very important to find the illness of persons in early stage in order to stop the serious tragedy of mental health diseases and suicidal activity. To recognize the mental condition is very difficult due to the lack of drugs and uniqueness of individual symptoms of illness and behavior which cannot be diagnose by medical officers easily. This chapter covers the possible part played by Artificial Intelligence in pandemic and many other difficult scenarios [10].

The COVID-19 pandemic affects seriously to the mental health of the person and even health care workers like depression, frustration, sadness, tension disorder and suicidal attempts. So in this chapter there is study of how to prevent all these disorders in the initial stage to prevent the tragedy due to the mental health disorder which includes some phases [11].

5.2 *Following are the phases*

a) Evaluation of the strength of workers tension which will depend on the medical and clinical reports depends on the daily routine schedule during COVID-19 pandemic, extra hour's work, the risk they suffered, leaves etc. This report generates by clinical sources without consulting the individual directly. These standards subjections trouble is suggested on computation of different history that have been consider for the analysis of stress levels.
b) Personal reports of tension at the time of pandemic by the psychological reports.
c) Research and developments of various encouragement patterns flawlessly elicit particular neuro-physiological response.
d) Impartial computation applicable neuro-physiological characteristics.
e) Previous phases the data computation is obtained from the machine learning computation. The next proposed technology focuses on the self report observation of mental health diseases with more data which is based on the artificial

intelligence.

f) This method became more relevant to find the tension factors during the COVID-19 pandemic and helped to the doctors to identify easily and accurately [12].

During this scenario, one among the other technologies artificial intelligence and machine learning helped for the early detection of mental health of health care workers which can prevent to develop the serious mental health disorder.

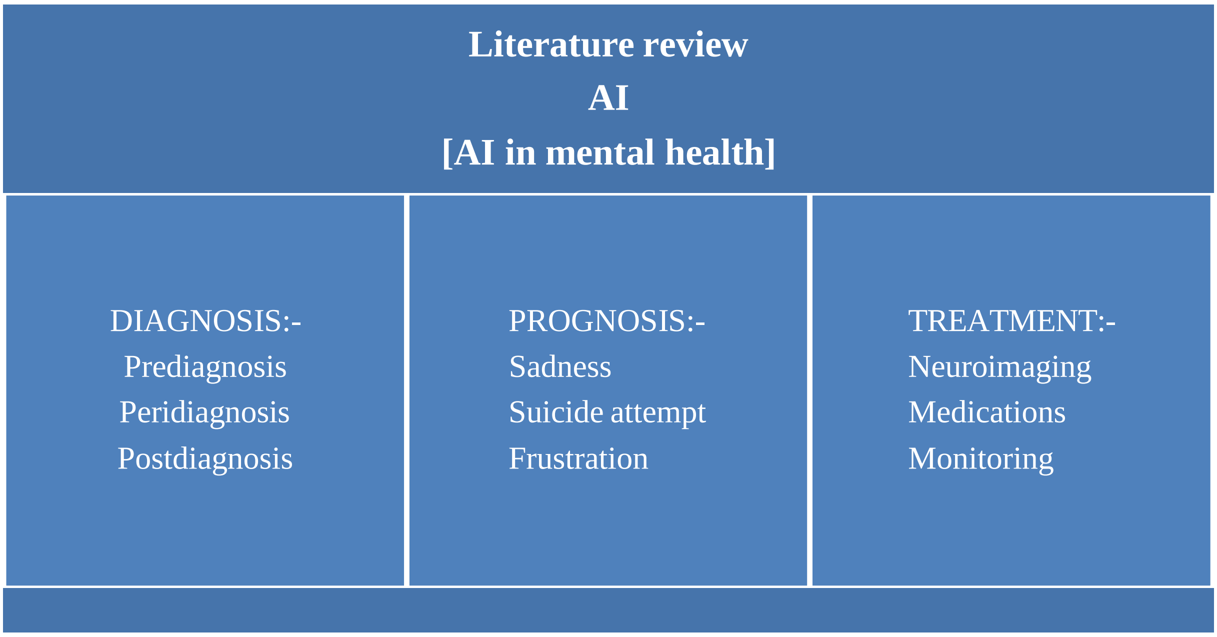

Figure 8: Role of AI in Mental Health care persons [13]

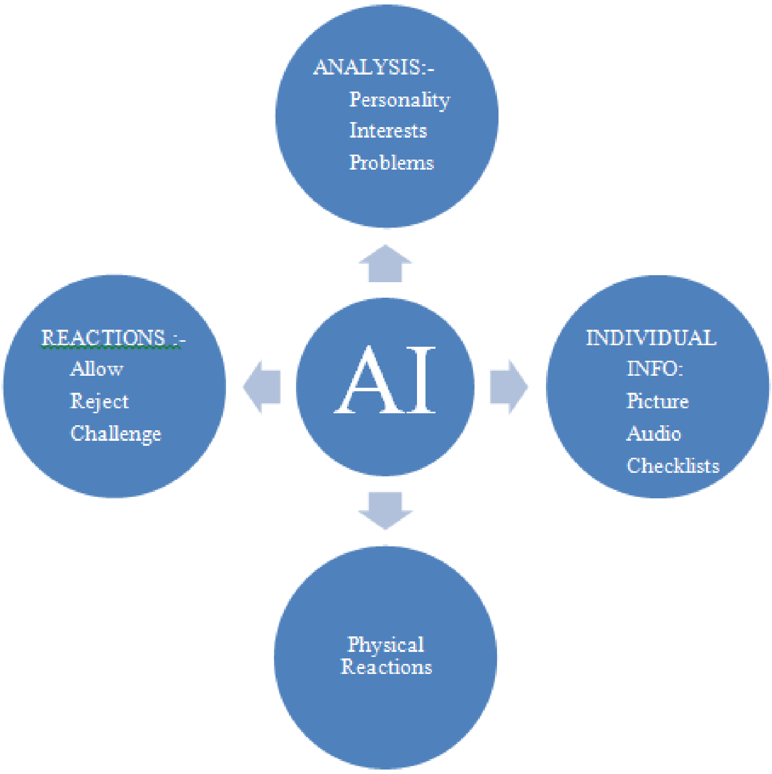

Figure 9: Pandemic increases mental health issues [5]

5.3 Benefits of AI in Mental health care

a) Accuracy

Accuracy of the treatment increases and human error reduces by using this technology and become more trust full. The treatment remains accurate and same even the consultants are different.

b) Advance Models

Advance technology are used which behaves like a human consultants and experts. It does not depend on the human consultation and approach to the more people. Also the patients feel good to interact with it because it behaves like human not a machine.

c) Sympathy

AI makes the user comfortable to interact with the machine. It behaves same like a human consultant and not like a machine. It also interacts telephonically with the people. Persons do the

telephonic discussion with the machine and it is not seems like it is machine it seems like the discussion with the therapists because machine behaves emotionally.

d) Stability

The treatment may be stable and customize according to the user's expectations. Human cannot show the robustness but machine can show the robustness and unaffected with the stress and circumstances like human have the different days.

e) Availability 24*7

Availability cab be vary with the humans but machine work is always available especially in emergency tough time. Human therapists can get tired after some time dealing with the patients but machine never tired and give the best result all over the time and can give the better results in mental illness. Machine can work for the long time without any constraints.

f) Reliability

AI builds a trust among the people that the data share with the machine is encrypted and safe. So that people get trust to share the illness history and also have authorization to keep the data private. People get the facility to share the data with that person only whom the person wants to share with otherwise the data won't get leaked. This makes the AI very useful because from this the one can avoid the embarrassment among the people.

g) Initial Stage Detection

Early detection method is very important in case of mental health care. AI ensures the early detection correct data of the illness so that it can saves the life like in suicidal case or any other tragedies.

h) Scared From Dishonor

The social environment is very important which affects the mental health of a person in every day even in every moment. Society plays a very important role for the people where they lie with the reputation and many people suffers from this mental illness where use of AI becomes again important tool. AI diagnoses and also cures the person.

i) Approachable

More and More people can get the advantage of AI as the people from village can also get the benefit of this program. To take the advantage of medical treatment people don't need to do the long distance travel from village to city. So the accessibility of AI program has been increased and ability to save the lives is also increased [14].

5.4 Drawback of AI

a) Complexity

AI machines are somehow costly and complex to design. It also required maintenance.

b) Emotionless

AI machines do all the work as a human can do but after all it is machine it cannot treat the person with the emotions as a human can do. It has programmed machine and have some limitations to do work as per the instructions only. It cannot think and work apart from the program it is designed. Many times it is required to treat the person with the emotions and behavior with the mental status of the person and overcome to the complexity but AI machine cannot do this process which is not programmed.

c) Lack of approval

The mental health issues are very personal and very sensitive which is not discussing with others. AI is the combination of human intelligence which increases the efficiency of the work in the worlds. The technology fulfills the gap between the person and the medical treatments. It includes cell phone applications, chat bots, cloud based systems, ecosystem and creates a bridge to fulfill the gap [14].

5.5 AI and Robotics

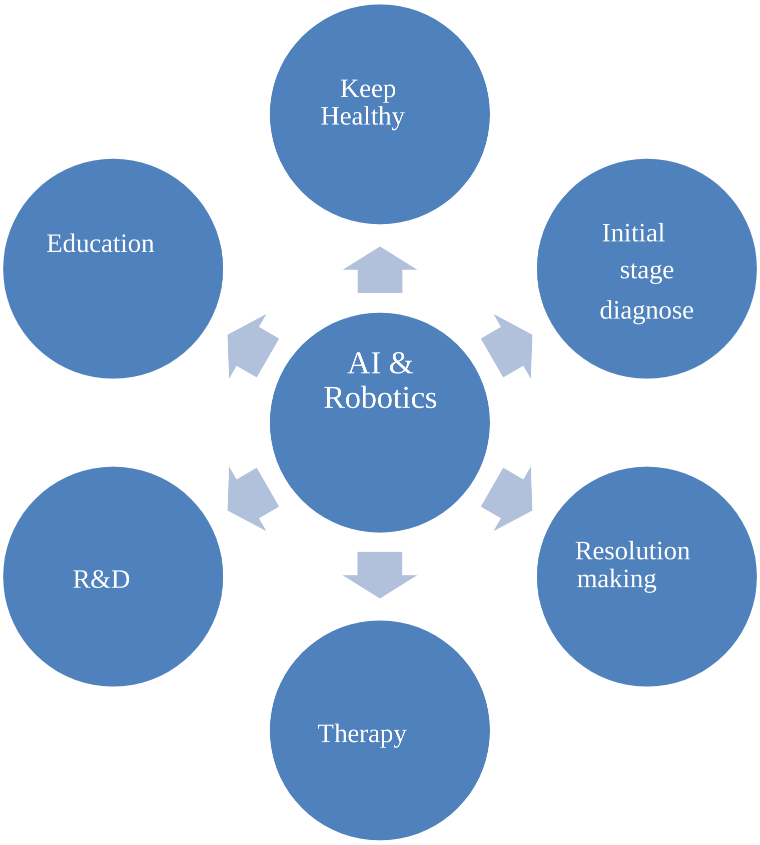

Figure 10: AI and Robotics [7]Keep Healthy

Through the technology the ability to keep the health good is increased and it encourage to the people to be healthy always.

a) Initial stage diagnose

According to the research many people get the false results of disease like cancer, the use of AI overcome this problem with 99% accuracy and reduce the process of biopsies.

b) Resolution Making

To be healthy it requires the time to time treatment and to take decisions on time. It supports to make decision and take actions on the predicted tasks.

c) Therapy

AI helps clinically to reach to the disease and help to get the treatment. It examines the issues and also gives the medical treatment. Give the care on time. Robots are contributing in this field from since years. Robots assist the surgery to the human doctors as well as robots can do surgery itself also. Robots with AI used in many hospitals and laboratories for the therapy.

d) Research and Development (R&D)

The distance between the pharmaceutical laboratories and the sufferers is very long and expensive. According to the research associations this time can be of many years to reach to the sufferers. It is found in the research that in 5000 only 5 drugs go for the tests and among these 5 drugs only 1 get approve for the human treatment.

For same AI is very important in drug research and development. AI helps in the drug discovery which also reduces the time consume to travel from laboratory to the patients and also reduces costs.

e) Education

AI gives the facility for the original simulation and not like codes and commands set in the software's. AI based computer has the facility for decision making, questionnaire solving etc. The education teaches from the all the feedbacks and can change accordingly if need. This learning can be done from smart cell phones, by various sessions [15].

VI. APPLICATION OF ARTIFICIAL INTELLIGENCE IN HEALTH CARE

Now a day's artificial intelligence is very popular for all the applications, many industries are using new technologies and artificial intelligence is one of them, there are many applications of artificial intelligence, health care is one of them, as we all know 'Health is Wealth' we can't perform our role without good health, so health care agencies involve artificial intelligence to

provide best services. So there are some ways by using them Artificial intelligence changing the healthcare presently and also will change in future [16].

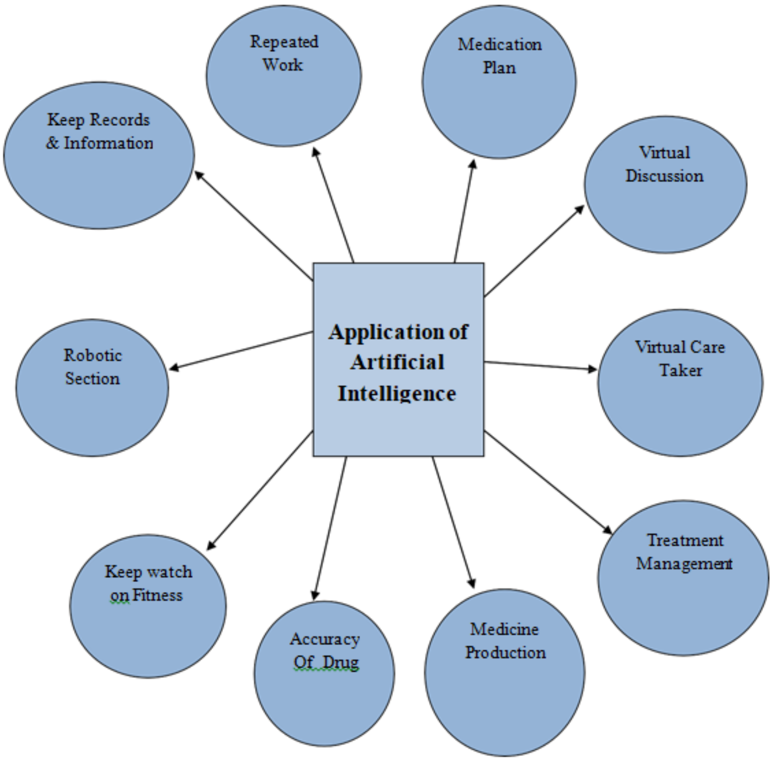

Figure 11: Application of Artificial Intelligence [10]Keep records and information

In healthcare the very first thing is to collect and investigate the data of the patient like patient previous medical history and some present reports, so this data handling application is commonly used application of artificial intelligence, for this record keeping work like data collection, stock the data, change the data, we can use robots. Instead of human being robots are safe because there is no risk of infection so we can say artificial intelligence is boon for human being.

a) Do repeated work

With the help of robots investigation of reports, X-Rays images, body scans and different routine work can perform very fast and precisely. In some fields like cardiology and roentgen logy investigation of data is lengthy and enormous, in future heart specialist and roentgenologist need to observe only complicated cases where human observation is needed.

b) Medication Plan

To design medication plan healthcare unit use artificial intelligence, artificial intelligence systems are designed to investigate data, record and details of patient file, to help choose the perfect medication plan.

c) Virtual Discussion

Number of applications uses artificial intelligence for virtual discussion about the health; it is based on the individual previous medical record and common awareness. Patient communicates his symptoms into the application, application use voice identification to collate in opposition of record of sickness. Then the application provides the solution in patient account.

d) Virtual Care taker

The virtual care taker observes the condition of patient and look into medication, in the middle of doctor's round.

g) Treatment Management

With the help of the applications which is designed by using artificial intelligence can observe the utilization of treatment by patient. To known the patient's situation and about the medicine which is suggested to patient is taking properly or not, application uses artificial intelligence with webcam of Smartphone. The person's who have serious medical issues can use such type of applications.

h) Medicine Production

To create new drug growing pharmaceuticals take lot of time and money, to make this whole procedure quick and inexpensive, used a program which is controlled by artificial intelligence, It examine the available drugs that can be remake to combat the infection.

i) Accuracy of Drug

From the DNA, Biology and genetic science get information for transformation of disease, some disease which is due to genetics like cancer and other disease can be identify by body scan with help of artificial intelligence.

j) Keep watch on Fitness

Some fitness trackers keep watch on cardiac activities and the investigator device may send the information to patient and doctor also with the help of artificial intelligence.

k) Robotic Section

With the help of artificial intelligence and robots can perform operations [16].

VII. APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN MENTAL HEALTH CARE

For precise investigation and medication psychiatric and mental health care experts use artificial intelligence. Mental health care experts are using Artificial intelligence to reduce their workload. The Artificial intelligence is helping in good medication and education of psychotherapist.

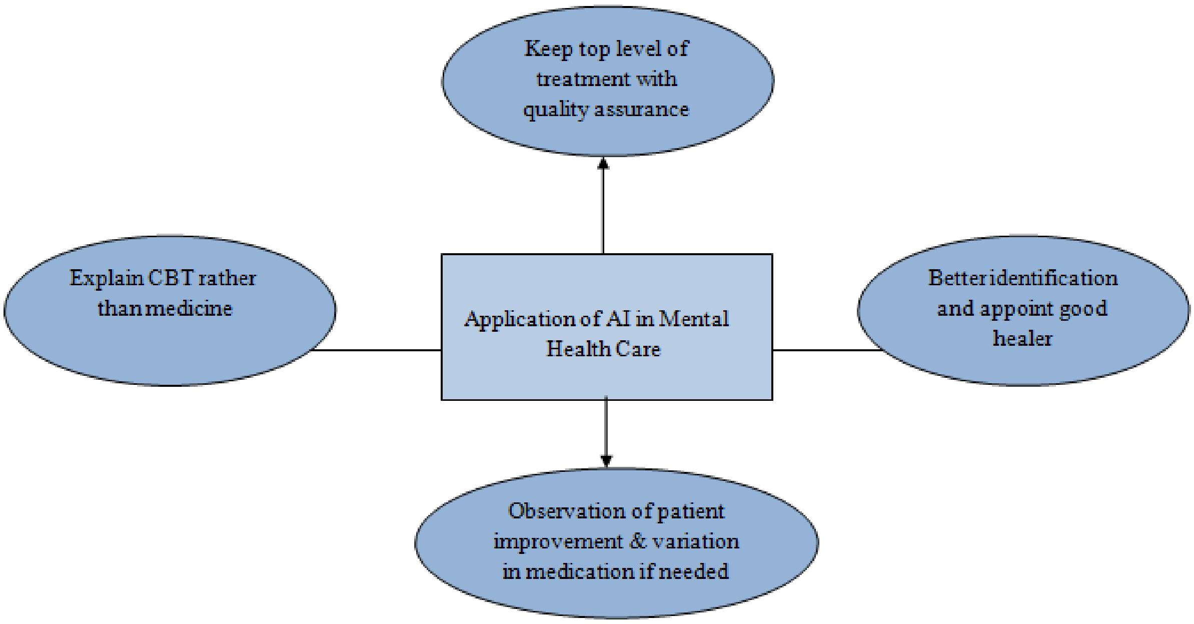

Figure 12: Application of AI in Mental Health Care [15]

There are some methods by this artificial intelligence is improving the mental health treatment.

a) Keep top level of treatment with quality assurance

Mental problems are increasing now days so the workload of psychologist is also increased; some brain health clinics are searching an automated system which observes quality assurance between the healers.

Some brain health care clinic is using artificial intelligence which observes the speech which is used in treatment sitting along with natural language processing; it is a method which machines use to process record. The main aim of brain health care clinics behind this is to give proper awareness to healers so they can provide good care.

So the technological societies provide tools to clinics using the tools there will be good understanding between patient and the healer.

b) Better identification and appoint good healer

Artificial intelligence help physicians to diagnose the mental sickness in advance and also help in precise medication plans.

Research fellows are believed that they may use information from the victories therapy sessions to help the patient to get good healer.

Artificial intelligence research may help physicians to investigate patient into individual situations and also help to provide medication.

By use of the artificial intelligence get large amount of data like patient's old medical history, his family background, patient's actions and effect of old mediations on his health using the all above information doctor can investigate very well and provide the proper medication to the patient.

c) Observation of Patient Improvement and Variation in Medication if needed

If patient connect with healer and starts taking treatment there is only need of observation on patient improvement, for this artificial intelligence can help to recognize to change in medication is needed or patient required any other therapy.

d) Explain cognitive behavioral therapy (CBT) rather than medicine

The use of medicines as a treatment for mental health issues has raised, according to the researchers artificial intelligence certify cognitive behavioral therapy as a medication. The focus of cognitive behavioral therapy to recognize the obstructive thinking and discover the method to crack the thoughts means for the variation in ways and in planning in the future the healers use declaration to discuss. Researchers found that recovery rate is high by using of cognitive behavioral therapy rather than general chat [16].

VIII. CONCLUSION:

It is been observed now a days that lot of mental problems are increasing day by day which increase mortality rate and crime. As per the study AI can be of great use to help in identification and solving problems. Mental uses solved earlier can avoid severe condition. As AI based system can be available 24X7, low cost, can be available and easy to use and will be helpful to day today users.

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Chapter - 2

Driver Stress Detection Based on IOT Motion Sensor Using Wearable Glove

S.M Revathi[1], R.Srinivasan[2], C.R Balamurugan[3], H.Kareemullah[4]

[1] Assistant Professor, Dept. of ECE, University College of Engineering, Arani, India
[2]Assistant Professor, Dept. of EEE, Annamalaiar College of Engineering, Modaiyur, India
[3]Professor, Dept. of EEE, Karpagam College of Engineering, Coimbatore, India
[4]Assistant Professor, Dept. of EIE, B.S.Abdur Rahman Crescent Institute of Science & Technology

Abstract— Stress conditions experienced by the driver is a serious problem in road safety. Driver error is the most common cause of road accidents. In this paper skin conductance is taken for analysis of driver drowsiness fatigue and mental stress. In order to minimize human error while driving it monitors stress and fatigue by measuring physiological parameters like skin acting like a conductor gives a response also called as Galvanic skin response and the motion is continuously monitored over a period of time. Internet of Things (IOT) based sensor used in driver's health care is novel approach from the classical ways that includes visiting hospitals for clinical procedure and constant supervision of the person. It connects the health care professionals with the driver through smart device to monitor vitals without affecting the freedom of movement of the driver. This chapter introduces a viewof IOT functionality and its application with the sensing and wireless technique for implementing the required stress monitoring system for drivers. Further the Captured data is sent to an IOT Cloud Where Machine learning algorithms were deployed for computing the percentage of alertness and stress if the stress levels go beyond the threshold levels, then alert signal is sent to the driver from buzzer.

I. INTRODUCTION

In most of the studies it shows that physical phenomenon and motion parameters of the driver's skin are closely associated with driver's stress level. Involuntary system a nerve stimulus primarily depends on emotional or psychological response. Additionally, it monitors the sleek muscular tissue and secretion of the glands in its physical structure. As a result of this bio-signal recordingsgives us various information about the condition of the physiological systems, circulatory, metabolism, muscular and endocrine system.This information will help in representing the dynamics of psychological states.Therefore, it is expected that the dynamic stress level of a driver can be derived from those recordings. Additional alcohol detector will give a state of the driver's drowsiness. There's proof that stress may result in several irreversible effects or diseases if it is not properly diagnosed and treated. Stress management can be done by modifying life style if diagnosed early Driver's stress level can also be evaluated from thedynamic variation of the steering wheel movement and its pattern of movement. This is often carried out by continuously monitoring themechanical phenomenon using motion detector, which will beimplanted on the surface of a glove surface of the driver or it can also be placed on the cover of steering wheel.

In this work, motion sensor was chosen as a result of for its low cost and reliable characteristics under various environmental conditions as compared with the physiological signal. The learning algorithms are trained using the results obtained from experiments that were conducted on different drivers in 3 completely different environmental conditions. These environmental conditions were labelled as "City," "Highway" and "Rural" these results were used for training vectors.

The Galvanic response of the palm of the driver, is a clear indicator of the stress experienced by the driver, thatwas recorded signal from sensor placed on the driver's palm,will be sent to a mobile device via Bluetooth for additional processing of data received. From the results it wasconcluded that monitoring bothstress from steering wheel movement pattern andthe Galvanic skin response get mean accuracy of up to 93.64% in stress level prediction. This gives a valid reason for considering motion sensor as a valuable information in wireless driver monitoring system for detecting stress levels to take appropriate actions.

The overall unit is shown in the block diagram (Figure.1) that has sensors such as Alcohol sensor, Eye blink detector, Accelerometer and Galvanic skin response sensor connected to the palm of the driver. All these sensors give valuable information about the stress levels of the driver this can be predicted from training data collected for prediction.

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https://dx.doi.org/10.36647/AAIMLH/2022.01.B1.Ch002

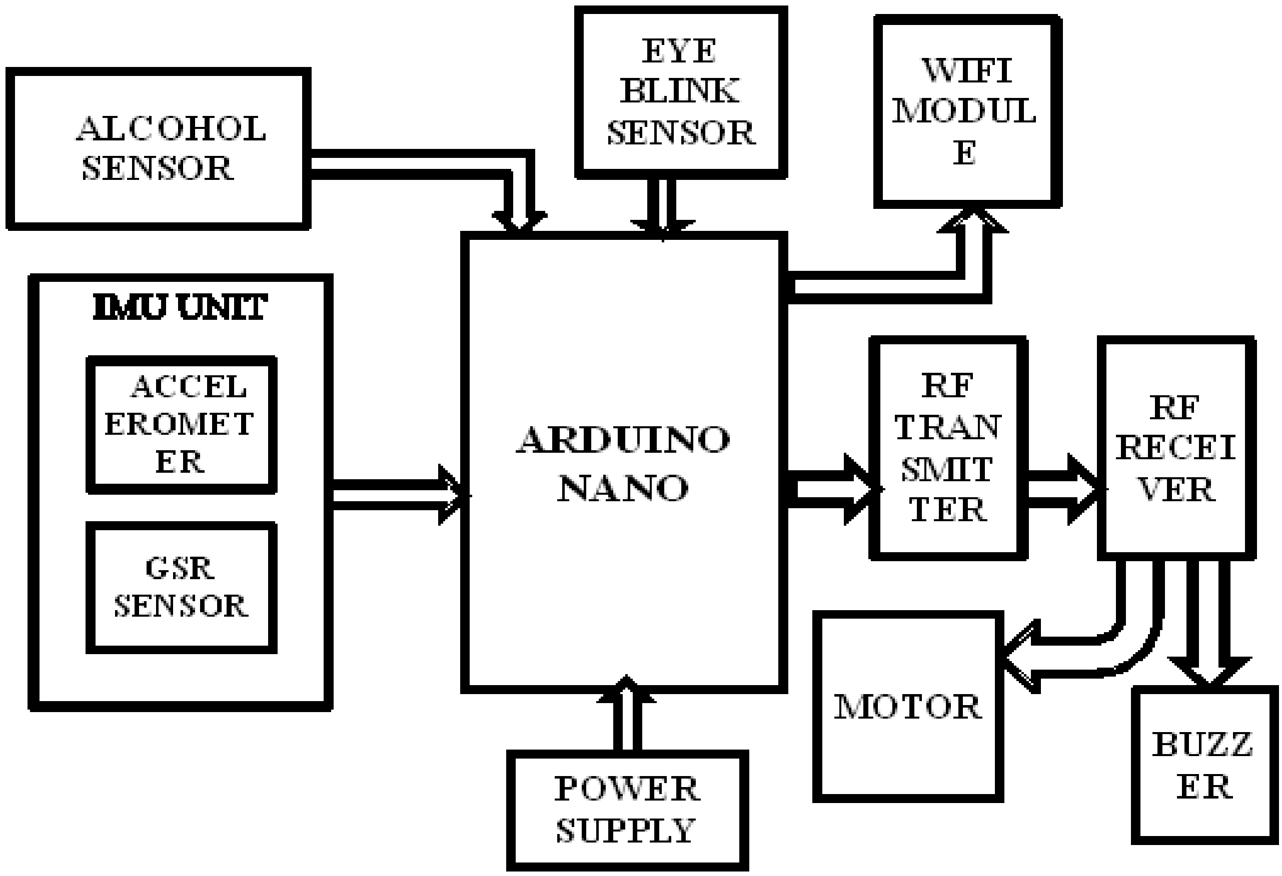

Figure 1 Block Diagram

All these signals received from sensors are sent via wireless medium between transmitter and receiver. This gives a valid reason for including motion sensor in a wireless driver assistances system for a good observance of driver stress level. The Internet of things (IoT) is a combined network comprised of a physical object capable of gathering and sharing data and controlling end nodes based on this received data. Internet of things (IoT) includes a large number of different "smart" devices, from industrial machines that transmit information related to the parameters to be classified from the sensors that track data of the concerned parameter, Often, these devices use Internet protocol (IP), an equivalent protocol that identifies computers over the globe wide internet and permits them to speak with each other. The evolution of IoT resulted in smart node devices that are capable of reporting to other devices in real time without human intervention and predict the future outcome, from the data collected by the surfing the internet without human intervention. There are various techniques these days for predicting driver mental stress. As a result of these techniques many lives has been saved from accidents.Therefore, our motivation isn't solely to predict the stress but to prevent fatal accidents that may occur due to driver's stress resulting in lack of concentration while driving. So to improve driver's mental stress level system mechanical motion sensing unit with wireless module with Internet of things (IOT) system together comes as a savior in predicting and preventing accidents. This system is employed to save lots of life from danger in accidents due to lack of concentration.

The setup of this mechanical phenomenon motion unit sensing element (IMU) model is emphasized with the rotating mechanism and measuring system parameters for hand wheel movement with victimization Arduino board, Galvanic skin response sensing element (GSR), alcohol sensing element, unconditioned reflex sensing element and conjointly victimization IOT based mostly wireless fidelity module to grasp the precise position of the mechanical phenomenon motion unit sensing element (IMU), wireless system fastened in foreign terrorist organization victimization IOT technologies for pursuit over the net.

A.Lanata in 2015 printed on "How the involuntary system of a nervosum and driving vogue varies with progressive stressing conditions throughout simulated driving". Autonomic system is nervosum (ANS) variation and driving vogue modification as a response to progressive steering and stressing level stimulation throughout simulated driving. In this, driving simulation experiment protocol has been performed for 3 driving session with progressive stress load. In 1st session, indiscriminately administering mechanical stimuli to the vehicle throughout steady driving nonparallel of explosive and sudden skids that was made by sturdy wind guest. This canturn out to extend the motive force stress. In second session, it tacit A Progressive psychological load. It consists of battery of your time pressing arithmetic question, additional to mechanical stimuli. In this whole experimental session, the driver'shealth vital signals and the parameter are recorded foranalysis.The changes in ANS were considered in terms of pulse variability, electro dermal response and respiration activity together with mechanical data like that feedbackof a steering wheel for angle corrections, rate of change and its response time. In particular, important variations are applied to statistical variations were found among the 3 driving sessions with an increasing stress each in ANS response with mechanical parameter variations.

P.Joosen, D .Beekman"s in 2015 printed by "An investigation on mental stress - profiling of machine drivers throughout a race ". car racing is stress intense sport that needs high and constant mental engagement. As the average age of machine drivers will increase, it becomes additional apparent that the mental settle for of the game is changing into additional vital. Body sensing element network was developed consisting of a pulse monitor, AN external GPS sensing element and 2 smart phones. Experiment was conducted with the 3D accelerometer of the movable victimization AN existing formula that's scheming the strain level of the motive force in real time. The strain, together with GPS data is later on transmitted via the movable network hymenopteran to envision the position of the motive force strain level in real time. Post analysis of the information indicates that there's a correlation between the strain level of the motive force and specific events. Weak correlation exists between the strain level of the motive force throughout an occasion and their performance. Finally, the distinction of the strain profiles among the motive force is shown.

I J.Gao, A.Yuce and J.P.Thiran in 2014 printed by "detection emotional stress from face expression for driving safety ". Monitoring the choice and emotional standing of the motive force is important for the security and luxury for driving. During this work a true time non - intrusive observance system developed, that detects the emotional states of the analyzing facial expressions. The system consisting 2 negative basic emotions, anger and disgust as stress connected emotions. We have a tendency to sight a personal feeling in every video frame and also the call on the strain level is formed on sequence level. Experimental results show that the developed system operates fine on simulated knowledge eve with generic module. an extra create standardization step reduces the impact of create pair because of camera setup and post variations, and therefore improves the detection accuracy.Quantitative results on stress detection shows smart performance with native descriptor - based feature illustration, once extra information is collected for model adaptation. This method is in a position to sight 95% in - door and 85% of in- automobile check cases. The pattern of temporal dynamics of countenance and action is integrated within the model coaching. In that, head motion and acoustic signals may even be integrated to realize higher performance.

HJ.HERMENS in 2015 printed by "through an experiment elicited stress valid by electromyogram activity "experienced of stress could result in enlarged diagnostic procedure activity in specific muscles compared to a non- stressful scenario. The main aim of this study was to develop and validate a stress electromyogram paradigm during which one uncontrollable and unpredictable sensitive input was gift. Electromyogram activity of the trapezius muscle muscles was the response of interest. In extra to linear time effects, nonlinear electromyogram time courses were conjointly examined. Electromyogram activity throughout the complete experiment was change a priori expectation. The pre-input section showed a considerable higher mean electromyogram activity compared to the opposite section and an on the spot electromyogram response to the input was incontestable. In addition, the analyses disclosed vital nonlinear electromyogram time course all told 3 phases. Linear and quadratic electromyogram time courses were considerably changed by subjective antecedent stress level, measured simply before the beginning of the strain task. Result counsel that the strain paradigm bestowed here may be a valid check to qualify individual variations in stress susceptibleness.

M.Singh and A.B.Quaymanin the year 2016 printed by "Stress detection automobile drivers use physiological parameters". In past few decades there's road may be steep increase in the number of road accidents and casualties involved in the road accidentfrom the previously known facts,due to the rise in the motive force such as sleepiness, fatigue and mental stress. so as to reduced human error whereas driving, we will monitor stress and fatigue by activity physiological parameters like graph (ECG), myogram (EMG), skin electrical phenomenon (SC) conjointly known as Galvanic Skin Response (GSR) and RespirationRate (RR) over an amount of time, from the previous studies it show that in most cases driver's skin physical phenomenon and vital signal parameter square measure closely associated with driver's stress level.

E.Garica-ceja in 2016 printed of "Automatic stress detection in operation environments from smartphones" Usage of smartphones increase in employment across several departments of an organization and results in subsequent increase in activity stress measure impacts negatively the human health.Activity stress levelsand humanphysiological and psychological dynamics is very difficult for analysis thanks to the self-reporting and variability among people with appearance of smartphone,it's currently attainable to watch various facet therefore human behavior, as well as objectively measured behavior associated with condition and results in stress. The information from the smartphone is utilize for stress measurement.Stress measuring system sensors are chosen keeping privacy as a main parameterlike (e.g., compared to video, or audio recording, location,), Thanks to its low - power consuming devices that makes it a good selection to be deployed in a smaller wearable embedded device, like concerning more than one subject from 2 totally different locationthrough a smart phone. The study lasted for 56 days and was conducted in real time in working atmosphere, without any constraintshence placing stress measurement sensors upon smartphone the topic is perceived for models to classify various levels of stress, we have a tendency to achieve a most overall accuracy of seventy-one. Validation of the commercially accessible driver stress detection shows that the systems exhibit additional dependence of the driving force stress level or the skin electrical phenomenon motion sensing element unit and galvanic skin response element (GSR). Due to the absence of a preventing driver, associatedegree alcohol sensing element and eye blink sensing element is needed during this style of systems.

II. IOT BASED SYSTEM DESIGN:

The wearable stress observance glove is a system that is divided into 2 parts:

- Sensing element module unit
- Data processing and Indication unit.

The sensing element unit consists of nine free mechanical phenomena sensing elements, which give "3D area orientation" extracted from relatedness measurement systems. Signal knowledge includes measurement of linear acceleration that has units in terms of m\s^2. This knowledge is provided by the measurement system is relevant motion from rest. The acceleration can give the value of the static acceleration even when the device is stationary.

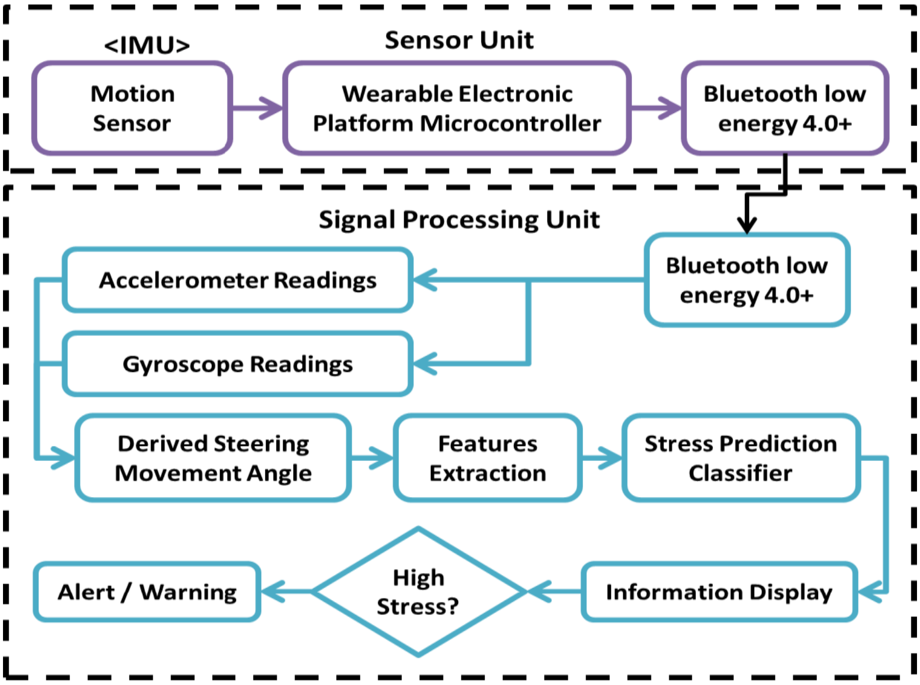

Figure 2 Systematic Design

So, to keep the system simple only linear acceleration is taken into account, which removes the attraction by taking the cyber acceleration of 0m\s^2 when the device is stationary. The information is measured in 3 axes connected to an Arduino Nano controller. The Arduino Nano converts the output from an analog input to a digital output. Galvanic skin response (GSM) is measured at the skin level of the driver's palm. A derivative formula is made to understand that the knowledge of the steering angle is expressed as angular movement, i.e., rotation in three directions such as pitch, roll and yaw. This mechanical phenomenon motion unit will now predict the stress level of the steering force in 3 completely different terrain like "City", "Highway" and "Rural".

In addition, there is an alcohol detection element and the blink detection built in to the stress monitor which monitors the driver's alertness. If the sensors are low, the buzzer is OFF and the engine can also operate in a conventional method. If the sensor indicates a high status, the buzzer will sound and the engine will be stopped. Finally, the wireless fidelity module is used to receive the signal from the Arduino Nano and transmit the received signal to the mobile device to see its stress status while driving.

2.1 Sensors Connectivity:

The sensor element is small in size and the battery is small with limited computing, communication and power capabilities. The primary detection element is illustrated in the figure. (Figure.3,4)

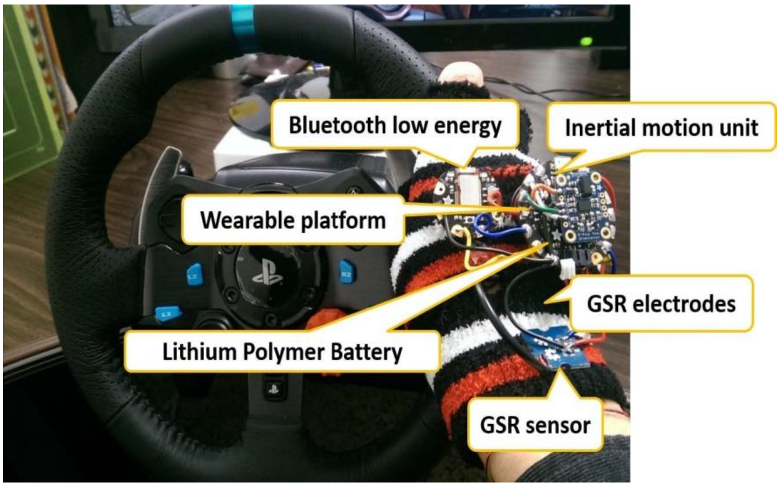

Figure 3 wearable glow

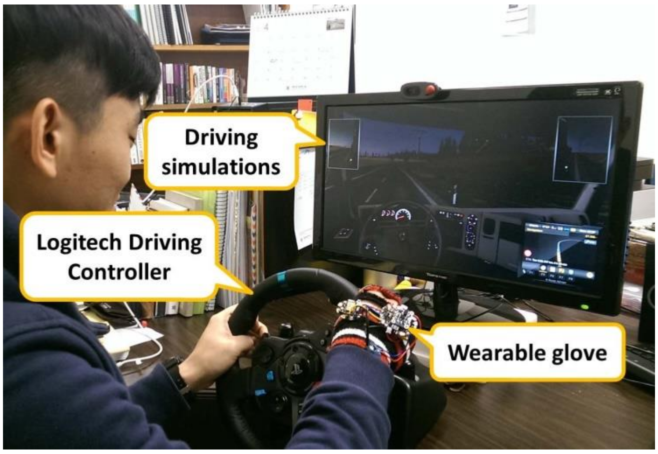

Figure 4 Logitech steering wheel controller

1. Sensor: It encloses associate degree embedded chip for sensing very important medical signs type the body of driver.

2. Microcontroller: It controls the performance of overall circuit and takes appropriate decision based on knowledge comparison.

3. Memory: It is quickly stores the perceived knowledge that obtained from the sensing element property.

4. Radio Transceiver: It communication the nodes and permits bio-signal information to be wirelessly send \ receive.

5. Charge controller: It controls and limits the charge stored in the batteries.

6. Signal conditioning: It amplifier and filters the bio-signal perceived knowledge to appropriate levels of digitization.

7. Analog to Digital Converter: It produces digital signals from the analogue ones to permit any require method.

8. Bluetooth: RF to attach with different body sensors. Bluetooth is used as communication protocol to attach the obtained perceiver knowledge with the personal serve.

3.2. Personal Server:

The personal server runs to connect wireless nodes via a Bluetooth communication protocol. It is organized by a medical server, which is the victim of the address of a scientific information server at the interface of the medical service. Private sensors are used as a complement to the way dynamic signals are generated from the sensors and prioritize the transmission of important signals that has to be sent through medical server. Thismedical serverwill perform the task of analyzing key indicators and compares the result of driver's health with the existing training data, the acquired knowledge of the medical server will be used to generate feedback through a graphical interface. The personal server hardware includes various blocks such as an input device, antenna, microcontroller, transceiver, Bluetooth, non-volatile storage, battery and charging unit. Information received in the next process for sound removal and factor measurement.

III. METHODS:

In this study, the variation of hand and steering wheel movement (SWM) is expected to reflect the stress levels of the driver, which are indirectly derived from a hand wheel driven by hand motion. Hence, the first step is obtaining a steering angle that supports the readings of the IMU. The readings from the measuring system (linear motion) and the rotating mechanism (rotation motion) are utilized to understand the speed and angle in a degree format. The following section gives anoverall view aboutthe steps taken to figure Steering Wheel Movement from FTO readings.

3.1 Steering Wheel Movement (SWM):

The data received from the motion sensor derived as SWM (MSD-SWM) can be divided into three angular motions such as pitch, yaw and roll. The speed of these three parametersis calculated in same way depending on the axle used. Equation (1) shows that the angle these each axis (x,y,z) at the i-th time instant is computedin the following method which is represented asagl_i

$Agl_i = 0.98 * agl_{i-1} + gyr_{HZ} + aglc_i * 0.02$ (1)

where

gy_{ri} is gyroscope sensor readings at i-th time

$gyr_{hz}$is gyroscope sensor sampling rate at i-th time

$agl_{ci}$is angular acceleration at i-th time

From the equation, the gyroscope readings of the x-axis is adopted to calculate the angle for the pitch. The same calculations apply for roll and yaw, with the Y-axis and Z-axis readings of the gyroscope sensor. Further, the angular acceleration is determined as shown in (2)

$Agl_i = arct_{an}(Ax, Ay) * 180/\pi$ (2)

Where

Axand Ay are the coordinates of the dedicated raw readings from the linear accelerometer.

From the previous studies it's clear that steering angle variation in the range [+90°, 0, -90°] were taken in to account. The Negative sign in degrees is a representation of steering wheel turning to the left and positive sign in degrees is a representation of turning to the right.

From theexperimental knowledge it is clear that subjects showed that steering wheel tended to turn left and right by more than 90°while cornering in a simulation. Therefore, in this work the steering angle limit was extended from [+90, 0, -90] to [+180°, +90, 0, -90,-180°]. Furthermore, during the trial phase of the driving simulation, most of the subjects attempted to turn the vehicle in a corner with small radius, the subjects made multiple adjustments to steer the wheel by changing the position of their hand over a steering wheel and performa complete rotation. These multiple manual movements of the hand over steering wheel can lead to errors and possibly could disturb the analysis. These errors are reduced by properly instructing the subjects to avoid taking off their hands from steering wheel throughout the course of this experiment. Furthermore, to curb the errors due to the usage of both hands the subjects are carefully selected as right-handed users of steering wheel. Finally, the sensor readings are collected at a rate of.001 samples per second.

3.2 Feature Extraction:

For simplicity of calculation pitch and roll angle are not considered for computation as these data do not convey any useful information regarding the driver stress level.This study discusses more on the transition rate of the angle from time (i) to time (i+1). Then the angular conversion is found by getting the first angular derivative of 10 s, with a Hamming window of 2s. Then the resulting values are called DynamicRatio (DR).From this dynamic ratio stress levels are calculated in the following three parameters such as Time, Phase and Frequency.

First, the characteristics of time is called statistical characteristics. In this case consider average or standard deviationas the type of statistical characteristics. These statistical characteristics are applied for the features such as yaw, roll and pitchfor extracting the characteristics. Here the roll and pitch and yaw arelabelled as X, Y and Z since these statistical data doesn't have any significant information on stress levels of the driver, however further research work has to be done for frequency analysis and power spectral analysis of the signal extracted from the signal received.

3.3. Stress Level Classifier Model:

The two parameter of stress level identifiers such as skin potential and angular position are tabulated as in given in Table (i). This table is further used to extract information and compared with the stress by giving a sample test questionnaire. This was developed by a psychological expert based on the questions the stress levels are monitored and trained by an algorithm. This survey questionnaire measures from 1 to 10, where 1denotes very low-level stress and 10 very highly stressed. To simplify the classifier model will fix some threshold to make the analysis simple, the scale has been reduced to two features such as 1 and 2, where 1 (1 to 5) indicatesrelaxed stress levels and 2 (6 to 10) indicateshighly stressed. Using the setup shown in fig 3 a total of 5000 sample data was collected from different person at different conditions of stress out of which 4250 data sets were "stressed" and "750" datasets were from non-stressed conditions dataset the total experiment was conducted at for about 4 days of about 6 hours every day so totally the experiment lasted about 24 hours but in the data there are some outliers these needs some statistical approach to clean the data by taking mode of each features separately. This outlier datasets are due to unusual behavior like coughing, sneezing, etc...

In the previous literature survey, it is clearly given that SVM (Support Vector Machine Classifier) is used for stress level classification. In this work SVM is further combined with several other features to predict stress levels. This is done by a feature extraction and selection method called Stepwise Feature Selection (SFS).SFS is a method in which the next highest performance criterion gets added with the existing SVM classification algorithm which improves the classification accuracy.

In this work the performance criterion to be considered is the correlation and accuracy rate of featuresbased on stress prediction using the SVM (Support Vector Machine) classification algorithm. (Figure.5) shows the accuracy ratio of stress prediction which is a graph of accuracy rate vs feature index.

Initially the accuracy of the strain level prediction using SVM without SFS is 67.98% after including SFS with 12 features increases the accuracy rate to 84.02% from 68.89% with an increase of about 15%.Whereas adding next 13 feature increases the accuracy by just 1% and it does not give any significant improvement in the accuracy. The next significant change in the accuracy rate occurs upon the total response of the features from 26th to 35th feature, with an accuracy rate of 93.55% with anincrease of about 7%.Finally adding the last feature gives an increase of 1% accuracy resulting in 94.55% accuracy. (Figure.6) shows the accuracy of stress prediction using SVM combined with SFS individual features as performance criteria.

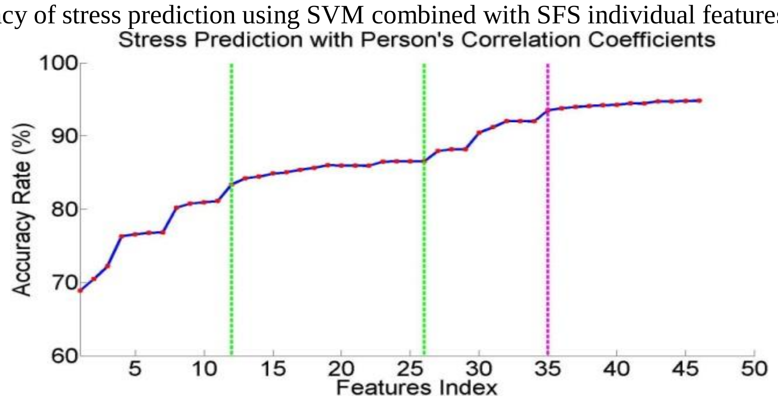

Figure 5 Pearson correlation coefficients

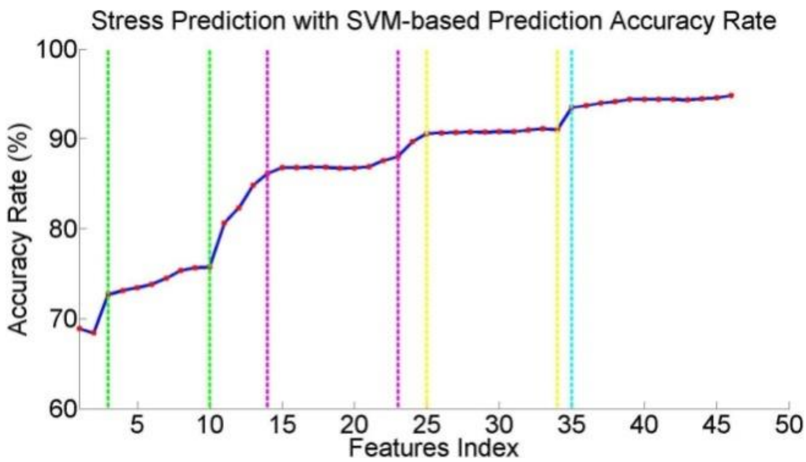

Figure 6 Solely SVM - based prediction accuracy rate

IV. RESULTS AND DISCUSSION:

As a first step, the integrity of the stress gauge should be checked for the primary gauge (GSR) and the secondary gauge. Based on this the correlation coefficient ρ for a person was fixedas a general method to compute the dependency of a linear correlation between the two dependent variables. The range ofcorrelation value for a person is taken in the rage of [-1,1]. Higher the correlation value ρ represents a good amount linear relationship between the dependent variables, while the polarity of correlation values indicates direct or inverse relationship between the variables. If the value of ρ is equal to 0 then it indicates that there is no significant relationship between the variables. From the results we got a correlation coefficient of 0.983 indicating that there is highly positive relationship between the two stress measures indicating that two measures give consistent performance and accepted for stress labelling.

From the observation based on the comments of a psychiatrist and GSR stress labels it is found that driver experienced very high level of stress while driving in Urban or city traffic (Figure.7.a) followed by moderately stressed while driving in the Rural areas and relaxed while driving in the highway. The reason behind this high stress levels in urban areas is due to frequent start and stop situations and more curves and bends occurring in the urban areas. In case of rural areas (Figure.7.b), the roads were narrow this causes the driver to get moderately stressed, whereas in case of highways (Figure.7.c) the driver is more relaxed due to separate lane. In this study the accident rate recorded in the highway road scenario is 0%, in the urban areas it is 23.5% and in rural areas it is 33.7%. This psychiatrist said that at night and on rainy days, irrespective of the driving environment, the driversshowed slow and cautious behavior as the driver needs more concentration in these situations to drive. Finally, it was concluded that stress levels depend on the speed of the vehicle being driven. And the transition time from low stress to high stress is very short compared to the transition time from high stress to low stress. These statements are well complemented by the GSR stress measurement label.

The three different experimental scenarios

Figure 7.a Urban

Figure 7.b Highway

Figure 7.c Country sides.

V. CONCLUSION

An inertial motion sensor unit is used to predict the level of driver stress in the actual path, which increases the accuracy of the measurement compared to the normal method. In the proposed program, we predicted and prevented the driver's stress level using an alcohol sensor and blindfolded sensor and optical sensor with the help of a car-based vehicle and alarm. Internet of Things (IoT) is used to provide an accurate level of driver stress level.

Validation of a commercially available driver stress sensor shows that the system relies more on the driver's stress level or skin conductivity to steering wheel movement to predict stress levels of the inertial motion sensor and the Galvanic Skin Response (GSR) sensor. Since there are no blocking drivers, this type of system requires alcohol and glare sensors. This measurement will have a higher accuracy with an average rate of 94.78%. The proposed module can also act as sensor nodes to assess driver stress levels in order to predict and prevent usage by various sensors. Furthermore, the proposed method outperforms conventional methods using the driver's biomedical vitals, face expressions or voice, and the following the lane is more sensitive to noise.

In this work, more focus is given for carrying out the study on the relationship between driver's stress levels and driving environmental and situation including cornering and frequent stopping at the traffic signals. The aim of providing a superior stress prediction model is to increase the reliability and safety in real lifedriving situations.

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Chapter - 3

Evaluation and Prediction of Covid-19 Disease Spread across Sixteen West Africa Countries Using a Machine Learning Approach

Michael Segun Olajide[1], Adekola Alex Ajayi[2], Oladoyin Anthony Abiodun[3], Oluwagboyega Peter Afolabi[4]

[1,2,3,4] Department of Computer Science, Adeyemi College of Education, Ondo, Nigeria
[3] School of Computing and Communications, Lancaster University, Lancaster, LA1 4YQ United Kingdom
[1]olajidems@aceondo.edu.ng, [2]ajayiaa@aceondo.edu.ng, [3]o.a.abiodun@lancaster.ac.uk, [3]abiodunoa@aceondo.edu.ng, [4]afolabiop@aceondo.edu.ng

Abstract— The covid-19 pandemic disease created a great scare and massive economic, social, political, and international challenges. Many lives were lost, and economic crisis coupled with crippling industrial activities. This work aims to assess the tragedy, take into account the depth of its spread, and make intelligent guesses and predictions that will help all parties take appropriate steps to stop the disease. Using the Covid-19 time series dataset, an analysis was conducted to reveal the confirmed, active, recovery, and death cases of Covid-19 cases in the 16 West African countries. Using three machine learning algorithms: Polynomial Regression (PR), Support Vector Machine (SVM), and Neural Network (NN) to carry out prediction, the polynomial regression model gave the best result when considering the generated results among the three techniques employed for the study.

Index Terms— Covid-19, Machine Learning (ML), Polynomial Regression (PR), Neural Network (NN), Support Vector Machine (SVM)

I. INTRODUCTION

There have been multiple disease outbreaks throughout history that have infected the planet at various periods. To date, the World Health Organization (WHO), alongside its partnering professionals, and other global efforts coordinated by national authorities have battled these pandemics [5]. The sudden outbreak of Covid-19, a viral disease with its earliest report from the Asia Continent towards the end of the year 2019 brought untold hardship to the global community due to its level of spread and devastation. The spontaneous spread across the globe in a short time triggered massive global concerns resulting in social and psychological crises. In addition, the increasing death casualty figures recorded from the disease further compounded the challenge posed to the entire world. The incidence of the spread of the disease presents very damaging dimensions and unfortunate panic in the minds of the global society.

Unfortunately, when the outbreak began, there were no vaccines or important treatments that could be used by the world's population to prevent it. The existing drugs and vaccines administered have very little or no significant anatomical and pharmacological effects on the dreaded viral disease. This further plunged the whole world especially the leaders of nations, health professionals, researchers, policymakers, and other stakeholders into aggressive collaborations where profiled measures and some immediate stop-gap solutions are implemented like the lockdown order restricting movements within countries and beyond.

Covid-19 has had the most destructive effect on human life, with a record of fatalities and social and economic difficulties. The pandemic has produced more than 504 million infections and 6.19 million fatalities as of the first week of April 2022, making it one of the worst in the history of man [11] [4]. The pandemic has claimed the lives of so many people throughout the entire globe and poses a significant threat to the health of the general public, food security, and global activities. It is projected that as a result of the adverse effects of the pandemic on the society and economy, millions of people are likely to fall into abject poverty. This is evident from the records showing that the undernourished category of people globally is close to 690 million, with projections that the record may rise as the effect of the pandemic is felt [12]. The upsurge in the spread of the disease has further plunged the world into another round of mind-bogging economic recession and attendant medical challenges.

Michael Segun Olajide – "Evaluation and Prediction of Covid-19 Disease Spread across Sixteen West Africa Countries Using a Machine Learning Approach" Pg no: 23 – 37.
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Because of the pandemic, many businesses were shut down leading to serious interruptions in business processes across several industrial divisions. Businesses face a variety of short-term challenges, including marketing, sales, distribution of goods and services, finance, personnel, health, and general safety. Several popular organizations, enterprises, and corporations in many industries are projected to go bankrupt as a result of people staying at home and economies being shut down owing to the COVID-19 epidemic [10]. Regrettably, the global population is currently counting their losses and still stood the risk of managing frequent waves of diseases globally. The first, second, and third waves have gone past. The world is somewhat witnessing the fourth wave with distinct characteristics each. The various aspects of human lives are not saved because the scourge is an ill wind blowing across the global landscape. The causalities have been several people across age groups, particularly the middle-aged and elderly. The medical personnel were equally badly affected in their attempts to rescue victims.

The objectives of this study are to undertake an evaluation and prediction of COVID-19 disease spread across sixteen West African counties using a ML approach to generate accurate reliable results, which will assist policymakers, health care professionals, academia, and other stakeholders in making good decisions on COVID -19 issues. The specific objectives include: (a) to identify the trend and status of Covid-19 infection on the global scale (b) to analyze the number of confirmed, recoveries and death cases across 16 West African countries (c) to compare confirmed Covid-19 cases, recoveries, and deaths in west African nations (d) to use ML techniques to predict confirmed cases in the West African region for the upcoming 365 days (e) to provide a platform, which can facilitate the timely generation of information (facts) as may be required.

II. REVIEW OF RELATED WORKS

The work in [1] focused on developing a machine-learning model to analyze and predict covid-19 using three techniques. These are the adaptive-network-based techniques, multilayer perceptron and fuzzy logic techniques. From the result of their experiment, the model presented was deemed suitable for simulating the Covid-19 epidemic. Following the experiment, the result and performance of the models demonstrated a high capacity to simplify a long-term prediction in the case of a pandemic.

A machine-learning model was utilized by [7] to predict potential coronavirus patients to improve decision-making. In their research, they employed four standard prediction methods: linear regression, exponential smoothing, SVM and absolute list reduction. The model was useful for the prediction of the number of new occurrences of the disease. In addition, their model is suitable to determine the occurrence and records of casualties that could be recorded over the next several days. Exponential smoothing is one of their models that are particularly well adapted to forecasting the epidemic.

A hybrid artificial intelligence model for the prediction of coronavirus was proposed by [17]. The model developed in the study was combined with the natural language processing module with a working structure similar to that of an enhanced vulnerable infected model. The model's projected conclusion was very close to what happened in the real-life outbreak. As a result, the suggested hybrid model may be used to investigate the growth and transmission pattern of the epidemic in greater detail. The researchers in [9] have also proposed an approach of employing ML to predict/forecast coronavirus. From the investigation of their work, the model proposed was to cater for the prediction of the transmission of Covid-19. The model combined three techniques: multi-layer perceptron, linear regression, and vector automatic regression, and found that multi-layer ML systems were the best predictors.

It was suggested by [3] that the corona tracker and data analysis approach be used to predict the Covid-19 epidemic. In the study conducted, it was revealed that the value derived from timely information is sufficient to improve reaction time and lower the danger of covid-19. Their study used the susceptible exposed infection recovered (SEIR) model and analytics to forecast the current trend of coronavirus disease, which was shown in the corona tracker. Using the maximum hunting parameter estimation approach and the SEIR model, a prediction was made for Covid19 in some African countries [16]. The model considered was different from previous SEIR models. This model was deemed to provide a better representation of the most recent novel epidemic patterns, as well as their quarantine status and intervention processes. Total Hassling was introduced based on the spectrum of previous parameter intervals.

To estimate Covid-19 mortality using the patient data at the time of the initial hospitalization, the researchers in [6] examined various ML techniques. The study made use of data from roughly 1500 patients. Three predictors, including ICU admission, dyspnea, and oxygen therapy, were discovered to be the leading predictors of Covid-19 mortality following the performance of feature selection utilizing about thirty-eight predictors. Their experimentation's outcomes showed that Random Forest outperformed other ML methods. A study by [15] used random forest, SVM, and logistic regression to predict the severity of covid-19 using the same factor of time of initial admission. Random forest produced a higher overall performance using the data of 287 patients with varying levels of COVID-19 severity and 23 features, including at least one clinical feature, one chest computed tomography feature, and twenty-one laboratory features.

An enhanced ML approach for detecting covid-19 early was presented by [2]. With a better objective function, Harris Hawks optimization was used to optimize the hyper-parameters of the extreme gradient boosting, light gradient boosting, categorical boosting, random forest, and support vector classifier. A publicly accessible clinical dataset was subjected to an ensemble technique on the optimized ML models, and the results demonstrated that the suggested method outperformed conventional ML techniques.

A review of how ML methods as well as artificial intelligence can be employed to predict the pandemic of Covid-19 disease was conducted by [5]. The work evaluated selective information in the research paper, which was conducted on databases connected to how the technologies of ML can be applied to Covid-19. We will promptly and critically consider three important elements: abstract, methodology, research background, and research objectives. The comparison of potential models for combatting the SARS-COV-2 outbreak led to a valuable conclusion. The work's result covers current studies that employ ML and artificial intelligence technology to enhance research from many angles. It also goes through some of the usual mistakes and challenges that people run into when trying to apply such algorithms to real-world problems. This layer also discussed recommendations for researchers, medical specialists, and policymakers in the current and future situations with the Covid-19 epidemic. This suggests that continuous improvements in artificial intelligence and ML have significantly improved COVID-19 disease contact tracing, prediction, therapy, and medication and vaccine development while lowering human participation in medical practice. Most models, though, haven't been put to the test sufficiently to see how well they perform in practice, but they're still capable of combatting the covid-19 epidemic.

With the discovery of a COVID-19 variant known as 'Omicron,' it is now necessary to discuss its dissemination and potential prediction analyses. According to World Health Organization research [13], in nations with existing community infections, the Omicron variant spreads much quicker than the Delta variant. Furthermore, many countries growth rates have slowed or stabilized, but they remain much greater than the Delta variation. While the evidence is a mounting suggestion that immune evasion plays a role in rapid dissemination, additional information is needed to better understand the relative roles of intrinsic enhanced transmissibility and immunity evasion in explaining the emergence and spread. There haven't been many evaluations or analyses of the Omicron variety as of the time of this research.

In a bid to carry out an analysis of the COVID-19 Omicron variant, a risk assessment was conducted by Ontario Public Health. The evidence brief released in the latter part of 2021 explains that when comparing the connection of Delta and Omicron variants concerning the angiotensin-converting enzyme 2 of humans, there is a greater binding affinity indicating an increase in the rate and spread of infection. It was however noted that as new evidence emerges, there could be changes to the overall risk assessment [8].

III. MATERIALS AND METHODS

3.1 Programming Language and Software

To conduct data analysis and estimate the daily number of coronavirus cases, a predictive model is created utilizing the Python programming language, Jupyter notebook, and Spyder. The following Python packages were used to analyze the data: NumPy, pandas, matplotlib, DateTime, and plotly, while the SkLearn module was utilized to make predictions.

3.2 Dataset

The dataset used was retrieved from the United Nations Office for the Coordination of Humanitarian Affairs (Humanitarian Data Website). The dataset is part of the Covid-19 pandemic dataset of the John Hopkins University Center for Systems Science and Engineering. The Live Updated dataset was retrieved on February 5, 2022. The data contained are records between January 22, 2020 – and February 5, 2022. The dataset which is in the form of time series consists of daily records of confirmed, recovered, and death cases of Covid-19 infections.

The data for recovery cases was discontinued as of August 5, 2021, as such the data used in the work are the records between January 22, 2020 – August 4, 2021.

(Link to the dataset: https://data.humdata.org/dataset/novel-coronavirus-2019-ncov-cases)

3.3 The Experiment

Three datasets were utilized for the experiment. All datasets imported are live updated. The first one contains the number of confirmed global occurrences of covid-19 infections recorded, the second contains the number of deaths recorded so far globally, and the third one contains data on the recovered cases. The datasets were consolidated into one and an exploratory data analysis was conducted using python, in which the outcome of the analysis is the figures and charts used to represent the results. A cross-sectional analysis was conducted on African countries based on the occurrence of confirmed cases, recoveries and deaths recorded and a comparison was made from the analysis.

3.4 ML Models

At the phase of the forecast, PR, NN, and SVM algorithms were utilized to train the data. We split the dataset into training (75% of the dataset) and testing datasets (25% of the dataset). Finally, a forecast of 365 days was made to ascertain the occurrence of cases confirming the virus across West African nations.

3.5 The Work Flow of the Proposed Work

In this task, we will start the experiment by getting the required time series Covid19 dataset. Data preprocessing and analysis were conducted on the data. The processed data were divided into training and testing data which is a requirement for the ML techniques used to perform prediction. After the training and testing were completed, PR, SVM, and NN were the chosen ML algorithms upon which the model created was used. We obtained performance evaluation for the algorithms to determine which one fits best and finally carried out prediction (forecasting) using the same algorithms. The diagrammatic representation of this workflow is revealed in figure 1.

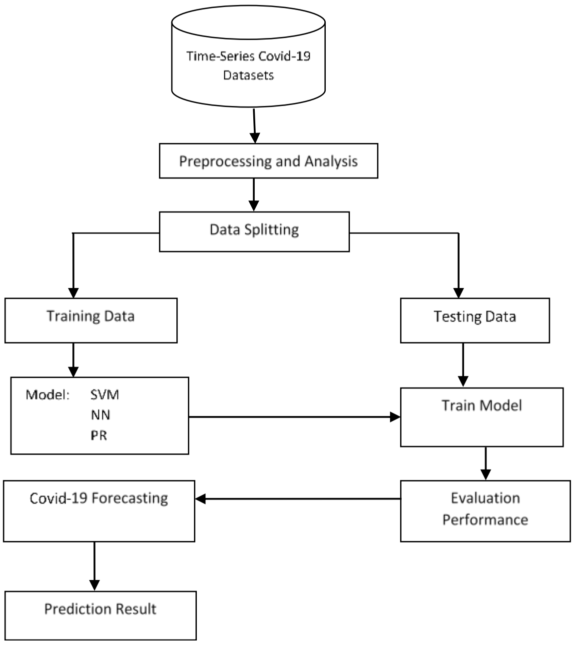

Figure 1: The workflow of the proposed work

IV. DISCUSSION OF RESULTS

Figure 2 offers a graphical representation of the statistical distribution of Covid-19 cases presented worldwide according to the parameters considered in the study: active cases, recovered cases, and death.

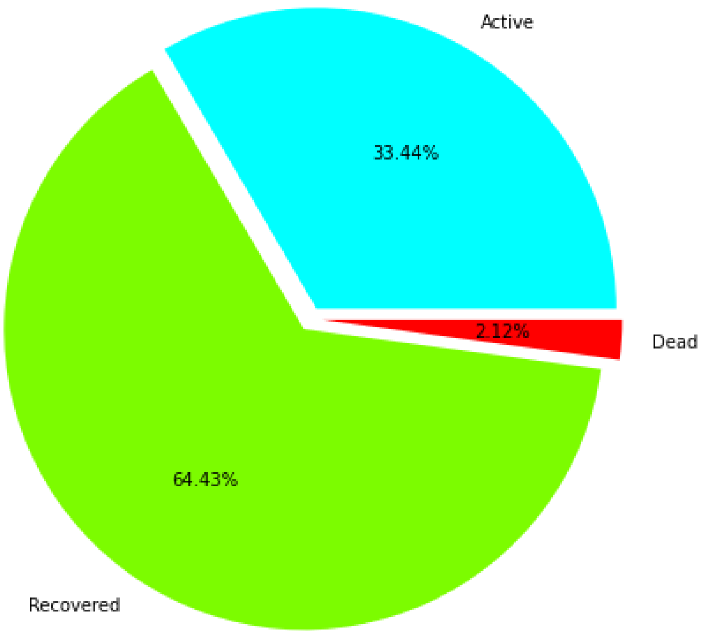

Figure 2: Percentage representation of Covid-19 cases globally

There are 33.44% active cases, 2.12% deaths, and 64.43% recoveries. From figure 2, we can conclude that the recovery rate is far superior to what society expects from the global spread of the virus.

However, an analysis of the number of confirmed, recoveries, death, and active cases of covid-19 across the 16 West African countries are represented in figure 3a, figure 3b, figure 3c, and figure 3d. The countries considered include Nigeria, Guinea Bissau, Cape Verde, Senegal, Niger, Benin, Ghana, Mauritania, Liberia, Sierra Leone, Cote d'Ívoire, Guinea, Burkina Faso, Gambia, Mali, and Togo.

However, considering figure 3a which involves Senegal, Ghana, Nigeria, and Cote d'Ívoire, the earliest occurrence of confirmed covid-19 cases were recorded in Cote d'Ívoire. About 170,000 confirmed cases were obtained in Nigeria while about 160,000 recovery cases were thusly recorded. Also, in Ghana, a little above 100,000 cases with more than 95,000 recovered cases were recorded. In Cote d'Ívoire, about 50,000 confirmed cases were recorded within the considered time frame with 48,000 recovery cases. Finally, about 60,000 confirmed cases were recorded in Senegal, and more than 47,000 cases were recovered. It very well may be seen that the percentage of death and active cases are most prevalent in Senegal from the result obtained from the dataset with the representation provided in figure 3a.

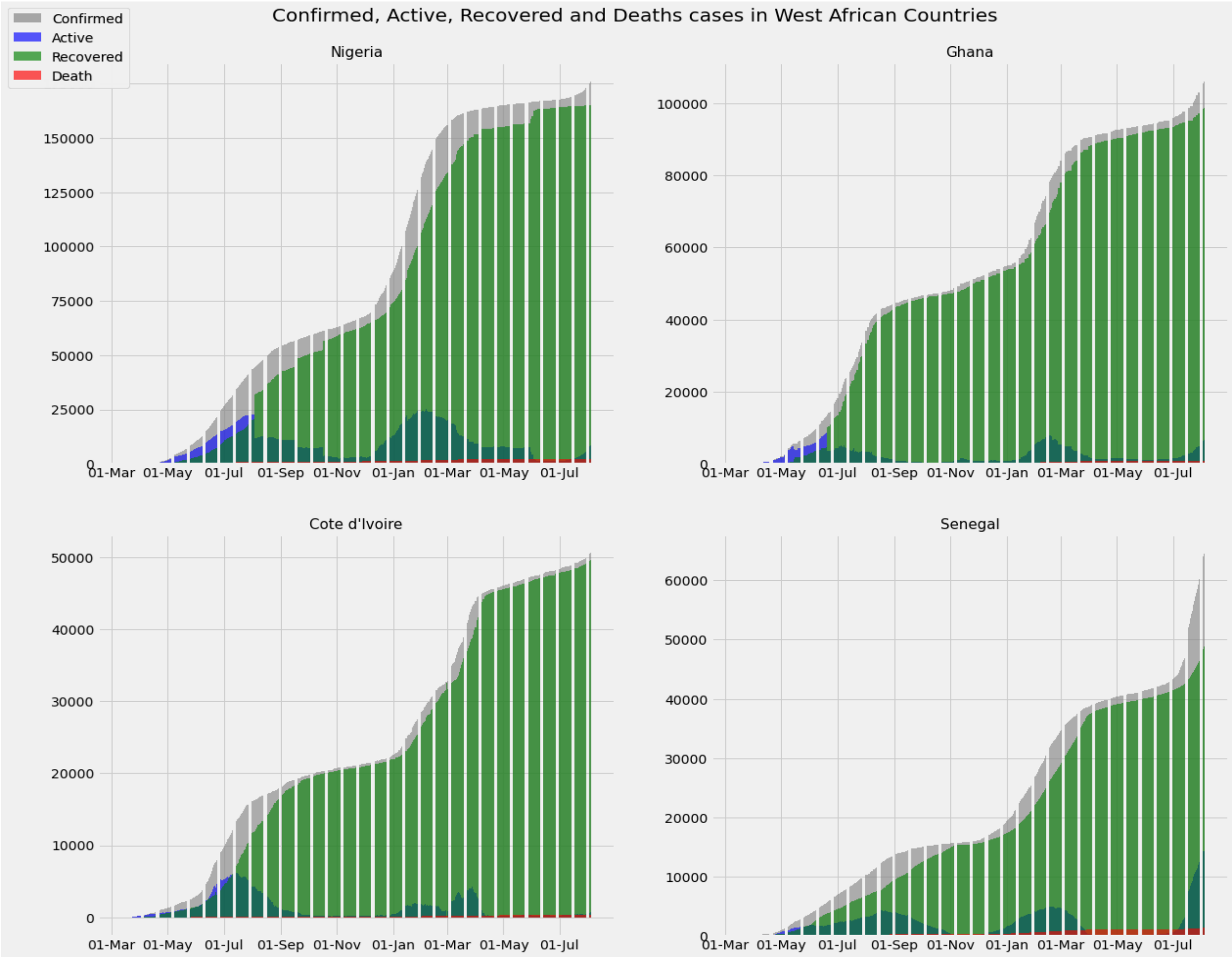

Figure 3a: Covid-19 cases for Nigeria, Ghana, Cote d'Ivoire, and Senegal

Moreover, in figure 3b, the following countries are considered: Guinea, Cape Verde, Mauritania, and Burkina Faso. Burkina Faso recorded the earliest confirmed cases with a little above 13,000 total confirmed cases and about 12,900 recovered cases within the time frame considered in this work. Also, Guinea posted over 25,000 confirmed cases of the virus spread with more than 24,000 recovered cases while Cape Verde recorded about 33,000 confirmed cases while slightly above 32,000 recovered cases from the pandemic spread. Mauritania's covid-19 confirmed cases stood at about 26,000 with about 24,000 recovery cases. In this classification of nations, Mauritania has the most elevated level of death and active cases.

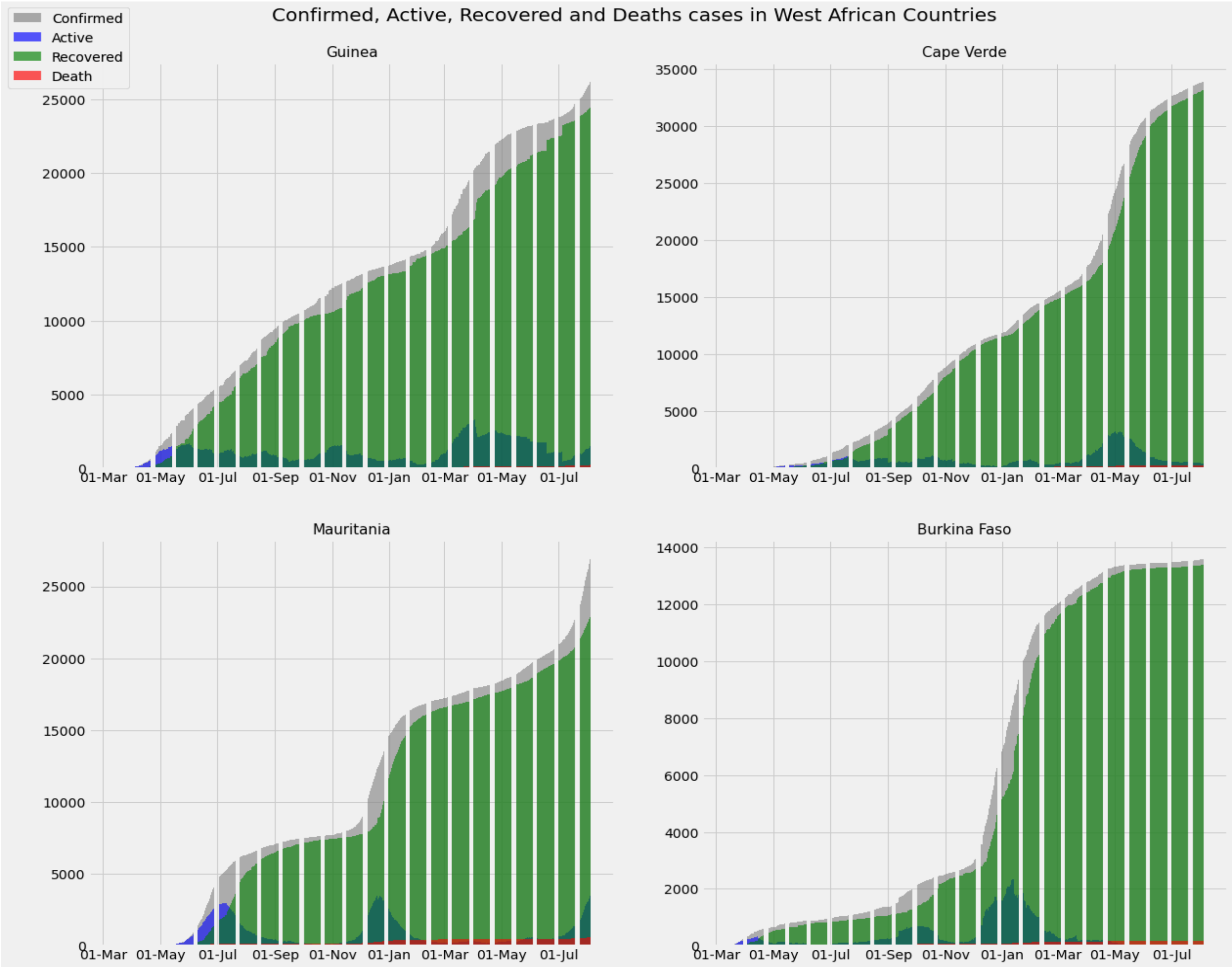

Figure 3b: Covid-19 cases for Guinea, Cape Verde, Mauritania and Burkina Faso

Furthermore, figure 3c considered Gambia, Guinea Bissau, Liberia, and Mali. The earliest confirmed cases of covid19 in this category were recorded in Liberia, from which the country reported about 5,500 confirmed cases of the virus and about 2500 recovered cases. In Mali, more than 14,000 confirmed cases were obtained with a little more than 13,000 recovered cases. In addition, Guinea Bissau posted over 4,000 confirmed cases with recovery cases of 3,850 of the pandemic spread while the Gambia recorded confirmed cases of over 7,500 with recovery cases of close to 6,000. For this category, Mali has the highest percentage of active and death cases.

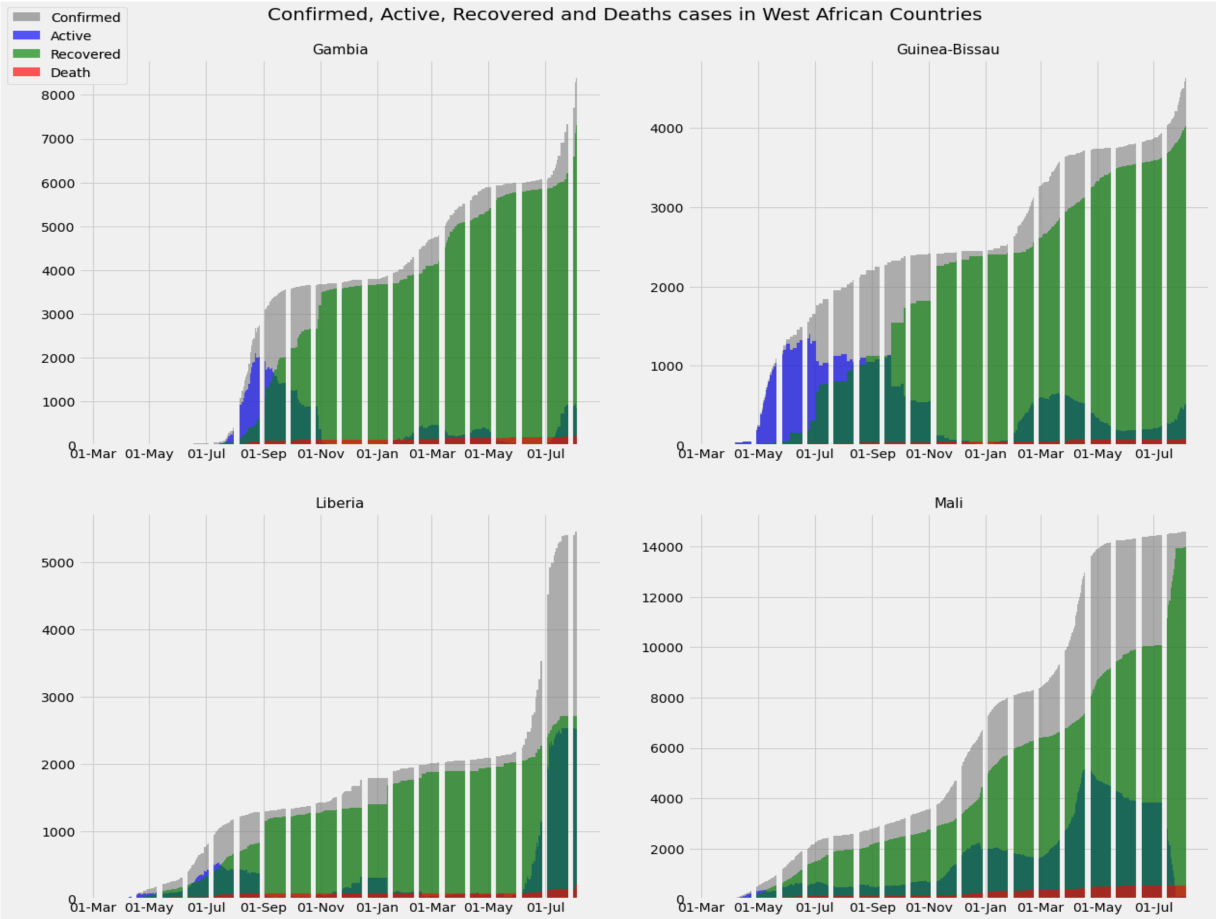

Figure 3c: Covid-19 cases in the Gambia, Guinea Bissau, Liberia, and Mali

Moreover, Niger, Sierra Leone, Benin, and Togo are the countries considered in figure 3d. The Niger Republic recorded the earliest confirmed case. The confirmed cases of about 6,000 were recorded in Niger while the recovery cases of close to 5,500 were likewise recorded. In Sierra Leone, about 6,200 confirmed cases were recorded with about 4,000 recovery cases. In the Benin Republic, the confirmed cases recorded stood at around 8,200 cases while those who recovered were about 8000. In Togo, the virus spread posted confirmed cases of over 16,000 with about 14,700 cases of recovery. In this group of countries, the analysis revealed that the highest percentage of active cases of death were recorded in Sierra Leone.

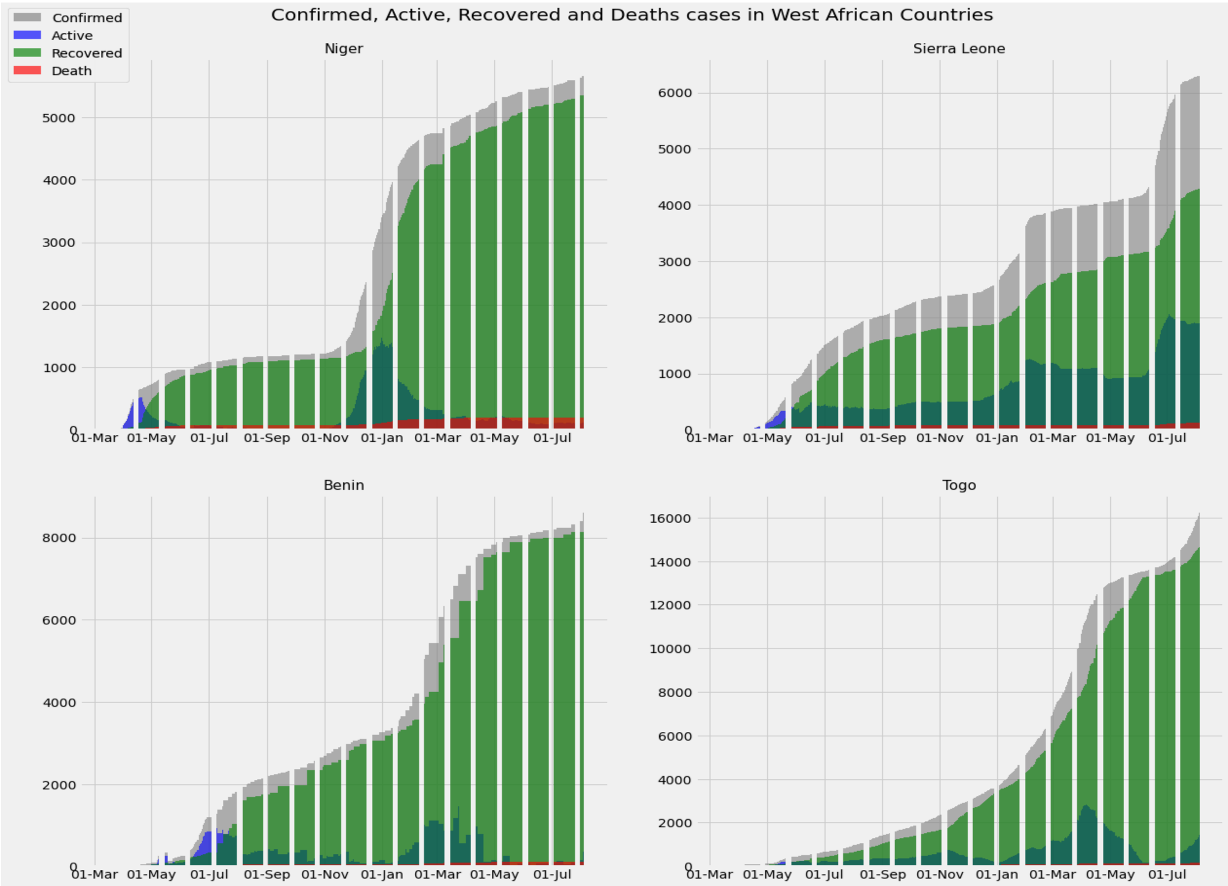

Figure 3d: Covid-19 cases for Niger, Sierra Leone, Benin, and Togo

Considering the occurrence of confirmed cases revealed in figure 4 from the 22nd of January 2020, to the 4th of August 2021, Nigeria has the highest number of cases, followed by Ghana, with Cote d'Ivoire having records close to Ghana, and then Senegal. Similar records are observed for coronavirus recovery and death during a pandemic, as shown in figure 5 and figure 6, respectively. From the statistics, it is assumed that these records are collected in this format as a result of the fact that these 4 countries are among the most populated countries in the West Africa sub-Sahara continent (See table 1)

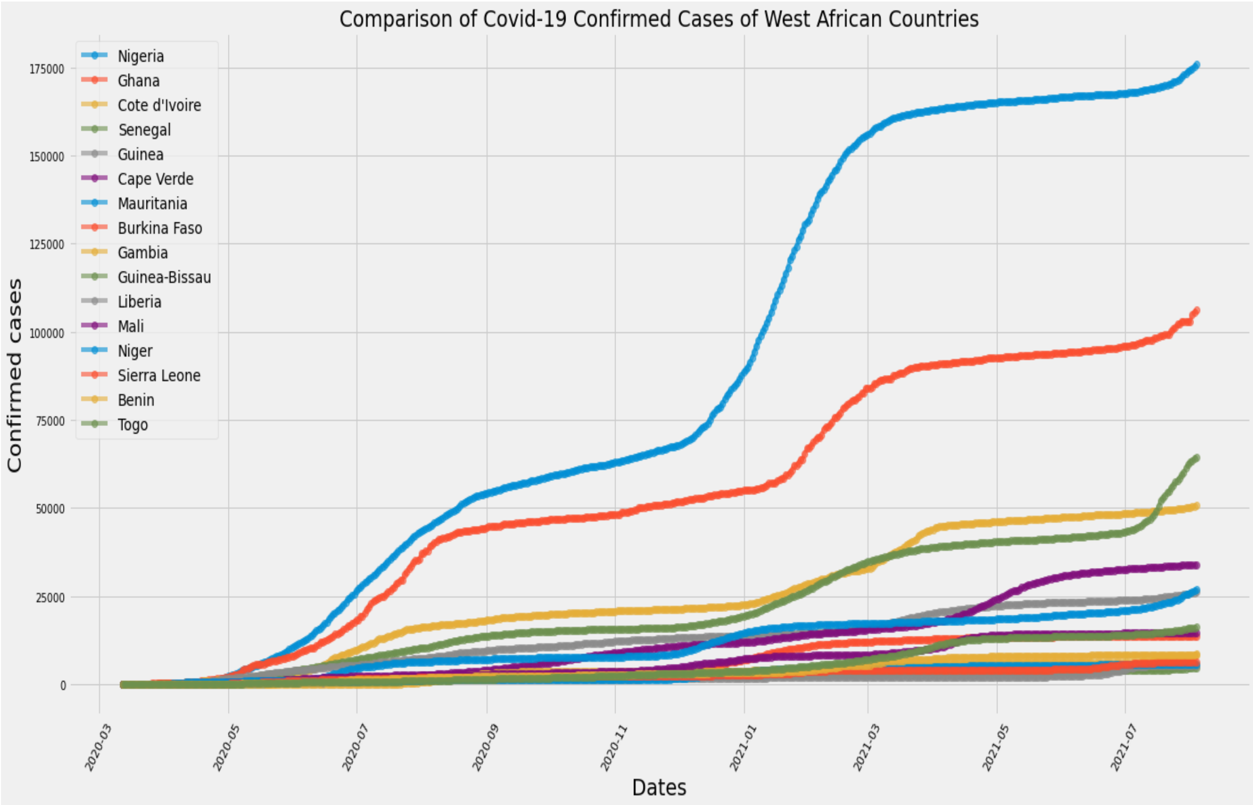

Figure 4: Covid-19 confirmed cases in West African Countries

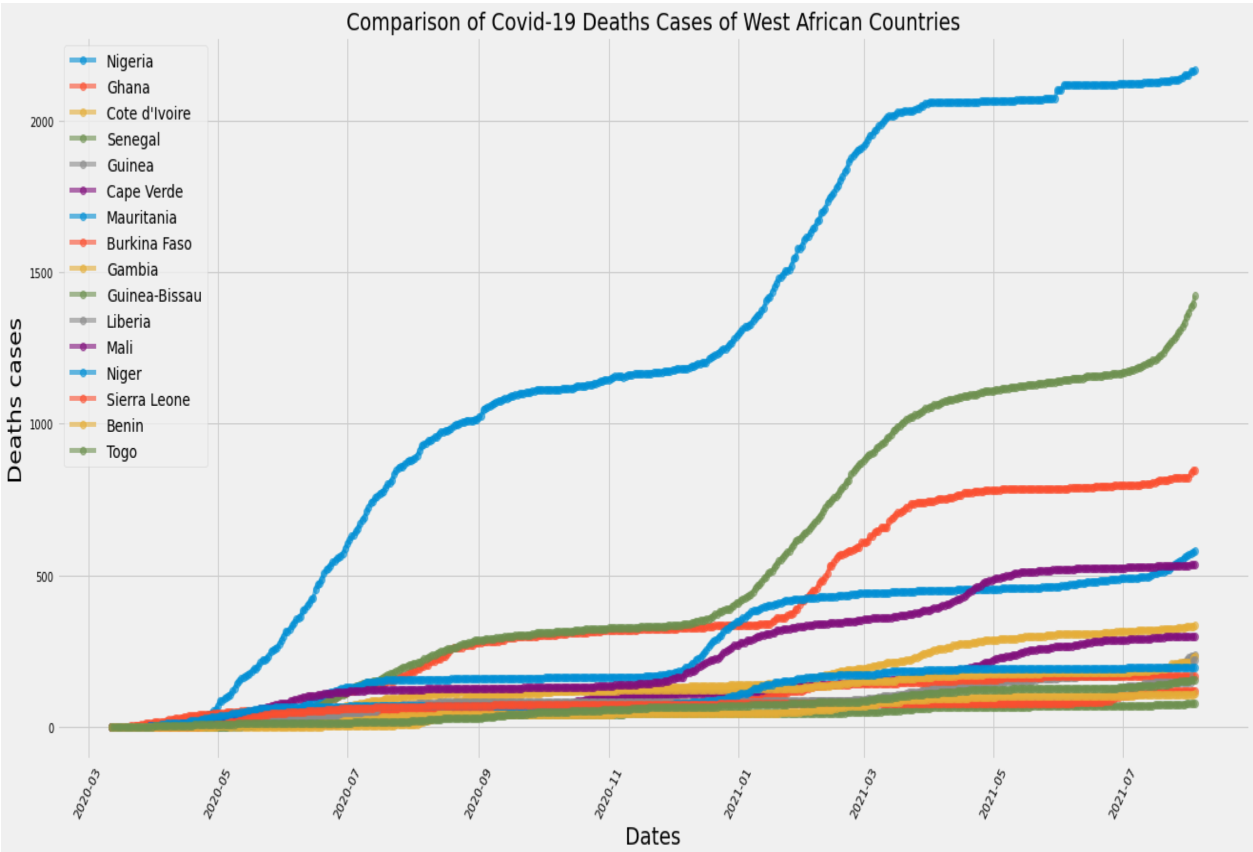

Figure 5: Covid-19 death cases in West African Countries

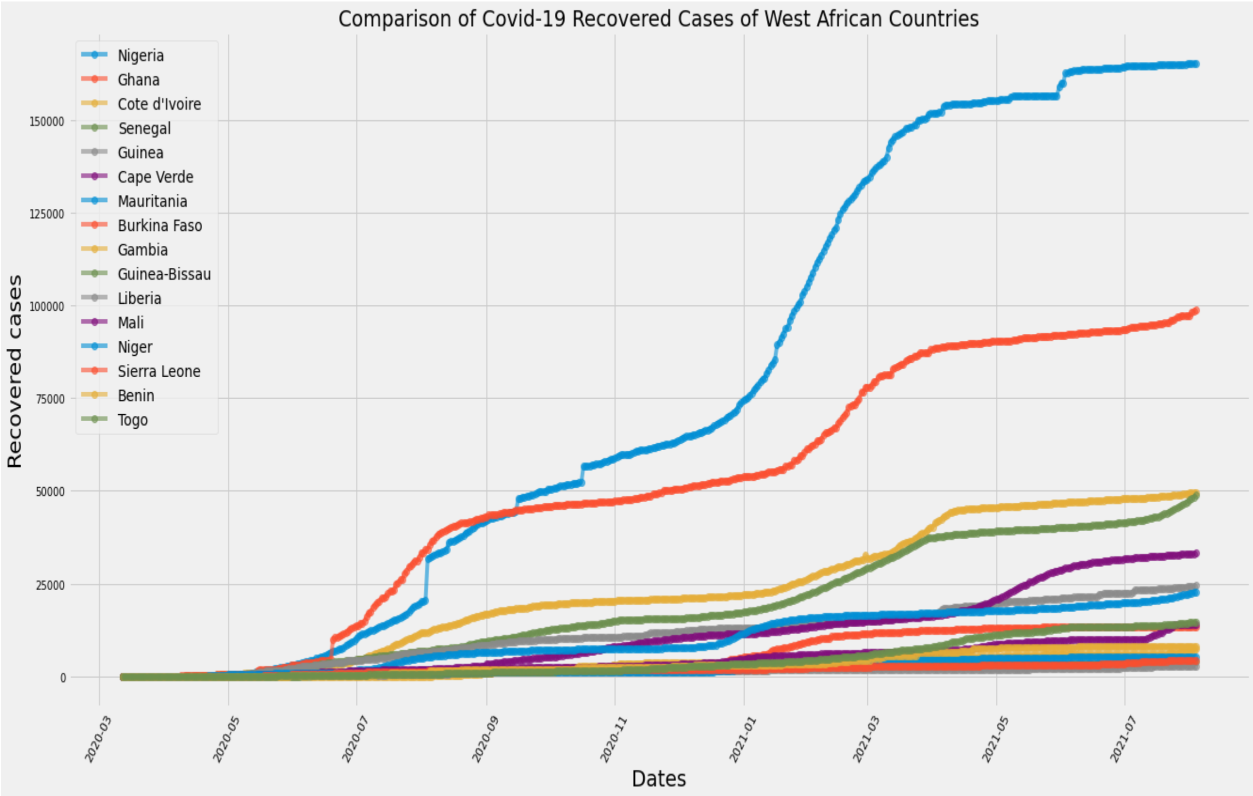

Figure 6: Covid-19 recovered cases in West African Countries

TABLE 1: THE SEVEN MOST POPULOUS COUNTRIES IN WEST AFRICA

Country	Population in 2020
Nigeria	206,139,589
Ghana	31,072,940
Cote d'Ivoire	26,378,274
Niger	24,206,644
Burkina Faso	20,903,273
Mali	20,250,833
Senegal	16,743,927

Source: Worldometers [14]

In the form of a plot graph, figure 7, figure 8, and figure 9 exhibit the accuracy of PR, SVM and NN models on test-confirmed cases data, respectively. The number of verified coronavirus infections is increasing by the day. PR is found to perform very well in this study, with an average performance of NN and an SVM performance that may be described as poor. This position is further fortified by the evaluation metrics shown in table 2.

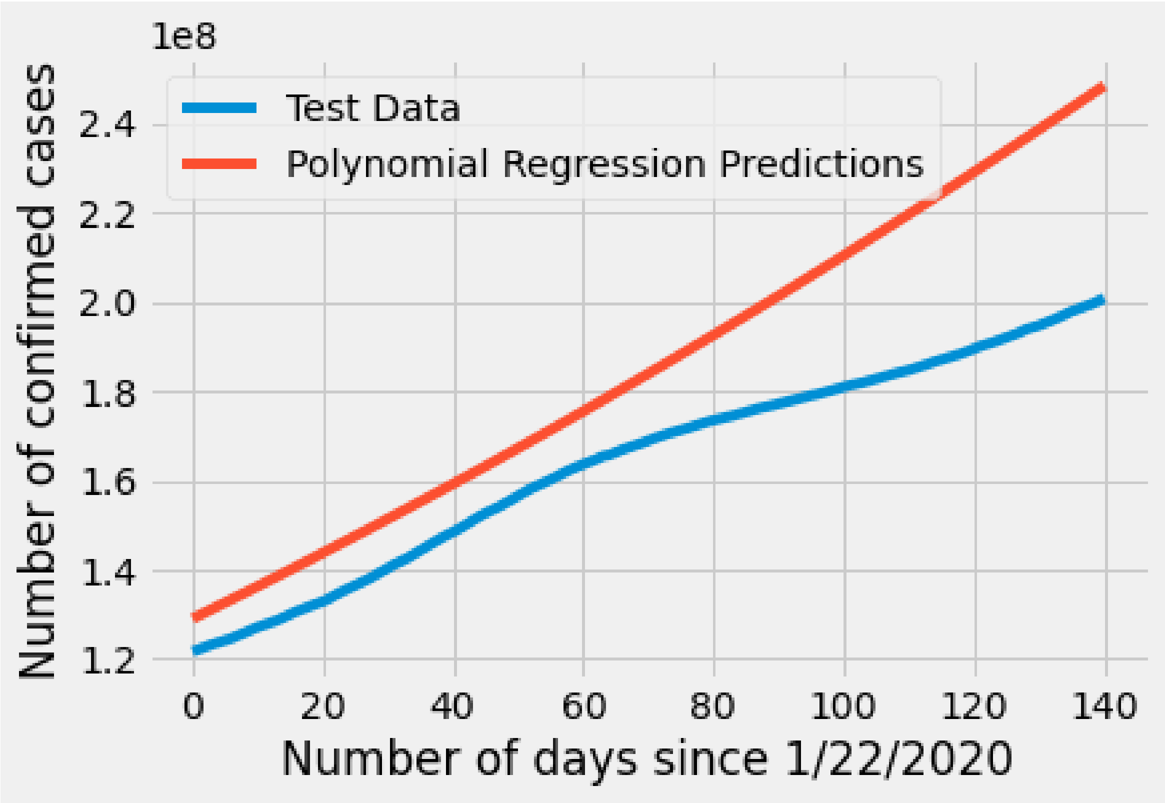

Figure 7: Prediction of confirmed cases by PR on test data

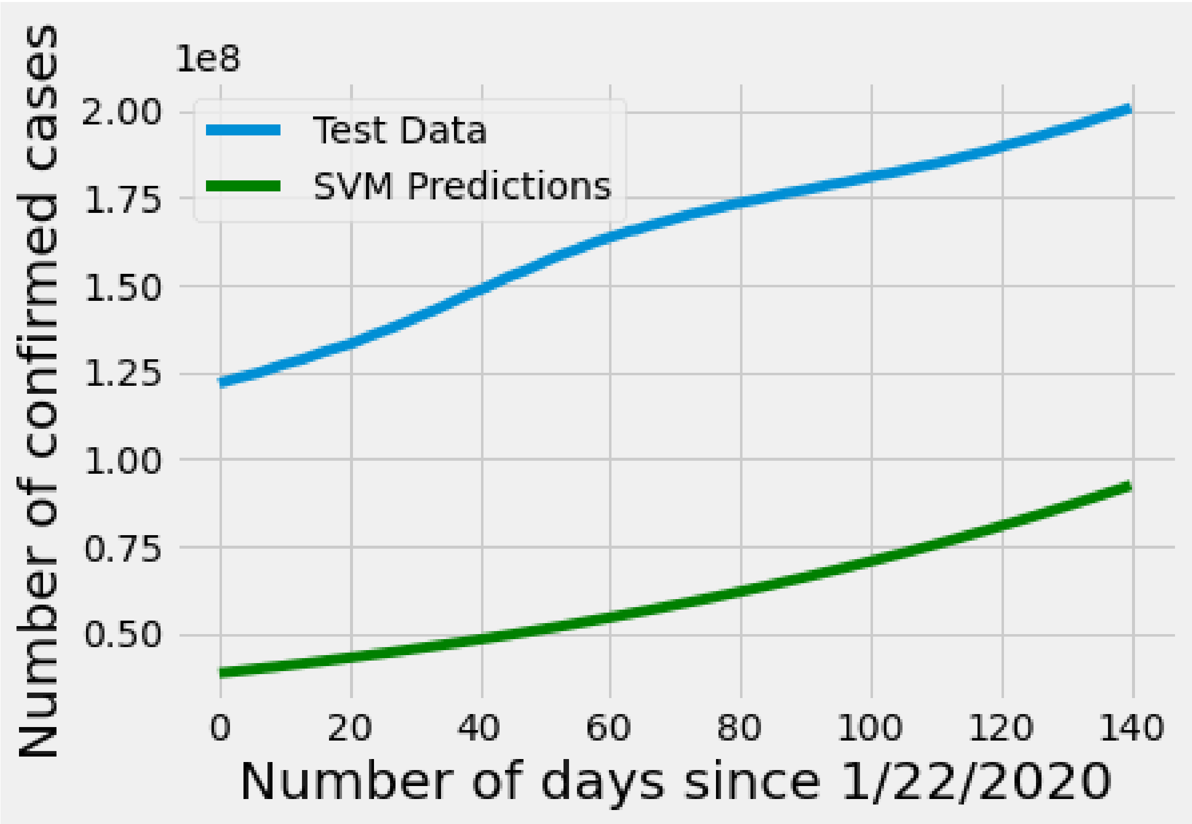

Figure 8: Prediction of confirmed cases by SVM on test data

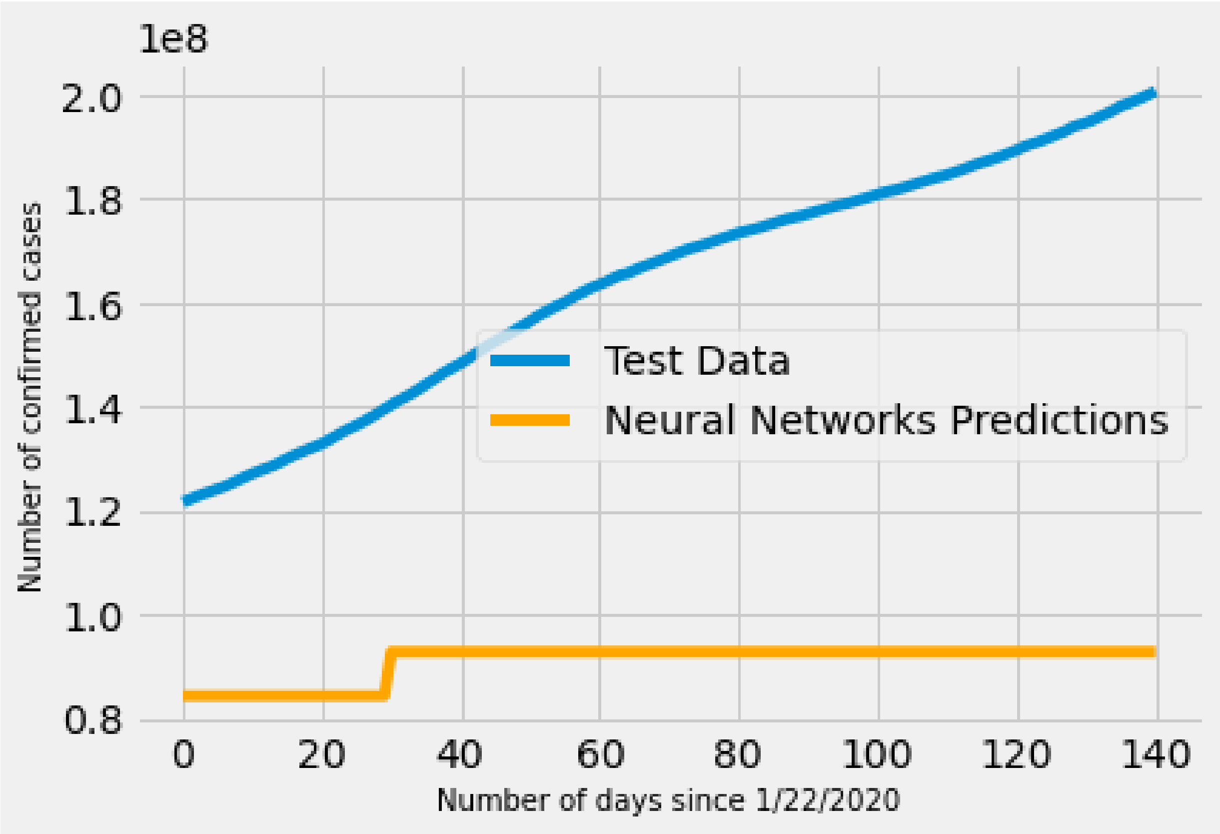

Figure 9: Prediction of confirmed cases by NN on test data

TABLE 2: PREDICTION PERFORMANCE OF VARIOUS MODEL

DATASET	MODEL	MAE (Mean Absolute Error)	MSE (Mean Square Error)
Confirmed Cases	PR	19115152.658099543	601959832009913.0
	SVM	176264386.1021695	86163893804311322.0
	NN	180118306.52400464	5769356808564965.0

The prediction pattern for the next 365 days is addressed in figure 10, figure 11, and figure 12. The pattern observed in the figures simply implies that PR prediction is more accurate than NN and SVM. Overall, PR is much better than the other two (NN and SVM) in all predictive cases.

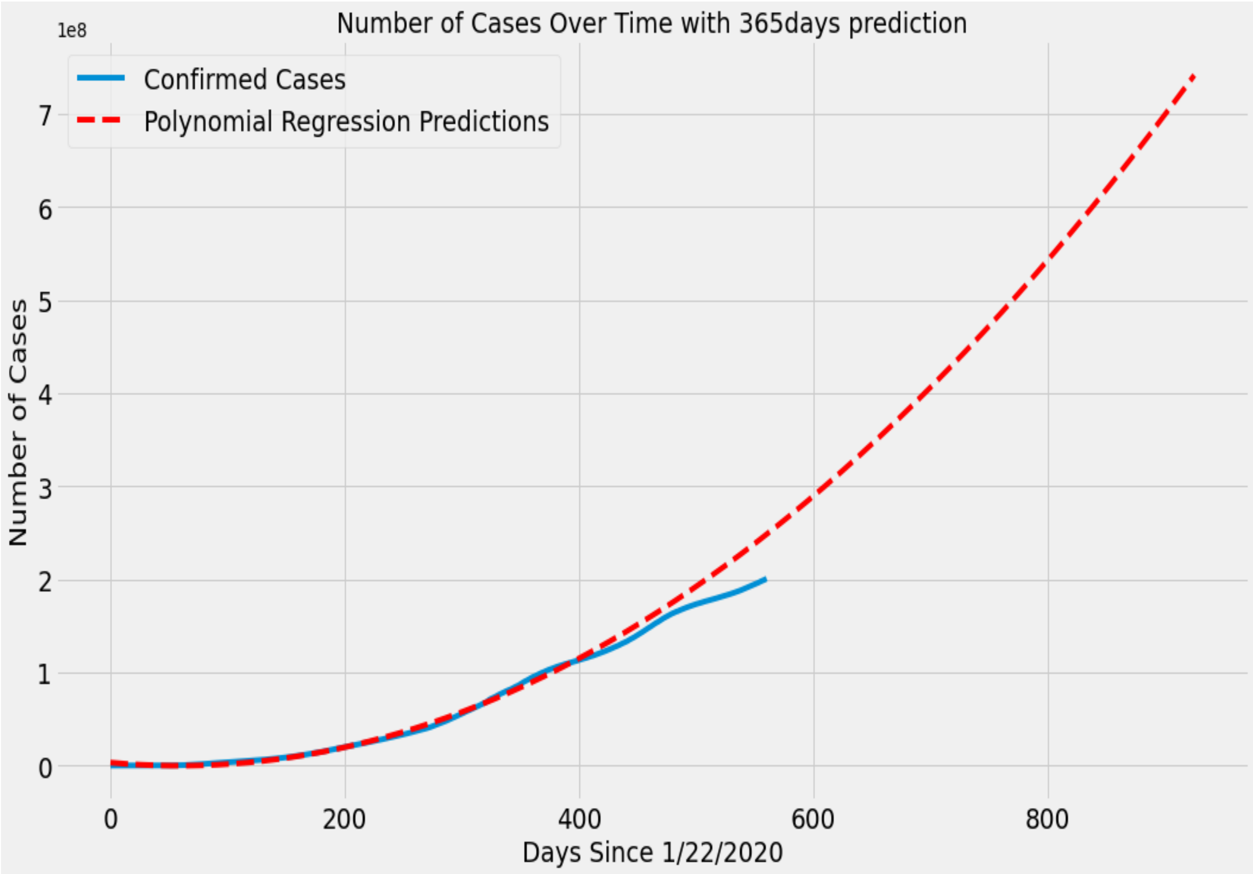

Figure 10: Prediction of confirmed cases by PR for the upcoming 365days

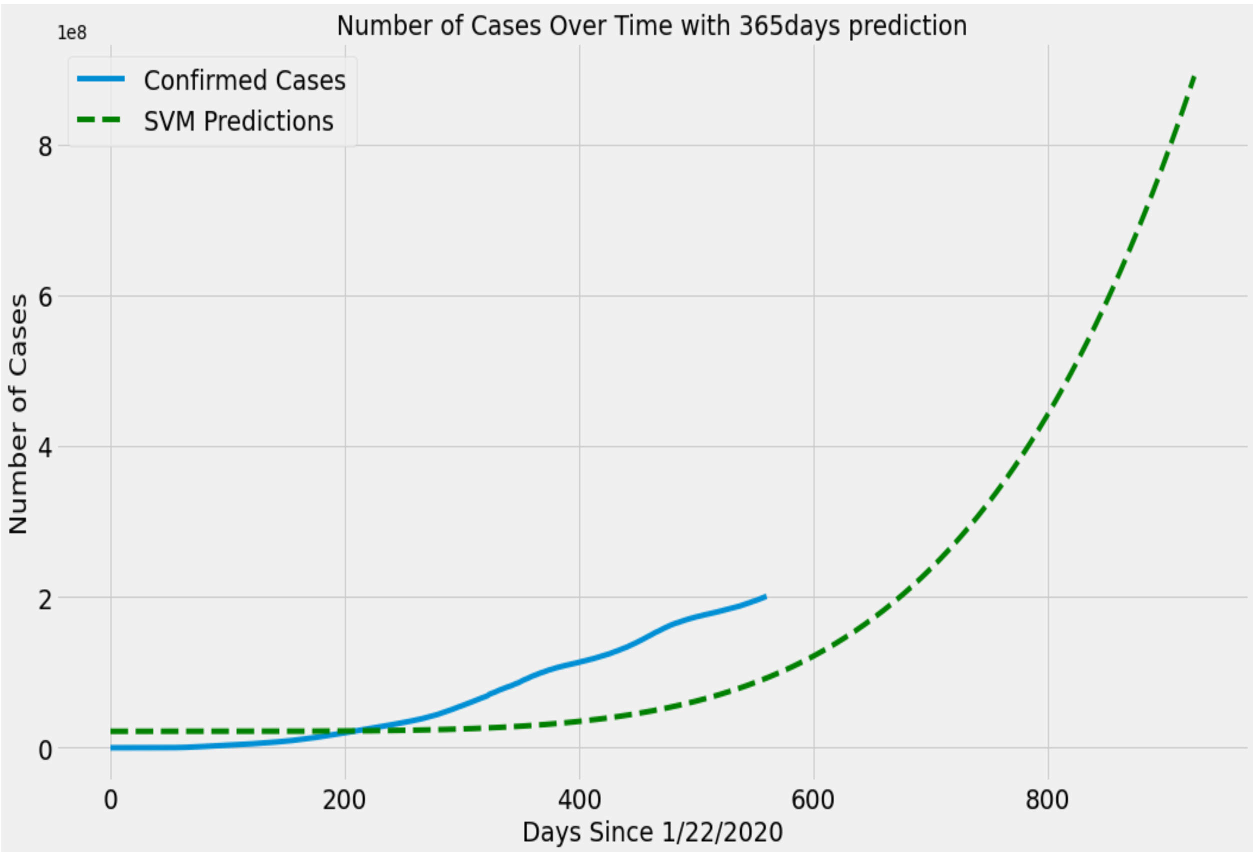

Figure 11: Prediction of confirmed cases by SVM for the upcoming 365days

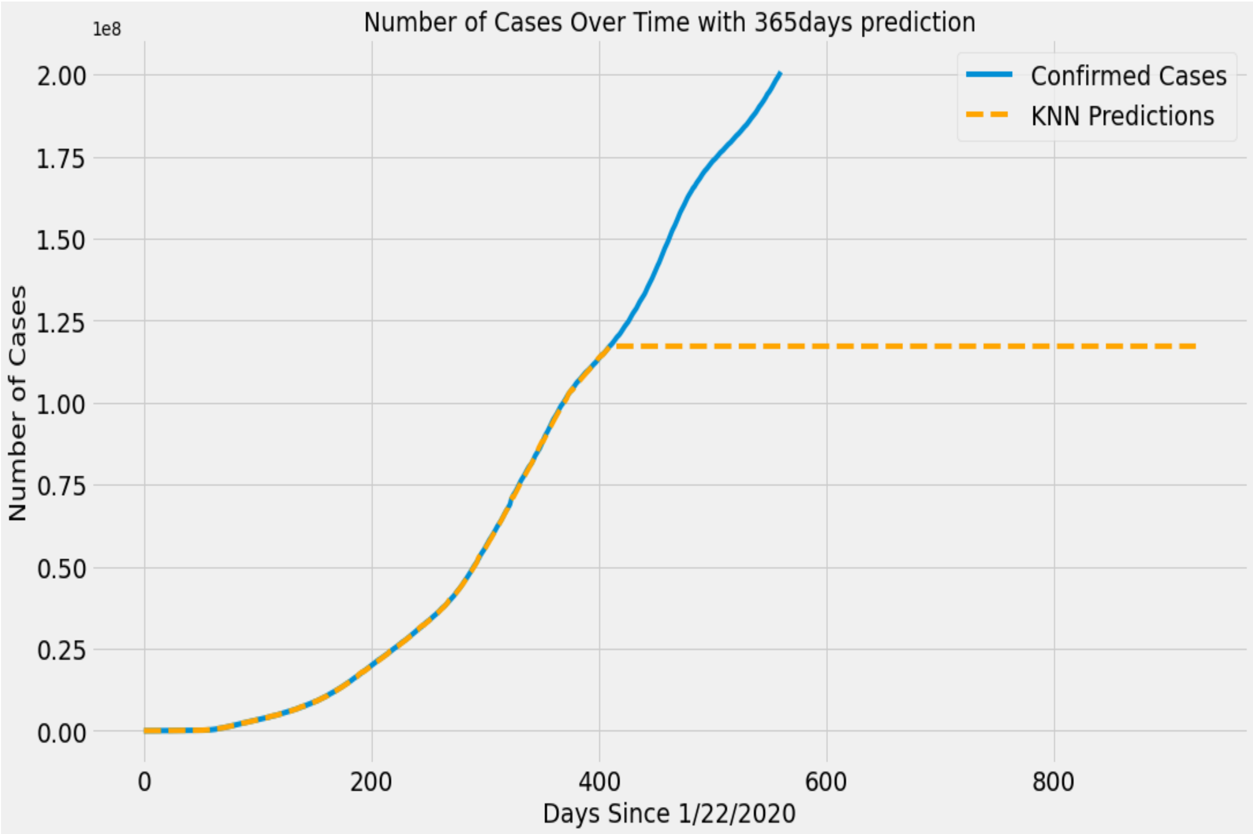

Figure 12: Prediction of confirmed cases by NN for the upcoming 365days

ML methods were employed in this study's research to forecast the risk of Covid-19 using the time series covid-19 dataset. Although infection rates are declining, the prognosis for Covid-19 is good due to global concerns because many people all over the world will be affected by the pandemic. With the use of ML algorithms, we were able to forecast the occurrence of a covid-19 outbreak. Policymakers, health experts, and governments may be able to take more inclusive and essential policies if they can predict the infection rate.

In a specific view in this study, we used SVM, NN, and PR models for the prediction of covid-19 across the 16 West African countries. Typical datasets contain a time series of daily occurrences of infections recorded and we predicted what the occurrence of infections would be in the next 365 days using PR, NN and SVM. According to the forecast model, the confirmed cases will still be on the increase over the next 365 days. We conclude that ML predictions rely on current data, so we can understand or predict the next state. It was utilized to take remedial actions by relevant bodies concerned as contingency plans for the immediate and the future ahead are strictly observed to combat the ugly scourge. For further studies, we will focus on employing the updated dataset and using some other ML models for prediction. ML algorithms that were not tested in this study may have revealed a significant pattern related to effective Covid-19 prediction.

V. CONCLUSION

The rampaging coronavirus pandemic disease has caused the entire world some problems ranging from health, social, political, economic, governance, international relations, and soon. The eruption of the disease has brought about monumental losses in virtually all spheres of human life. The study examined the causative organism coronavirus. The idea of the virus was thought of and narrowed down the peck of the SARS-CoV virus. Some notable variants of the virus were appraised before considering SARS-CoV-2 itself, which is the contributing factor to COVID-19 disease. The origin and transmission of the disease covered some of the studies related to subsequent infections that occurred.

Moreover, the ML techniques or models were highlighted with emphasis on three notable ones used in the study namely NN, PR and SVM. The datasets utilized for the study were intentionally retrieved from a genuine source to provide credibility to the work. The models are implemented appropriately with results generated in graphic form and carefully analyzed. The results of confirmed cases, deaths, and recoveries are produced for the sixteen West African countries considered for the studies. In addition, comparisons are made on Covid-19 confirmed cases among the sixteen nations as well as the deaths and recoveries cases. Thereafter, predictions on recoveries, deaths and confirmed cases are also conducted.

Studies based on the analysis performed have observed that ML models use time-series datasets to make predictions on a global scale. It is observed that the forecast for Covid-19 infections aligns with the world's assumed worries about how the pandemic is likely to cause massive devastation to mankind. Three notable ML models namely SVM, NN, and PR are employed for the study to make the predictions on the sixteen West African nations, which are expected to serve as a subset of the entire world. This option is thought of in that it will be administratively and technically feasible given the resources available for the study. According to the forecast model, observation from the result revealed that the occurrence of confirmed cases of covid-19 will still be on the rise in the next 365 days. However, ML predictions are supposed to depend on current data, so you can see what will happen next.

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Chapter - 4

Machine Learning based CMOS Readout Circuit for Advance Detection of Parkinson's Disease

Jyoti M Roogi[1], Dr.Manju Devi[2]

[1] VTU Scholar CMR Institute of Technology Bengaluru,India, CMR Institute of Technology, AECS Layout Bengaluru,
[2] The Oxford College of Engineering Bommanahalli Bengaluru, The Oxford College of Engineering Bengaluru, India,
[1]jyotimr@gmail.com, [2]manju3devi@gmail.com

Abstract— An Organic chemical called Dopamine belongs to catecholamine and phenethylamine chemical families. A neurotransmitter chemical released by neurons and is one of prime function of Dopamine in the brain. They are essential in communicating messages for all parts of the brain and between the brain and body organs. Body movement is controlled by dopamine. A lack of or an insufficient dopamine generation in part of the brain can lead to Parkinson 's Disease (PD). It is a one of neurological disorder that affects body movement. It may cause stiffness, trembling in body parts. Detection of low level dopamine is challenging and complex as the low level of dopamine is related to Parkinson's disease. In this chapter we present an approach towards early detection of this neurological disorder PD by employing CMOS readout circuit which measures and amplifies low level dopamine in the form of electrical signal from brain with help of electrodes.ADC is used to convert amplified analog signal to digital information. Machine learning algorithms are used to predict the disease based on the data received from the readout circuit. Dopamine level is measured in current which ranges from pA to nA. CMOS Amplifiers are used to strengthen the acquired signal in the range of millivolts (mV) with the help of bio amplifiers. For conversion of acquired current in the range of pA to voltage with amplitude of micro voltage (µV) CMOS front called Transimpedance amplifier (TIA) is employed. This chapter provides complete design and analysis of low noise, low power CMOS machine learning based readout circuit for detection and prediction of Parkinson's disease.

Index Terms— Dopamine, Machine learning, CMOS, readout circuit, TIA, Bio amplifier.

I. INTRODUCTION

Readout circuit is one of the vital parts in the detection of many diseases in the medical field. Employing Complementary Metal Oxide Semiconductor (CMOS) design because of its advantages low area, power and deadly. Parkinson's Disease (PD) and Alzheimer's disease are common neurological disease, mostly found in 3% of the population age greater than 60 years (Krismer, F.; Mahlknecht, P.; Poewe, W.; Seppi, K). Parkinson's disease is clinically detected using imaging modalities related to neurology like MRI, PET, and SPECT. Testing Techniques used to like image-based tests (single photon emission computed tomography (SPECT), M-iodobenzyl-guanidine cardiac scintiscan (MIBG) are costly to diagnose and facility is not easily available.

An electroencephalogram (EEG) is a test used to evaluate the electrical activity in your brain,epileptic disorders are studied and also one of los cost technique. Mainly PD is because of deficiency of one of important chemical Dopamine. It is a type of neurotransmitter. Generated in the brain and used by nervous system to send messages between nerve cells. Dopamine concentration effects the human behavior, in the abnormal behavior leads to variation in dopamine signal (Beitz, J.M :,Dickson, D.W). We present in this work detection of low level dopamine with the help of CMOS readout circuit. Fig. 1 shows block diagram of CMOS readout circuit for the advance detection of PD.Block diagram shows Transimpedance Amplifier followed by post high gain amplifier for further amplification. Analog to Digital Converter (ADC) is used to convert amplified analog voltage to digital signal. Digital signal is processed and compared with already existing data set with the help of machine learning algorithms data is analyzed for detection of PD.

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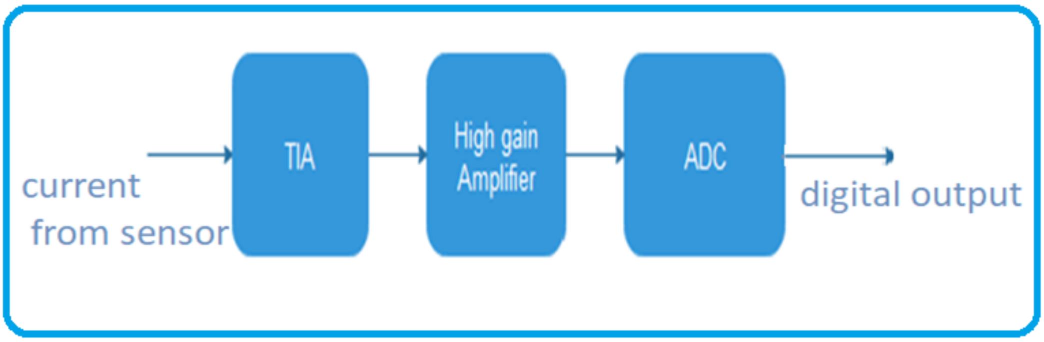


Fig.1 Block diagram of CMOS Readout Circuit

There are different types of sensors for the measurement of bio signal, among all electrochemical sensors is used widely because of its advantages. A biosensor is a circuit that converts a biological response into an electrical signal. In this work current based biosensors are considered. The electrochemical biosensors which convert analyte concentration into current or voltage. In these a signal in the form of a current is generated when biological events perturb the charge distribution of the electrode/electrolyte interface. In electrochemical cells, a charge transfer current called I_{redox}, occurs when the target molecule reduces or oxidizes on the surface of the working electrode with an applied analyte specific potential between the working and reference electrodes respectively [Feiyun Cui:, H. Susan Zhou :, Yi Zhang:,Yun Yue and Ziming Zhang]. The current amplitude of these sensors can vary in magnitude. For example, in an electrochemical biosensor the detection of neurotransmitters requires more than 120 dB of dynamic range, where from 1 nM to 1 mM the concentration of Dopamine can vary due to spontaneously spike activity or pharmacological stimulus [Feiyun Cui et all].The current will be in the range of uA to pA. These biosensing applications require a current readout front-end with a dynamic range higher than 140 dB and an input-referred current noise less than 1 pArms [A. Chaddad; , E. Kamrani;, Lesage; ,M. Sawan]. The sensor response is converted to an electric signal and amplified by an electronic front-end CMOS circuit called Transimpedance Amplifier.TIA is one of the important front design for low current measurement application. It is used in much application like communication modules; photonic system which uses photo diode is a one of the source of input.

II. CURRENT MEASUREMENT FRONT-ENDS FOR BIOSENSING APPLICATIONS

CMOS readout circuit consists of current measuring front end followed by post amplifier. For the further process ADC is used for digital interface to apply machine learning algorithm to detect the PD. Many biosensors provide a current signal during the detection of target molecules or proteins, and this current signal is captured by a signal amplifier for further signal processing. The most critical current signals in biosensing applications typically range from sub-pA to more than a few µA within some kHz bandwidth. Thus, the amplifier requires a more dynamic range more than 140dB, and very low input-referred noise of the value tens to hundreds of fA in the kHz bandwidth [Brian Goldstein;,Dongsoo Kim;, Fred J; , Eugenio Culurciello :, Sigworth and Wei Tang] In addition, the input impedance of the signal amplifier should be low compared to the sensor's output impedance to avoid attenuation. To design an amplifier and analyze the effect of the noise, a current input biosensor can be modeled as a current source. The conventional implementations of these are a current conveyor (CC) and a transimpedance amplifier (TIA), respectively [Chuah and David Holburn ;,Joon Huang]. The signals after amplification can be filtered and then quantized into a discrete-time digital signal by an ADC for further analysis. Although the amplifier and the ADC can be designed separately, a current-input ADC provides a lower noise, higher linearity, and lower power consumption when the ADC is designed to amplify and quantize the input signal at the same time. For example, a current-input ΔΣ modulator (DSM) uses global feedback to improve the linearity as well as reduce power consumption. An oscillator-based ADC is another example that provides signal amplification from current to time domain and quantizes this time information efficiently in a mostly digital way. CMOS integrated circuit miniaturization shrink complex current-sensing architectures into silicon chips and offer a unique opportunity to co integrate biosensors directly with the readout circuit. The integration of the sensor and amplifier provides a lower noise due to a reduction in interconnection capacitances. This enables biosensing and point-of-care applications and arranges high, density compact arrays for high throughput applications. For conversion of sensor current to voltage for further processing a circuit called Transimpedance Amplifier is used. Fig. 2 shows a schematic of a resistive feedback TIA (R-TIA). The gain of the R-TIA is determined by the feedback resistor where the output voltage vo is feedback resistor times input current. The noise from the feedback component 4kT/Rf,

The feedback resistor generates noise in addition to the noise from the amplifier, so the noise from Rf should be minimized. For example, Rf should be larger than 165 MΩ to obtain a current noise density less than 10 fA/√Hz. An additional shunt capacitor CBW can be used to reduce the total noise by controlling both the bandwidth of the R-TIA and the wideband white noise. This CBW can also stabilize the amplifier when the parasitic capacitances from RF and the inverting input node of the amplifier affects the stability of an R-TIA. Therefore, the minimum detectable signal of R-TIA can be determined and is usually limited by the extra noise from the feedback resistor in a well-designed low noise amplifier [Ibrahim and Peter M;, Levine Mark M. R].

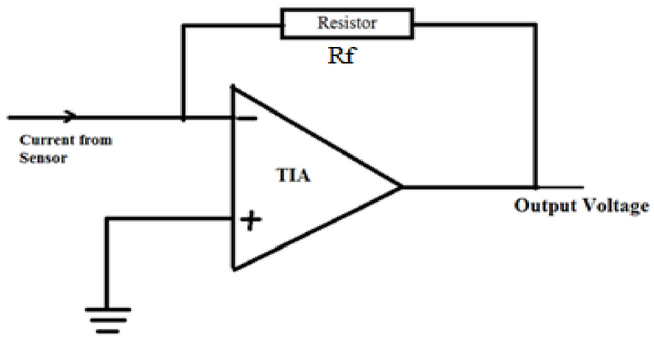


Fig. 2 schematic of a resistive feedback TIA (R-TIA)

2.1 Design of Two Stage Inverter Based Transimpedance Amplifier

For the conversion from sensor current to voltage in this work we employed inverter based TIA. Cadence virtuoso is used for the simulation of Transimpedance amplifier. Figures 3 and 4 shows schematic diagrams of Inverter based TIA whereas Fig.5 show transient analysis of TIA.

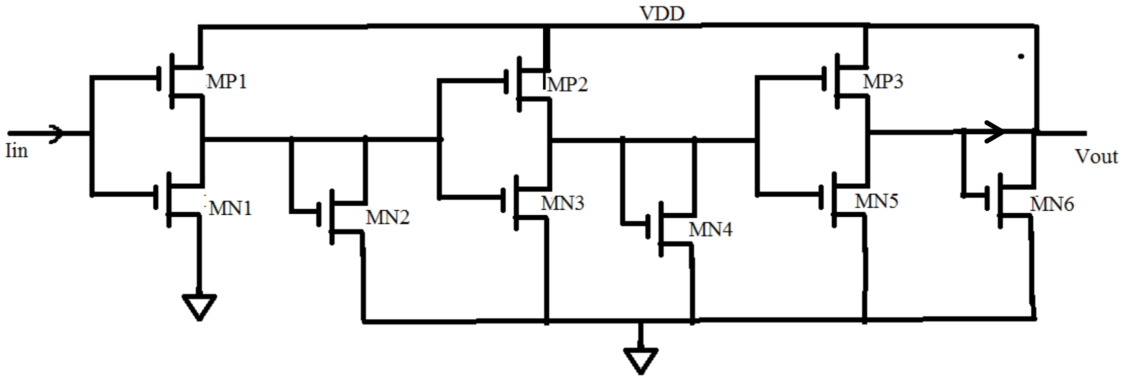


Fig. 3 Schematic of an Inverter based TIA

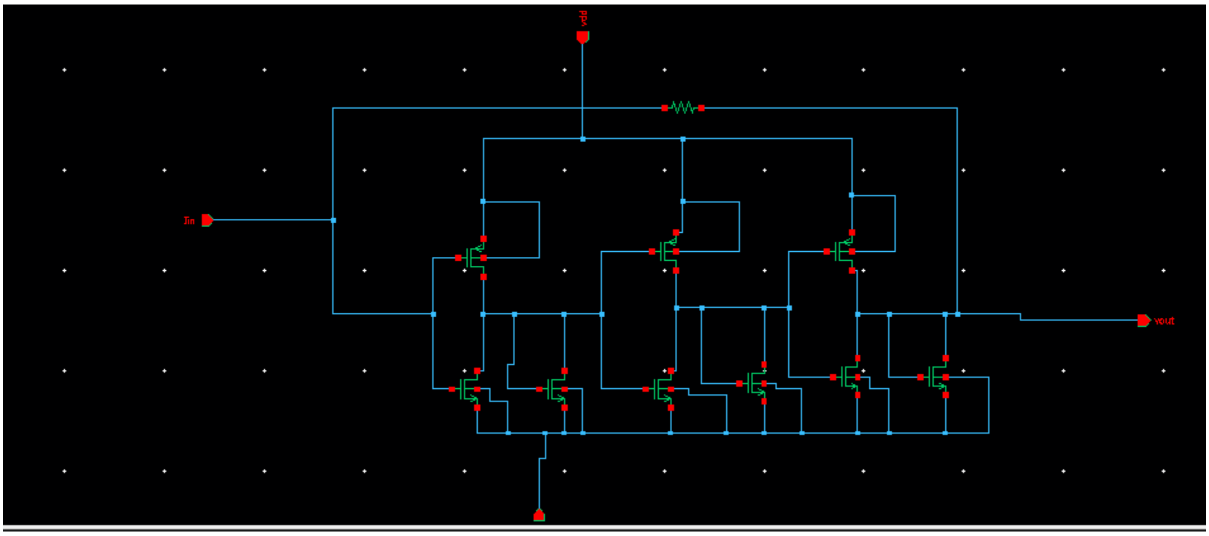


Fig. 4 Schematic of a Inverter based TIA

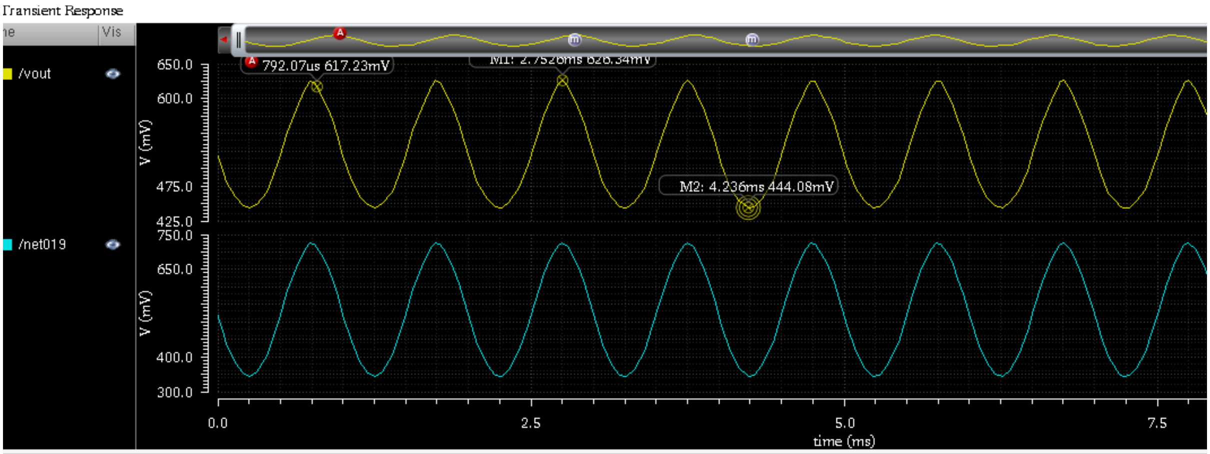


Fig. 5 Transient analysis of Inverter based TIA

III. DESIGN OF FOLDED CASCODE OPERATIONAL AMPLIFER

For the design post amplifier for the amplification of sensor signal is performed with CMOS folded cascade Operational amplifier. Amplifier stage is required for the amplification of low amplitude signal which is generating from transimpedance amplifier (TIA) in turn TIA is interfaced with sensor. The design of two-stage Op-Amp is done by using different specifications to scale each device to find the transconductance as well as W/L ratio of each device [Allen, P. E.;, Baker, J.;, Gray, P. R.;, Holberg D. R]. Circuit diagram for the design is as shown in the Fig. 6 below.

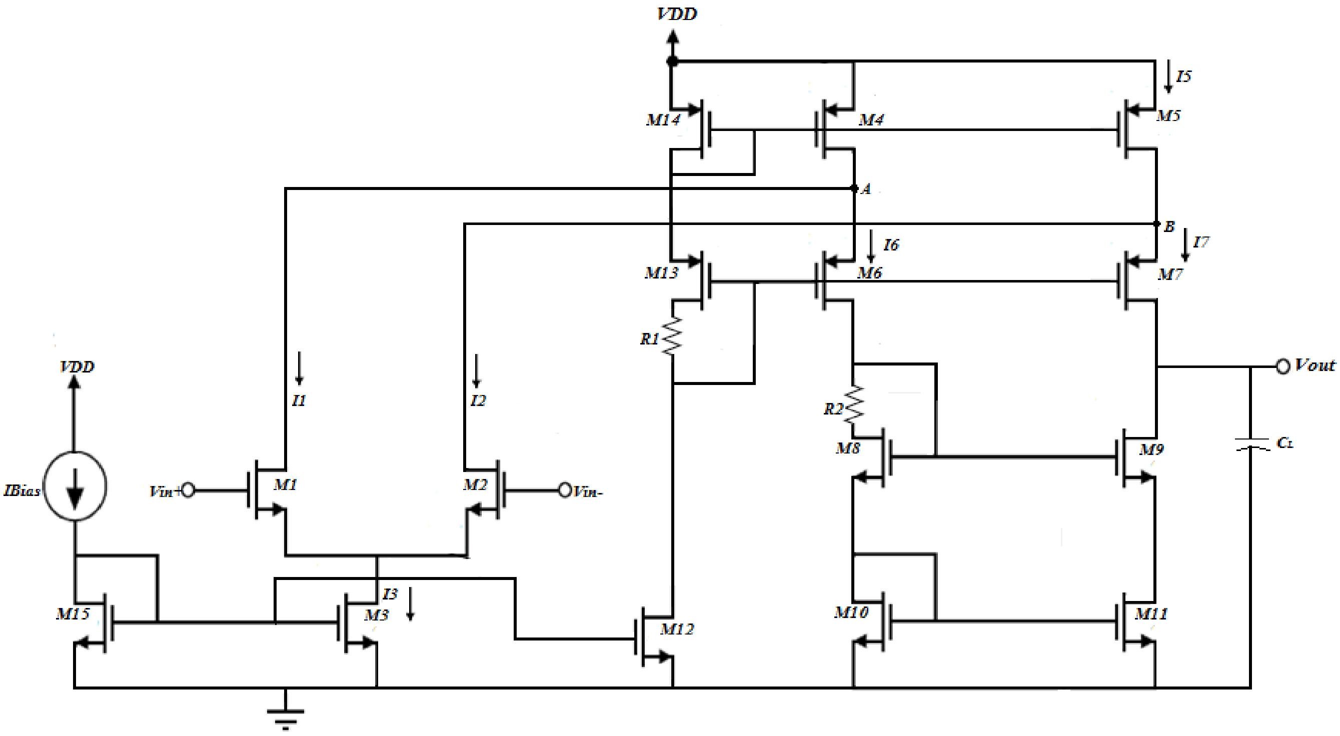


Fig. 6 Folded Cascode Op-amp using MOS load and current mirror

From the circuit diagram of folded cascode op-amp we need to calculate W/L ratio of all the MOS devices which shall provide a gain greater than 80 dB for high performance applications. Design specifications for Folded Cascode amplifier are given in the Table 1.

Table 1 Design Specification

Parameter	Value
Slew Rate	≥ 10 V/μs
P_{diss}	≤ 5 *mW*
C_L	10 *pf*
Small signal gain, A_v	≥ 15000 V/V
GB	≥ 10 MHz

$ICMR_{min}$	-0.6V
$ICMR_{max}$	1.6V
Vout Range	±2 V

Table 2 specifies the different process parameters required to design Folded Cascode amplifier for 180 nm technology. These parameters are required for hand calculations.

Table 2 Process parameters

Parameter	**Value**
$V_{DD} = -V_{SS}$	1.8 V
$\lambda_n = \lambda_p$	0.1 V^{-1}
V_{TN}	0.43 V
V_{TP}	-0.38 V
$\mu_n C_{ox}$	300 $\mu A/V^2$
$\mu_p C_{ox}$	100 $\mu A/V^2$

2.1 **Folded Cascode Op-Amp Design Procedure**

Circuit design for Two-Stage Op-Amp to satisfy different parameters is as below. Design procedure for the folded cascode amplifier includes the following steps.

Step 1: "Using Slew rate calculate the maximum tail current I_3"

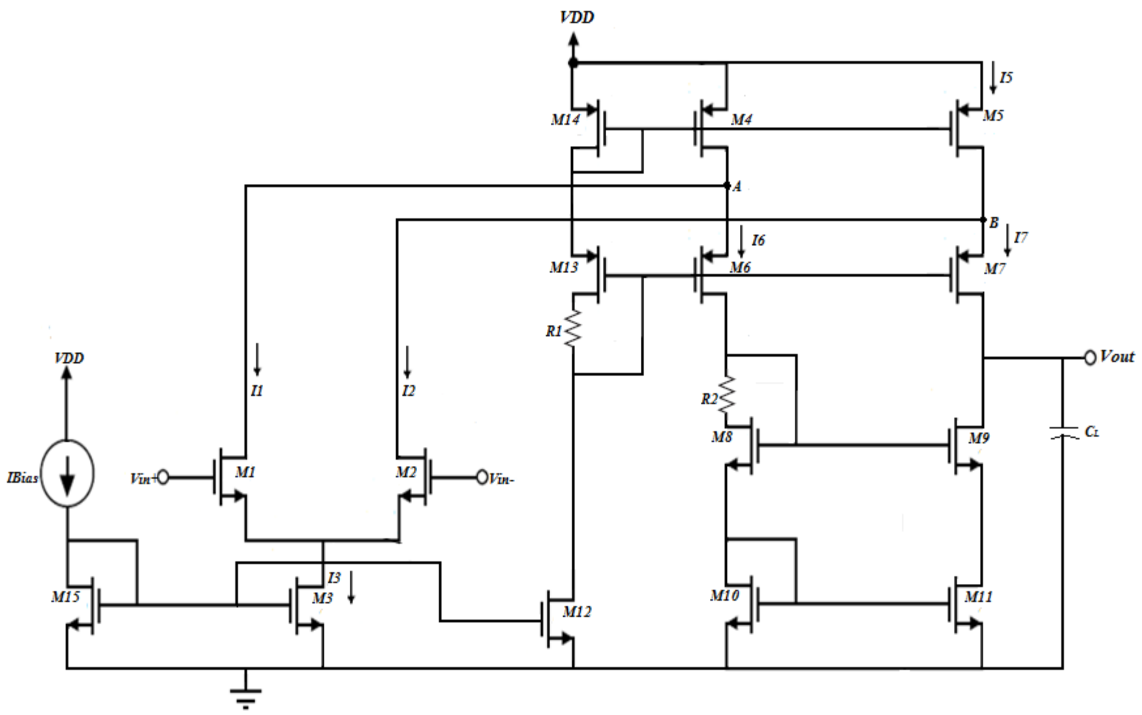


Fig. 7 Folded cascode Op-amp using MOS current mirror

Using equation for slew rate for the tail current and the load capacitor as shown below, we can get the value of tail current I_3.

$$\text{Slew Rate} = \frac{I_3}{C_L} = \frac{I_{SS}}{C_L} \qquad (1)$$

With slew rate = 10 V/μS and C_L = 10*pf*, we get

$$\therefore I_3 = 100\ \mu A \qquad (2)$$

$$\because I_1 + I_2 = I_3 \qquad (3)$$

This gives I_1=I_2=50 μA, i.e. current through M1 and M2 transistors will be equal since they form a differential pair. In all the equations, S is the value of (W/L) of each transistor.

Step 2: "In the output cascade Bias currents are assumed"

In the design of amplifier bias currents are assumed.

$I_4 = I_5 = 1.2 \text{ X } I_3$ (4)

Hence we take $I_4 = I_5 = 125\ \mu A$

Step 3: "Using maximum output voltage, calculate saturation voltage of M_5 or M_7 to calculate S_4, S_5 and S_{14}"

For this we should find the saturation voltage which is required to calculate S_4 and S_5.Saturation voltage can be calculated by the following equation;

$$V_{DS5}(sat) = V_{DS7}(sat) = \frac{V_{DD} - V_{out}(max)}{2} \quad (5)$$

Constant values are $V_{DD} = 1.8V$ and $V_{out}(min) = 1.6\text{V}$, we get

$$V_{DS5}(sat) = V_{DS7}(sat) = 0.1V \quad (6)$$

Now to calculate S_4, S_{14} and S_5 we have to use the following equation;

$$S_4 = S_5 = S_{14} = \frac{8 \times I_5}{K_P{}' {V_{SD5}}^2} \quad (7)$$

Substituting for I5, $K_P{}'$ and V_{SD5}, we get

$$S_4 = S_5 = S_{14} = \frac{2 \times 125\mu}{100\mu \times 0.1^2} \quad (8)$$

$$\therefore S_4 = S_5 = S_{14} = 250 \quad (9)$$

Again to calculate S_6, S_7 and S_{13} we have to use the following equation;

$$S_6 = S_7 = S_{13} = \frac{8 \times I_7}{K_P{}' {V_{SD7}}^2} \quad (10)$$

Substituting the values we get

$$S_6 = S_7 = S_{13} = 250 \quad (11)$$

Step 4: "Using minimum output voltage, calculate saturation voltage of M_9 or M_{11} to calculate S_4, S_5 and S_{14}"

Here, the value of $V_{DS9}(sat) = V_{DS11}(sat)$ equals 0.1V with the minimum output voltage of -1.6V and supply voltage of 1.8V and is given by the following equation;

$$V_{DS9}(sat) = V_{DS11}(sat) = \frac{V_{out}(min) - |\, V_{SS}|}{2} \quad (12)$$

With this we get,

$$S_8 = S_9 = \frac{2 \times I_9}{K_P{}' {V_{SD9}}^2} \quad (13)$$

And,

$$S_{10} = S_{11} = \frac{8 \times I_{11}}{K_P{}' {V_{SD11}}^2} \quad (14)$$

Therefore substituting all the values we get,

$$S_8 = S_9 = S_{10} = S_{11} = 83.33 \quad (15)$$

Step 5: "Self Bias cascode"

To get the proper biasing of the circuit we need to use the biasing resistors R_1 and R_2. To find the values of R_1 and R_2 we need to use the saturation voltages of transistors M_{14} and M_6 respectively. This can be achieved by using the following equation[Sedra, A. S;, Smith, K. C].

Where, $R_1 = \frac{V_{SD14}(sat)}{I_{14}}$ and $R_2 = \frac{V_{SD6}(sat)}{I_6}$ (16)

Since we know, $V_{SD14}(sat) = V_{SD6}(sat) = 0.1V$ and $I_{14} = I_6 = 125\mu A$, we get

$$R_1 = R_2 = 800\,\Omega \quad (17)$$

Step 6: "Using Gain Bandwidth, calculate S_1 and S_2"

The value of GB is used to calculate S1 and S2 and is given by the equation below;

$$S_1 = S_2 = \frac{GB^2 \times {C_L}^2}{K_N{}' \times I_3} \quad (18)$$

With GB = 10 MHz,$K_N{}' = 300\ \mu\text{A/V}^2$, $C_L = 10\,pf$ and $I_3 = 100\mu A$, we get

$$S_1 = S_2 = 13.159 \quad (19)$$

Step 7: "Minimum input common mode voltage to calculate S_3"

The minimum input common mode voltage gives S_3 as

$$S_3 = \frac{2 \times I_3}{K_N{}'\left[V_{in}(min) - V_{SS} - \sqrt{\frac{I_3}{K_N{}' \times S_1}} - V_{T1}\right]^2} \quad (20)$$

Substituting,$K_N{}' = 300\ \mu\text{A/V}^2$, $I_3 = 100\mu A$, $V_{SS} = -1.8\,V$, $V_{in}(min) = -0.6\,V$ and$V_{T1} = 0.43\,V$, we get

$$S_3 = 2.119 \quad (21)$$

Step 8: "Maximum input common mode voltage to calculate S_4 and S_5"

The maximum input common mode voltage requires

$$S_4 = S_5 \geq \frac{2 \times I_4}{K_P{}'[V_{DD} - V_{in}(max) + V_{T1}]^2} \quad (22)$$

Using,$K_P{}' = 100\ \mu\text{A/V}^2$, $I_3 = 125\ \mu A$, $V_{DD} = 1.8\,V$, $V_{in}(max) = 1.6\,V$ and $V_{T1} = 0.43\,V$, we get

$$S_4 = S_5 = 6.29 \tag{23}$$

This is less than 250; with $S_4 = S_5 = 250$ we can find the value of S_{12} and is given by

$$S_{12} = \frac{I_{12}}{I_3} \times S_3 \tag{24}$$

$$S_{12} = \frac{125}{100} \times 2.119 \tag{25}$$

$$\therefore S_{12} = 2.648 \tag{26}$$

Step 9: "In this step gain of the amplifier is calculated."

To calculate the small signal gain of the amplifier it is required to calculate the following values:

$$A_V = \frac{(2+K)}{2 \times (1+K)} \times g_m \times R_1 \tag{27}$$

With all transistors W/L ratios will find g_m and g_{ds} of all the transistors, and is given as follows:

With S_4, S_5, S_{13}, S_{14}:

$$g_m = \sqrt{2 \times K_P' \times S_4 \times I_4} = \sqrt{2 \times 100\mu \times 250 \times 125\mu} \tag{28}$$

$$\therefore g_m = 2.5\ mS \tag{29}$$

And

$$g_{ds} = 125\mu \times 0.05 = 6.25\ \mu S \tag{30}$$

Similarly, S_6 and S_7 give,

$$g_m = \sqrt{2 \times 100\mu \times 250 \times 75\mu} \tag{31}$$

$$\therefore g_m = 1.936\ mS \tag{32}$$

And

$$g_{ds} = 75\mu \times 0.05 = 3.75\ \mu S \tag{33}$$

Again, S_8, S_9, S_{10}, S_{11} give:

$$g_m = \sqrt{2 \times 300\mu \times 83.33 \times 75\mu} \tag{34}$$

$$\therefore g_m = 1.936\ mS \tag{35}$$

And

$$g_{ds} = 75\mu \times 0.04 = 3\ \mu S \tag{36}$$

Finally, S1 and S2 give:

$$g_m = \sqrt{2 \times 300\mu \times 13.159 \times 50\mu} \tag{37}$$

$$\therefore g_m = 628.30\ \mu S \tag{38}$$

And

$$g_{ds} = 50\mu \times 0.04 = 2\ \mu S \tag{39}$$

Now, to get the values of the resistors we have;

$$R_9 = g_{m9} \times r_{ds9} \times r_{ds11} \tag{40}$$

$$R_9 = g_{m9} \times \frac{1}{g_{ds9}} \times \frac{1}{g_{ds11}} \tag{41}$$

$$R_9 = 1.936m \times \frac{1}{3\mu} \times \frac{1}{3\mu} \tag{42}$$

$$\therefore R_9 = 215\ M\Omega \tag{43}$$

And R_{11} is given by

$$R_{11} = R_9 \parallel (g_{m9}) \times (r_{ds7}) \times (r_{ds1} \parallel r_{ds4}) \tag{44}$$

$$R_{11} = 215\ M \parallel (1.93\ m) \times \left(\frac{1}{3.75\ \mu}\right) \times \left(\frac{1}{2\ \mu} \parallel \frac{1}{6.25\mu}\right) \tag{45}$$

$$\therefore R_{11} = 48.46\ M\Omega \tag{46}$$

Now the value of K is found by using the following equation:

$$K = \frac{R_9(g_{ds2} + g_{ds4})}{g_{m7} r_{ds7}} \tag{47}$$

$$K = \frac{215\ M(2\ \mu + 6.25\ \mu)}{1.936\ m \times \frac{1}{3.75\ \mu}} \tag{48}$$

$$\therefore K = 3.4374 \tag{49}$$

Hence small signal gain of the amplifier is;

$$A_V = \frac{(2+3.4374)}{2 \times (1+3.4374)} \times 628.3\ \mu \times 48.46\ M \tag{50}$$

$$A_V = 18654.48\,V/V = 85.41\text{dB} \quad (51)$$

Step 10: “Total power dissipation of the amplifier”

Total power dissipation is given by:

$$P_{diss} = (V_{DD} - V_{SS})(I_3 + I_{12} + I_{10} + I_{11}) \quad (52)$$

$$P_{diss} = (3.6)(100\mu + 125\mu + 75\mu + 75\mu) \quad (53)$$

$$P_{diss} = 1.35\,mW \quad (54)$$

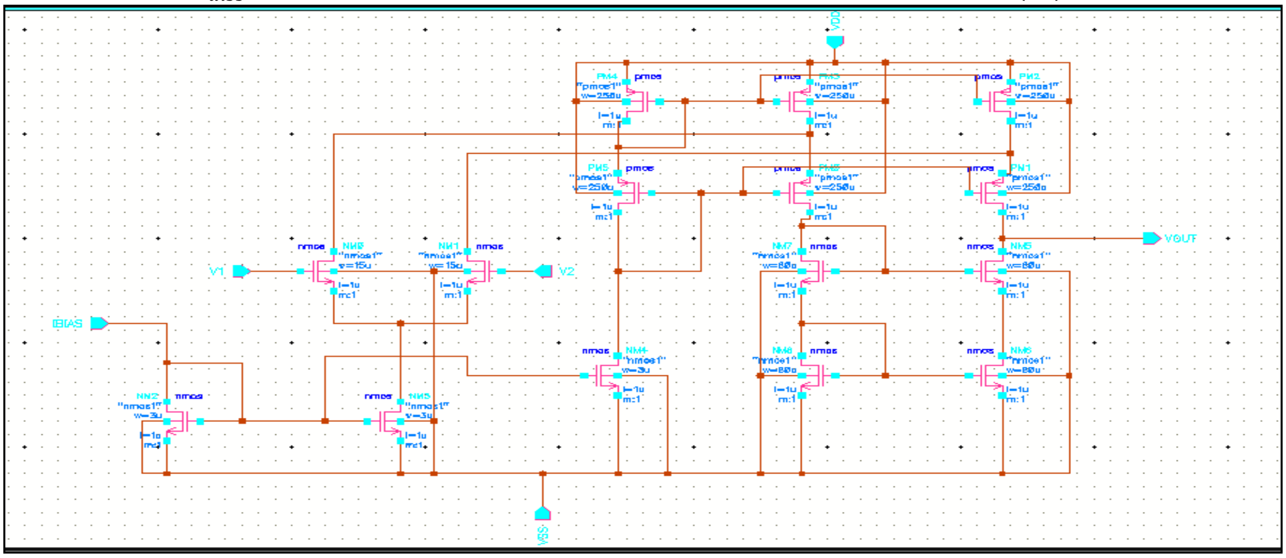


Fig. 8 Folded Cascode Op-amp circuit schematic

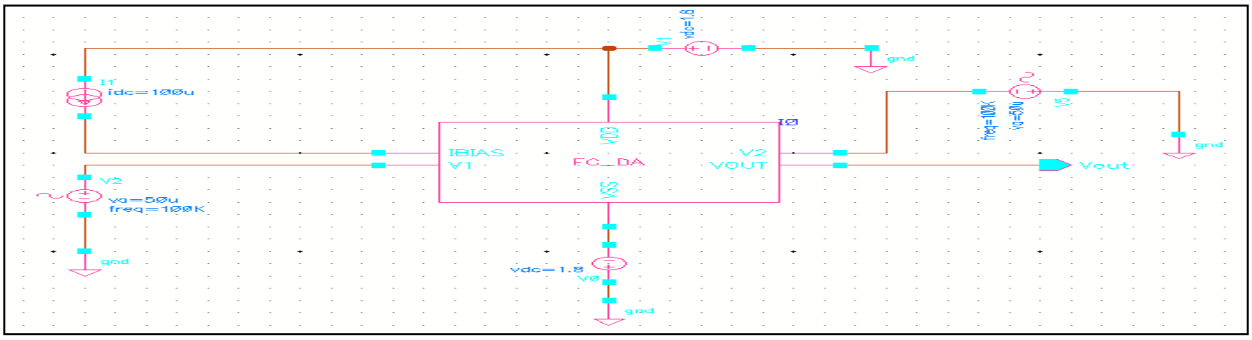
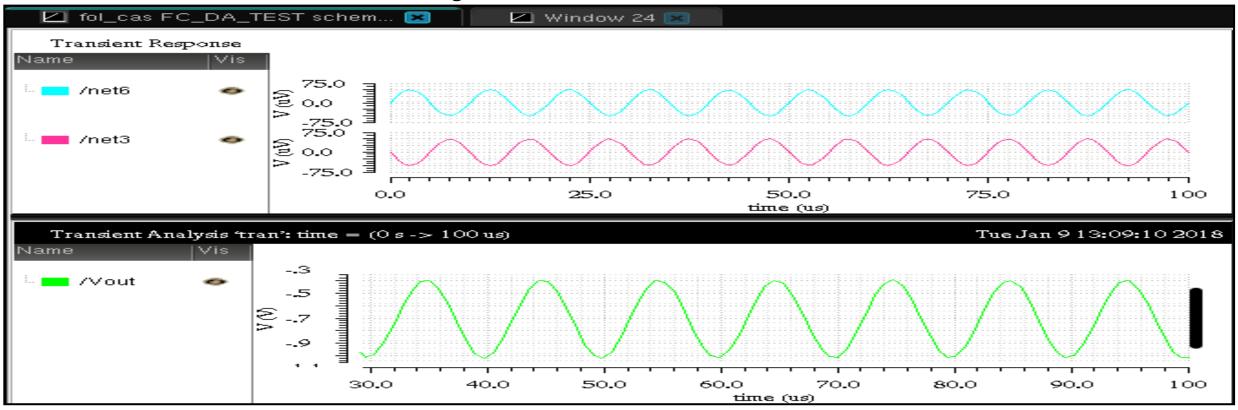
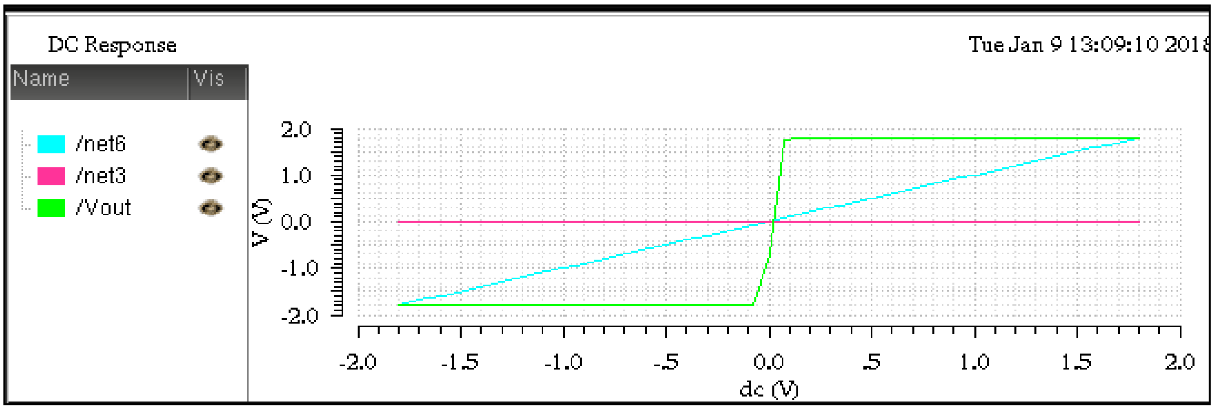


Fig. 9 Folded cascode circuit test schematic



A)



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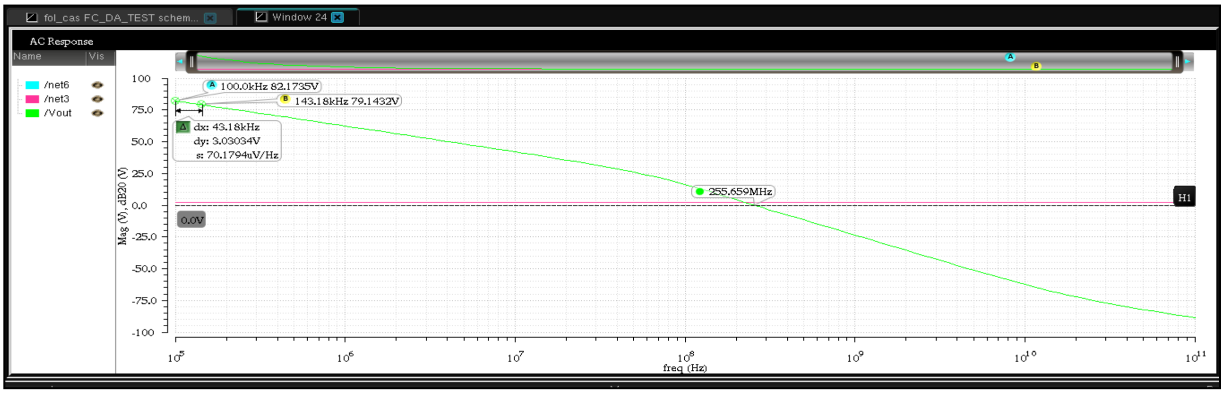

C)

Fig. 10 Simulation Output of folded cascode Op-amp; A) Transient response, B) DC response, C) AC response,

Table 3 Folded cascode amplifier comparison parameters

parameters	**Folded cascode op-amp**
Gain (dB)	82.1735
Power (mW)	0.933
Gain-Bandwidth (MHz)	255.656

Fig 8,9 shows schematic of folded cascade amplifier schematic and test bench for the analysis, whereas Fig.10 shows different folded cascade amplifier analysis.Table 3 shows the results obtained from folded cascaded amplifier which shows approximate gain of 82dB and also shows marginal power of 0.933 mW, compared to two stage amplifier its more because of more number of transistors.

After amplifying the signal from sensor, the data has to be converted in to digital signal using ADC. In this work 8bit ADC is considered for the conversion. The converted data is mapped to remove noise and stored in the form of matrix for the further process.

IV. MACHINE LEARNING ALGORITHMS FOR ADVANCE DETECTION OF PD

Electrochemical sensors are considered in this work and also sensor output is in the form of analog signal. To apply machine learning algorithms analog data is converted into digital and represented in matrix form for the feature extraction. The literature survey shows different types of machine learning algorithms are applied for detection of PD from an image and from many other sources. In this work electrical detection is used. Data sets for electrochemical sensors are in incept stage. Sensing data is complex and represented in matrix. Noise is one of the unavoidable parts of sensing signal but level of noise should be reduced for further processing. One way of reduce noise is to train the ML model which extracts noise free signal from sensing data. ML only will help effectively developing the patterns for better interpretation of sensing data. [Feiyun Cui, Yun Yue, Yi Zhang, Ziming Zhang, and H. Susan Zhou]. Using appropriate ML algorithms possibility of getting comparative results from sensor data as data is noisy and low resolution. ML analysis gives co-relations between parameters and sensing data with optimized data visualization techniques, further ML can be applied for the analysis of raw sensing data [Ayodele T. O].

Important concepts of machine learning include supervised learning in which set of predefined label are used along with the data input. First algorithm extracts best parameter to predict mentioned labels on test data. Second one is unsupervised learning, in this type predefined labels are not used algorithm itself will find best parameter. One more methods which is usually used for complex set like neuron behavior. Convolutional Neural Network (CNN) is one specific form of ANN. These are designed for image based detection like tracking, object detection and also video classification. For many supervised learning classification one of the specific algorithm called Support Vector Machine (SVM) is used. In this type of algorithm N-dimensions set are given as input [Dasgupta, A.; Nath]. To apply machine learning algorithm trained data set is very important, as more number of data set more accurate is the algorithm and also labels for data set plays very important role. There are different biosensing technique are used for the detection of analyte like microscopic method, optical flow cyclometery and electrical detection. As per our work is concerned its electrical method. As we know in electrical method data is in the form of impedance, voltage or current in turn this data is converted into digital for application of machine learning algorithm. [Massah, J.; Asefpour Vakilian, K].

For this work machine learning algorithms for electrical detection we have to use. Following procedure is followed for the analysis of Parkinson disease.

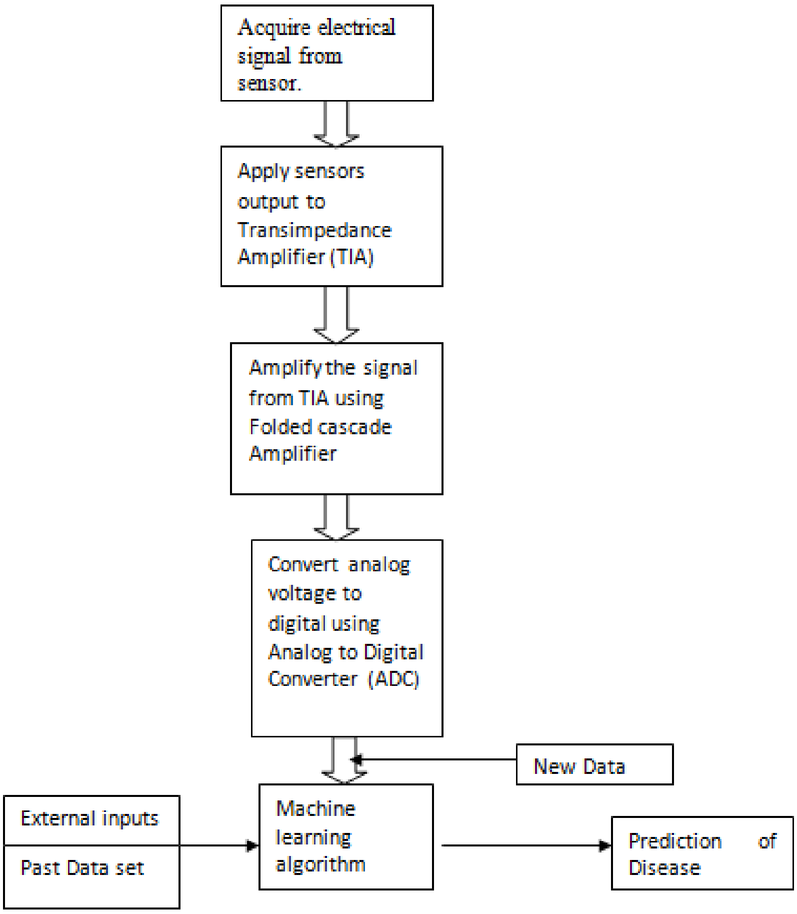

Fig. 11 Flow diagram for the conversion and prediction process

Fig. 11 shows flow diagram for the acquisition of sensor data and conversion from analog to digital. This digital is mapped and stored in after removal of noise. Applying appropriate machine learning algorithm Parkinson's disease can be predicted.

V. CONCLUSION

In this work we present a CMOS readout circuit which quantifies sensor current in the range of pA to uA. This low amplitude current is applied to TIA for the conversion of voltage with the bandwidth of 10 kHz and low noise from 10 to 50 pA/$\sqrt{Hz}$. The feedback resistor value is used between 10KΩ to 1MΩ. For the conversion from analog to digital SAR ADC converter is used. As we present electrochemical method for data acquisition and also machine learning algorithms for electrical detection. Different algorithms are studied and analysed for the detection of Parkinson's disease.

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Chapter - 5

IOT Based Smart Healthcare Applications Using Artificial Intelligence or Machine Learning Algorithms

Sudhakar Hallur[1], Vinay Sangolli[2], Vishweshkumar Aithal[3]

[1,2,3] Department of Electronics and Communication Engineering, KLS Gogte Institute of Technology, Udyambag, Belagavi, Karnataka, India

Abstract— Applications that include remote correspondences via IoT are profoundly inclined to security chances. Larger part of the applications currently goes remote including IoT as an innovation to convey to their particular objective. IoT is considered as a fate of Web. The Web of Things is imagined to fill quickly in the field of medical care in the approaching a very long time due the multiplication of correspondence innovation, the accessibility, combination and use of the application-coordinated gadgets and administrations. In addition, in this pandemic, the integration and competent correspondence of patient wellbeing watching bounds is critical. The IoT architecture is discussed in this chapter, which includes equipment correspondence protocols that support a layer of medical care administrations and apps that use Machine Learning and Artificial Intelligence algorithms. In addition, difficulties in data security, security, and incompatibility are explored. This chapter also includes some of the real-time Healthcare test cases where decisions are taken by a sample algorithm whose solution is proposed to the user.

Keywords — Application (API), COVID19, Regulation, Resource, Omissions, Threats, Monitoring

I. INTRODUCTION

Applications and articles with more insightfulness on the Internet of Things (IoT) includes more complex difficulties. An IoT information security is the most pivotal part and is hard to accomplish. As the compromise between usable frameworks and profoundly secure frameworks procure more noteworthy significance, security is one such component which frequently costs exorbitant. Regardless of the compromise between the expense and nature of use security, the arrangement of different effective protection and security conventions in IoT networks is of outrageous need to guarantee the classification, access-control, verification and trustworthiness of the wellbeing information moved. Likewise, to ensure the accessibility of the administrations to the patient anytime of time.

Openness, unaltered and unauthorized access of data, wide-distribution and relatively high processing power of IoT objects opens up the complete technology to a series of issues. As most of the IoT nodes collect the data to process it and give results, data transfer using IoT not only eases the data analysis but also facilitates the decision making. One of the application of data transfer of IoT is medical decision making based on the data received. Analysis is done on the patient's medical data received using various Machine Learning Algorithms and suitable decision making is done, due to which immediate relief can be provided to the patient remotely. Simple case studies like: "Detection of seizure a-priori before its physical appearance on a patient", is being discussed.

In healthcare, its highly essential for profiling, determining and recording the person's location and health parameters through space and time such as localization and tracking, transmitting information securely via a public medium without concealing information so as to extract the condition of the patient's health parameters at any point of time over secure data transmission.[27] Other challenges include device to function as Sensors to acquire the data via light-weight protocols and decide based on results obtained.[16] Devices are expected to be low cost, self-maintained via use very-low power. Data corruption, infrastructure-failure, service-failure are some of the risks highly associated with healthcare. A. Al-Fuqaha, et. al, state a few security solutions and methods are being proposed in order to safeguard the healthcare application data during the wireless transmission so as to efficient and secure IoT communication and monitoring may take place.

Artificial Intelligence (AI) gives a gadget or programming program the capacity to decipher complex information, including pictures, video, text, and discourse or different sounds, and follow up on that translation to accomplish an objective. Computer based intelligence tooling trained professionals and merchants have begun to target and handle probably the greatest problem

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areas across the well-being area. The well-being area faces ceaselessly increasing expenses and needs assistance to accomplish improved results with restricted assets.

Most partners in many areas oppose interruption since they like business as usual. Medical services, then again, presently requests interruption. With taking off costs and sat around in all aspects of the environment, the medical services area necessities to develop to convey top notch predictable consideration and worth. Subsequently, various kinds of AI applications have arisen, including drug revelation, observing patients for clinical preliminaries, interpreting notes for Electronic Health Records (EHR), giving pre-essential consideration data to patients, foreseeing demolishing heart conditions, apnea or asthma and making clinicians aware of potential 'code blue' crises hours before they happen.

II. TECHNOLOGICAL APPROACHES IN HEALTHCARE

Networked smart health sensors and other smart applications will be very helpful in extracting the health information from the patient. The patient, who awakes in the morning and stands before a mirror outfitted with cameras, will have the option to lay out an association with the going to doctor in the event that he has side effects. Based on the patient information, he then chooses progressively which steps are reasonable. Notwithstanding, the entire thing goes much further: in the most pessimistic scenario, fall sensors introduced in the floor covering and in the house or reasonable medical services wearables could distinguish when a patient falls and is lying on the floor or when help is expected for different reasons. Robotized with regards to a brilliant city, the relating control focus could be educated and an emergency vehicle sent, with the fitting medical clinic with the suitable limit being chosen in view of the determination. M. Aoyagi, K. Nishimori, et. al, say mix with savvy diagnostics and wearables, such shrewd frameworks could help more established patients specifically to live freely longer than before in their own homes despite everything not need to manage without dependable components for care.[1]

The procurement of patient information takes up a huge piece of the restricted season of nursing staff, particularly in the medical clinic climate. Here, astute gadgets can be utilized to gather the significant patient information through voice order, for instance, and allocate it accurately and assess it with the assistance of computerized reasoning and large information. This can't be in every way recorded utilizing wearables yet is frequently additionally acquired from the impression and appraisal of the patient by the nursing staff. The nursing staff would then possess more energy for the real care and wouldn't need to record every one of the information or considerably later exchange it to the electronic patient document by means of a PC. Essentially, this could be a (incomplete) reply to the intense crisis care required in the consideration area according to M. Aoyagi, K. Nishimori, et. al, since, supposing that we take a gander at the deficiency of talented specialists and work force, it rapidly turns out to be evident that its is probably the best test of things to come considering an undeniably maturing society.[1]

2.1. Scope of Healthcare Applications

Currently, the situation of COVID-19 has highly demanded the patient monitoring. As per Hu, M et. al, the passing rate for different get-togethers, the rate of the spread of the contamination, and fitting seeing of the clinical benefits system[6]. Present day, IoT-engaged devices are important for dealing with a patient's inward hotness level and prompting something basically the same as the expert during any strange situation. The wearable smart devices based on Internet of Things are extremely useful in monitoring different medical conditions as applicable. This advancement helps with giving movement to deal with the current pandemic. IoT-enabled devices have reached a tipping point in terms of remote discovery in a clinical benefits structure, ensuring the patient's safety. Throughout the epidemic, patient participation with the master grows more persuasive and realistic. It irritates attention re-statement and shortens the time a patient spends in the appointment. Continued monitoring of a patient's well-being improves the treatment outcomes of COVID patients as well as stated by Chen C, et. al, in their work.[7]

In the clinical consideration situation, the utilisation of adaptable development and contraptions has been demonstrated to be beneficial. Any therapeutic benefit practise that is maintained by cells has been dubbed "mHealth." For example, a mobile health app might help clinicians manage clinical defilements and educate patients for self-checking of their illness while also promoting medication adherence. Because of the utilisation of mobile health applications, clinical benefits and flourishing data have been more available. According to Faasse K et. al, in their work, employing mHealth applications at the convenience of the client helps to prevent the occurrence of minor emergency department visits by stable patients, restricting the flexibility of immunocompromised patients in high-risk settings.[8]

In the relationship of debasements, the execution of essential aspects in mHealth that can with everything taken into consideration or final consequence outlining has wonderful potential. Furthermore, merging pertinent epidemiological data with geological data on adaptive disease inevitability in an area would allow for the tracking of cases. which may be used as a possible device to prevent the spread of contamination. Data may be traded swiftly and enhanced with high intensity using mHealth applications, making it more potent to pass on success-related data. Adaptable apps may be able to avoid the occurrence of a certain ailment, since exchanged messages via a conservative programme can encourage correspondence, data storage, and message generation that encourages customers to adopt healthy lifestyle choices.

2.2. Internet of Things in Healthcare

Customary observing in medical services utilizes the assets and time deficiently. A confirmed clinician needs to continually mind the patient face to face and experimental outcomes now and again need days to prepare.[12] Additionally, after clinic release, recuperating patients might have to make two or three arrangements for the accompanying check-ups to ensure everything is doing great with their wellbeing.

These difficulties are being addressed in a precise manner because to the introduction of IoT. Wearables and implantable gadgets are also being used to continuously monitor the strength of patients who are free of time and their true areas. These gadgets may also detect and forecast illnesses and dangerous situations by utilising area and also more advanced focused AI models. They can then alert the patient as well as the appropriate qualified expert. The investigations around here are referred to as Omnipresent, Electronic, and Mobile Health, and their overarching purpose is to reduce the cost of healthcare benefits and boost patient satisfaction, decline the store of the crisis facilities especially if there should arise an occurrence of a crisis, and give direct yet definite and solid AI models to help experts in recognizing and hindering diseases and giving tweaked prescriptions

2.2.1. Big Data in IoT Health

Hundreds of billions of sensors are attached to patients, monitoring and collecting routine, physical, and physiological data. Lead also decreases tenacity. Recent examples show the rise of clinical super sensors with more memory and control force that can use Improved Particle Swarm Optimization estimation to assist with difficult medicine transport to various organs of the human body, to perceive whether the medication has arrived at a specific location, and more. As predicted, these sensors produce a large quantity of data every second. Big Data is a term used to describe a large volume of heterogeneous data that contains a wealth of and related information. This data should be extracted and evaluated from a unified server using the most basic technique feasible, which generates challenges such as network bottlenecks for data delivery and insufficient handling power, as well as assets for continuous data analysis. Several methods have been offered to remedy the aforementioned issue, including deleting extra data and exceptions in the adjacent computer, conglomerating the data before sending it, and doing a very basic inquiry utilising light portable devices. [16] AI models and possibly sending information when the results hint at an issue. AI and Deep Learning procedures are the most popular approach for managing, analysing, and deleting information from obtained data and further improving the dynamic cycle, since once they've completed the preparation stage, they don't need any more supervision and may proceed with their task.[29]

2.2.2. Big Data inclusive Machine Learning for IoT based Health monitoring

AI and profound learning methods have been applied and are being utilized in a wide range of shrewd frameworks. These savvy frameworks are included numerous more modest parts, each offering a totally different assistance. In one expansive view classification, we can isolate the AI calculations into managed and solo strategies.[12] In solo methods, the model gets unlabelled information, and henceforth its will likely self-find any kind of importance and secret examples inside the information to play out the information gathering.[28] For signals and clustered information, we apply several algorithms such as Fuzzy, K-means, Hidden Markov Model, etc. As opposite to clustering, classification in the model deals with labelling in training phase resulting in the categorization of the input data with the least amount of error. Support Vector Machine (SVM), RF, K-nearest neighbor (KNN), etc. are few commonly used classifiers. For Images, we apply Convolutional Neural Networks (CNN).

2.2.3. Features of Internet of Things Needed for Monitoring of Health

There are a couple of trademark includes that should be moved by the IoT gadgets for the exchange of information in medical care framework as depicted by M. Aoyagi, et. al, and M. Irshad, et. al, in their works.[1] Some of them are recorded beneath:

a. Diverse device pairing capability

To build a broad IoT framework, a significant number of devices will be necessary, and these devices must be highly diverse from one another. The majority of IoT gadgets are one-of-a-kind in that they rely on data to develop focal point associations and correspondence shows. Making areas of strength for a framework, for example, between gadget correspondence, interoperable contraptions, and evaluation of data from various gadgets, is a big test.

b. Elevated Dependency

Appropriate and precise data conveyance is the principle motivation behind use of IoT.[10] This is a profoundly anticipated highlight at each layer to convey continuous and non-mistaken information from source to the objective.

c. Instant Information Transfer

These devices provide continuous data to the base station, which may be utilised for a number of purposes and with a base deferral. [10] While power is available, remote broadcasts from sensors may be set up at predictable time intervals to offer continuing information security.

d. Security of flow of data

Different techniques are utilized to move the information through various layers from the source to objective. [10] In this manner, there is a high gamble of information break. Defending the information is the essential element.

e. Application Configurability

Sensors get out of date every so often, and there are chances of breakdown, so it is more astute to orchestrate them now and again as demonstrated by the application.

f. Monitoring of the data and Traffic Management

A sheer need for the monitoring of the incoming and the outgoing data is needed. Looking into the amount of incoming and the outgoing data and keeping a track of what is being transmitted and received in what path is extremely important. [10]

g. Cost-Effectiveness

The more devices you install, the more money you'll spend. As a result, a capable framework that supports more devices on fewer connection points is required. [10]

2.2.4. Wearables and Monitoring of Health

Wearable Health Devices are an impending innovation that take into consideration steady estimation of specific essential signs under different circumstances. The way in to their initial reception and achievement is their application adaptability — Clients are now ready to track their activities when jogging, thinking, or sleeping. The goal is to offer consumers a sense of financial control by allowing them to segregate data and manage their own accounts. Essentially, WHDs make individual fortifying as depicted in Fig 1.

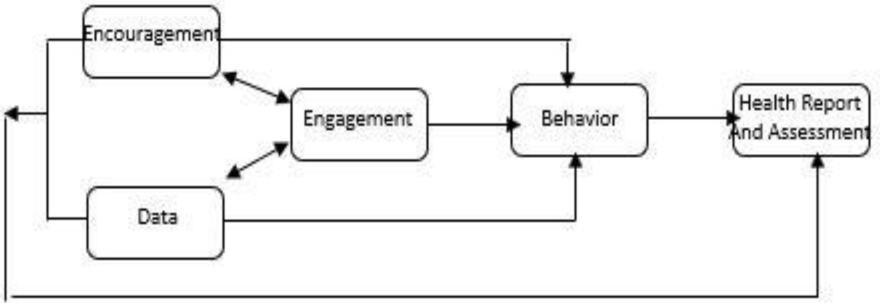

Fig 1. Block diagram of a wearable

[The evaluation of an individual health parameters via a wearable is based on the inputs extracted from the patient's bodies and depicting a definite outcome of the scenario by analysing the behaviour]

At first look, a wearable gadget could seem to be a common band or watch; nonetheless, these gadgets overcome any barrier between numerous logical trains, for example, biomedical designing, materials science, hardware, PC programming, and information science, among numerous others.

Remote observing and getting on early indications of sickness could be gigantically gainful for the people who experience the ill effects of constant circumstances and the old. Individuals will need to communicate with their clinical consideration workers without disrupting their daily schedules by using a smart gadget or for a long time. This is a fantastic example of math collaborating with medical professionals to get a useful outcome for people.

2.2.4.1. IoT and ML Devices in Healthcare (Wearable Devices)

There are a ton numerous medical services gadgets or sensors that should be coordinated with the primary frameworks to process and examine the information and come to an end result regarding the patient's wellbeing.[30] A portion of the wellbeing procurement gadgets in IoT are as given underneath:

a. Smart-watches

Wearables sold at client contraptions stores go with a sensor and web alliance. Few could monitor your pulse, control the diabetes, help in talk treatment and sense the seizures.

b. Smart-Monitoring Device for Glucose

These contraptions can monitor blood glucose levels and send the data to a legitimate PDA application Diabetic patients can use these devices to monitor their glucose levels and communicate the information with a clinical benefits office.

c. Swallowable Microtots

To eradicate the photographs within the body, a few of sensors are swallowed via a patient's entrance. These sensors collect images from within the body's organs and transmit them over a long distance to be viewed on a screen or a cell phone. This assists in the diagnosis of the patient's illness. In addition, the drug is taken with a small clinical sensor that sends a message to a wearable receiver on the patient, who then relays the information to a legal PDA software. This sensor can assist doctors in ensuring that patients take their drugs as prescribed.

d. Diabetes-Monitoring Devices

There are sensors, such as m-IoT, that picture a patient's fingertip to monitor their glucose level. As per Prasad. D, et. al, the graphical data is then extracted from the vascular framework at the tip of the patient's finger using the laser shaft.[2] Furthermore, optical sensors in the infrared layer band, such as infrared LEDs and photodiodes, can aid in the detection of a patient's diabetes status.

e. Temperature Sensing and Monitoring Devices

In the case that the patient's temperature has to be checked, a small 3D printed ear-placeable temperature checking cathode is employed. Using an infrared light sensor, this sensor detects the inner intensity level of the tympanic film. According to Prasad. D, et. al, the isolated temperature is stored in a data base[2], which is subsequently transported away from the target to a nearby/far station, where it is screened on a page and input is given.

f. Hypertension Monitoring Devices

Sleeves are wrapped around the patient's arm and directed until the bulb reaches its maximum limit and the mercury level drops, revealing the patient's blood pressure. However, nowadays, robotized leading to the sleeves around the arm is done, as well as motorised noticing, caring for, and transmitting of the readings.

g. Oxygen-Monitoring Devices (Oximeter)

In the clinical thinking business, the improvement in beat oximetry coming from the split difference of IoT-based headway has shown promising outcomes. The blood oxygen saturation level, nearby heartbeat, and heartbeat limitations are all checked with a simple tissue oximeter.

h. Asthma Monitoring Tools

A respiratory screen that records the patient's breathed and exhaled air velocity and indicates the patient's respiratory state's criticality by establishing a limit.

2.2.4.2. Applicability of Health-IoT in monitoring the Vitals

COVID affects most of the total populace. As shown that it spreads through air-medium, it turns out to be a lot of important to protect the soundness of the wellbeing checking authorities like specialists, attendants, and so forth and furthermore of the neighbouring patients and relatives of the patients if there should arise an occurrence of non-accessibility of beds and home-quarantine. No close to convenience or close observing of the patient's wellbeing is conceivable if there should be an occurrence of COVID impacted patient. Also, Prasad. D, et. al states that, in this way, a portion of the substantial boundaries that can be estimated remotely utilizing IoT information transmission [2] whose gathering are recorded underneath:

a. Brain Signal Monitoring

It turns out to be especially challenging to screen the patient's oxygen level during the basic Covid times. The individual impacted with COVID should be observed for his mind exercises assuming he is basically sick. Extricating the EEG signal from the casualty's cerebrum by means of EEG anodes of different sorts, accumulating the data and afterward communicating it to the remote stations where the specialists can dissect the data by translating the information and answer fittingly.

b. ECG Monitoring

Electrocardiogram (ECG) addresses the electrical development of the heart in view of the depolarization and repolarization of atria and ventricles. An ECG gives information about the fundamental rhythms of the heart muscles and goes probably as a marker for various cardiovascular anomalies. The use of IoT development has found conceivable application in the early disclosure of heart peculiarities through ECG noticing. IoT-based ECG looking at structure is made of a far-off data acquiring system and a getting processor that used a chase computerization strategy that was used to ceaselessly separate cardiovascular peculiarity. A bio-potential chip is used to get incredible quality data which can be conveyed through Bluetooth or any IoT suitable show. The recorded data can be then shipped off the end-clients where the recorded ECG data could be envisioned using a flexible application.

c. Blood Sugar Monitoring

In instances of the COVID impacted patients who have been impacted by diabetes, glucose-observing is an unquestionable requirement. Along these lines, a painless, helpful, agreeable and safe wearable contraption named m-IoT to screen glucose remotely can be utilized progressively.

d. Body Temperature Watch

An essential side effect in COVID impacted patient is fever thus observing the patient's temperature turns out to be generally basic. Checking the change of temperature after some time helps the experts with making determinations about the patient's illness. The normal strategy for assessing temperature is using a temperature thermometer that is either annexed to the mouth, ear, or rectum which can be abnormal to the patients. In this way, a far-off wearable sensor ought to be used to screen the patient's temperature distantly.

e. Monitoring of Blood Pressure

A mandatory system in any understanding's demonstrative is Blood Pressure observing. If there should arise an occurrence of COVID patients checking turns out to be exceptionally basic as it demonstrates the speed of patient's blood flow to every one of the pieces of the human body particularly to the lungs and the three-way blood course arrangement of the heart.

f. Monitoring of Oxygen Saturation Level

Observing the oxygen level is one of the most basic necessities if there should be an occurrence of a COVID patient as the patient fundamentally experiences the shortage of oxygen to every one of the pieces of his body since the predominantly impacted organs in the event of COVID are lungs which are the primary wellsprings of oxygen exchangers in human body. The oxygen level in the patient's body is estimated utilizing the Pulse Oximeter. Beat oximetry is the harmless assessment of oxygen inundation and can be used as a principal limit in clinical consideration examination. The painless technique takes out the issues related to the normal procedure and gives progressing observing. Integrating the oximeter with IoT screens, stores and communicates the information through IoT coordinated advancements on a long reach or by means of WIFI on a more limited range.

g. Monitoring of Breathing Irregularities

A symptom of COVID is asthma. Asthma is a tenacious infection that can impact the respiratory courses and may create problems in relaxing. In asthma, the respiratory courses withdraw due to the extending of the air area. This follows various clinical issues, for instance, wheezing, hacking, chest misery, and shortness of breath. The inhaler or nebulizer one of the sole helps at this moment. Ongoing innovation progression has consolidated a respiratory sensor which estimates the breathed in and breathed out air by the patient, stores the information and communicates it through an IoT-coordinated transmitter. A wearable asthma sensor, can conclude the indications of an asthma attack quite a bit early, which allows the owner to go to preventive lengths on time. A vibration sign and a message forewarning about a peril are shipped off the individual connected with the patient. Among various features, the contraption has an inhaler usage tracker. Such respiratory problem checking is extremely useful in cases on the patients impacted with Covid'19. The sensors sense the oxygen level in the blood utilizing oximeter alongside the detecting of the breathing example of the patient and communicate it over IoT.

h. Monitoring Mental State

Hardship of the oxygen level of the patients straightforwardly influences the blood flow to the cerebrum of the patient by closing down the pieces of the mind and unusually working of the cerebrum. This can be observed by estimating the mind cues utilizing the EEG cathodes, putting away the qualities in the information base and afterward unequivocally sending it to show it on a website page or on any product.

i. Medication Management

Cure adherence is an ordinary issue in the clinical thought industry. Nonadherence to the prescription timetable could manufacture the contradicting frightening issues in patients. Cure nonadherence is all around found in old individuals as they develop clinical conditions like mental decay, dementia, etc as the age drives. From this point forward, it is challenging for them to seriously follow the drugs of specialists. A sharp clinical box was supported that can help individuals with reviewing their prescription. The case has three plates where each plate contains the medication for three stand-out occasions. The construction likewise actually takes a look at a piece of the fundamental health parameters. Each of the recorded information are then conveyed off the cloud trained professional. A conservative application was utilized to foster correspondence between the two end-clients. The recorded data can be gotten to by informed authorities and patients utilizing the adaptable application.

2.2.4.3. AI Health Screening Applications:

There are a ton numerous applications created by organizations that screen the wellbeing information by removing the body wellbeing boundaries utilizing different sensors as depicted by Bikash P, et, al. in his paper[3]. A portion of the wellbeing applications are as recorded underneath:

a. Google-Fit

It is a health-following app. It is the only way to link data from different devices and applications using programming connection points (API). A programming connection point is a data transfer handling edge that connects many programmes. Google Fit tracks our actual health behaviour, such as running, walking, cycling, and other activities, using sensors embedded in our cells. They examined against an expanding viewpoint on their health level, as suggested by the client's wellbeing purpose.

b. Zepp Life

Another tool, Zepp Life, assesses an individual's strength in light of the resources used during the day. In addition, the MI Fit monitors the patient's heart rate, pulse, rest cycles, and Body Mass Index. It mixes the data and delivers it to the client through Bluetooth, or it may be shared with others using IoT protocols.

c. Fingerprint Thermometer

A sensor-based application detects the interior hotness level and squeezing factor using the client's finger. It notices our finger pressed against the exhibit board. Instead of relying on a catch, these sensors may allow customers to just set the screen and see the print. Long silver nanofibers are used to keep unpredictable associations of a hybrid nanostructure, and fine silver nanowires are used to give clear, flexible sensor terminals for this project's sensor group.

d. Instant Heart-Rate

Its use and invention are essentially the same as the technology used in heart rate monitoring. Predefined computations and computer programmes, for example, are utilised in this. The typical idea behind this application is to measure a beat in a fraction of a second.

III. Architecture of the Smart Healthcare

The proposed framework has the capacity of decision making according to the noticed states of the patient in light of internal heat level, beat rate, and pulses. This engineering is likewise energy productive arrangement since it doesn't turn on every one of the sensors constantly. The calculation utilized in the framework will deal with the utilization of the sensors and control their expense and lifetime.[12] The proposed framework in Fig 2 addresses the issue of remote checking of patients and furnishes them with vital treatment through specialists in the emergency clinic.

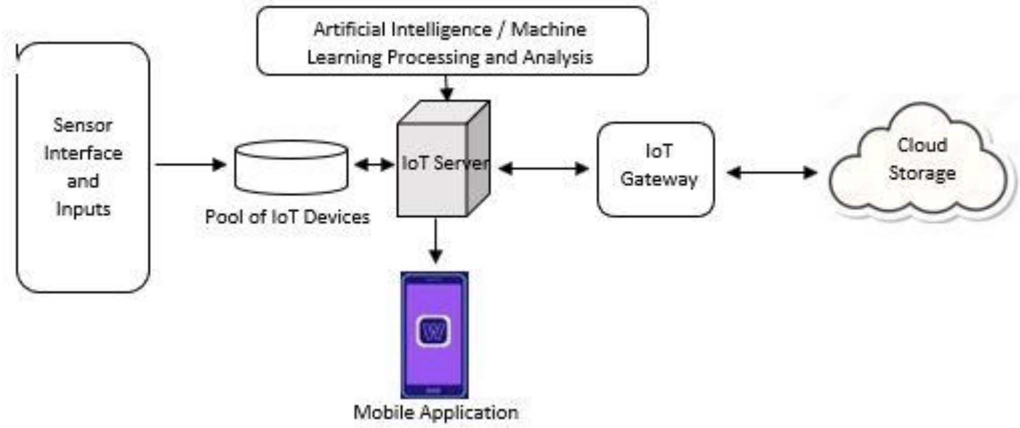

Fig 2. Smart Healthcare System Architecture

[The interaction of various components together resulting in a data depicting the critical characteristics of the health of a person, processed, analysed and transmitted via a wireless gateway to the intended destination]

3.1 Health Care Monitoring Steps

A fundamental approach in acquiring the patient health data would consists of the following steps: Monitoring of the patient, Drugging digitally, Extraction of the data by the medical equipment and Association of the equipment with Medical Institutions for analysis of the data acquired.

a. Monitoring of the Patient

Trend setting innovations in medical services permit both long term and short-term care to be observed all the more intently. Far off persistent checking empowers medical care experts to screen imperative signs and survey actual responses to past medicines without having to be in a similar spot as the patient. The gadget utilized relies upon the soundness of the particular patient. For instance, it very well may be an embedded cardiovascular gadget, a wind stream screen, or an arranged blood glucose meter. The gadget being referred to gathers the ideal information. On the off chance that the qualities are not as they ought to be, the information are all the while sent to a information base for recording and to the treating specialist. The specialist can examine the data continuously and respond in like manner. Such gadgets are frequently utilized following an activity. They assist with lessening the quantity of clinics stays and keep away from re-affirmations since issues are distinguished all the more rapidly. This permits specialists to respond prior and keep away from possible intricacies. With the assistance of the information gathered continuously, it is too conceivable to change and adjust treatment choices all the more rapidly, contingent upon the patient's actual response and condition. This permits specialists to respond prior and avoid further complications.

b. Drugging Digitally

One of the fresh developments in the medical industry is "smart pills". Smart pills are purchased and inhaled as ordinary prescription yet are outfitted with some sort of checking innovation not withstanding the real prescription. They utilise it to send data to a sensor that is worn on the body. In case where patients can be treated or drugged based on the medical imaging transmission technology remotely, A. S. Anwar et. al, state that the image transmission has to be highly confidential and secured.[19] In light of a patient's apparent or assessed state, these sensors monitor medication levels in the body. The information from the compact sensors is then communicated to a cell phone application, and that implies that patients can get to information on their essential capacities themselves. Specialists can do this assuming that the patient concurs. This is the way the treating doctors decide if a medication is filling in as expected or potentially causing incidental effects.

c. Extraction of the data by the medical equipment

Wearable clinical gadgets are the most appealing choice today for purchasers of all ages for following their own important bodily functions continuously. Besides the fact that they record information, be that as it may, they additionally fill specific roles in view of orders or perceived circumstances. One model is "wise affiliations". They are furnished with sensors that survey the size of the hidden injury to decide if it is mending or not, or on the other hand in the event that there is a contamination, also, whether an effective arrangement might should be managed.

d. Association of the Equipment with Medical Institutions for data analysis

Large numbers of the advantages of the IoT for the medical care industry lie in working on the quality of care for patients. Notwithstanding, on account of the Internet of Things, clinical offices have likewise improved, for instance through additional productive cycles and by rationing important assets. Clever innovation in medical clinics and care offices guarantees, for instance, that specialists can more readily screen costly gadgets like MRIs, CT and PT scanners and X-beam machines concerning adequacy and administration life. Along these lines, breakdowns or erroneous activity can be kept away from. Distant sensors limit the quantity of manual tests or on the other hand might even wipe out the requirement for them. That saves time for additional critical assignments.

A normal issue in clinical offices is the movement of hardware or frameworks that are utilized all the time. This turns into an issue on the off chance that a gadget can't be situated in a crisis. The utilization of Bluetooth low-energy area innovation empowers gadgets to be situated in genuine time. This stays away from outrage and stress in the event that you can't track down a gadget experiencing the same thing. A little advancement assists with saving innumerable lives. Conversely, the expenses are immaterial. Medical care is one of the ventures where the IoT has previously done something significant.

IV. HEALTHCARE PARAMETERS IN ARTIFICIAL INTELLIGENCE

Artificial Intelligence shall address the following parameters[30] below:

4.1. Precision Medicine

The precision of the medicine enables the capacity to customise therapeutic consideration treatments to persons or social events of patients based on their sickness profile, expressive or prognostic information, or therapy response. Genetic variations as well as clinical treatment contributing components such as age, direction, geology, race, family parentage, safe profile, metabolic profile, microbiome, and environmental deficit will be considered by the designer-made treatment open entry. The purpose of precision medicine is to use individual science instead of people science throughout a patient's treatment path. This requires gathering information from patients, including as genetic information, physiological data, and EMR data, and adapting their treatment to current models. Precision drug benefits include lower clinical consideration expenses, a decrease in hostile medicine responses, and improved prescription movement efficacy as per Mayra. S. in their work. Precision drug benefits include lower clinical consideration expenses, a decrease in hostile medicine responses, and improved prescription movement efficacy. Precision medicine's progress is predicted to benefit patients significantly and profoundly change how health services are offered and assessed.

4.2. Genetic Solutions

Genome sequencing is assessed to take up huge memory of information and will permit an extraordinary instrument for accuracy medication. Connecting the genomic and aggregate data is as yet progressing. The ongoing clinical framework would require an update to have the option to utilize such genomics information and the advantages in this regard.

Many gained diseases achieve incidental effects without a specific examination and remembering that translating whole genome data is at this point testing a direct result of the various inherited profiles. With complete genome sequencing and AI, precision medicine can help systems identify genetic alterations.

4.3. Drug Initiation, Development and Usage

The amount of data accessible for evaluating pharmacological compound research and biological data has expanded considerably in the previous two or three years. This is due to increased robotization and the development of new preparatory approaches such as hidden Markov model-based message to talk mix and equivalent mix. In any case, mining massive extension science data is anticipated to be able to accurately depict prospective drug combos, and AI methodologies have shown tremendous promise as stated in the work done by K. Salah, et. al. Support vector machines, cerebrum associations, and erratic woodlands, for example, have all been employed to entice models to help with sedating exposure.[15] In light of the increased proportion of data and the reliable overhauls in handling power, DL has just begun to be done. Throughout the drug disclosure process, AI may be utilised to help simplify certain processes. This includes assumptions about medication compound properties and activities, a new arrangement of medicine compounds, coordinated drug-receptor attempts, and prescription response supposition.

The medication atoms and the related highlights utilized in the integrated-silico models are changed into vector design so they can be perused by the learning frameworks. For the most part, the information utilized here incorporate atomic descriptors and sub-atomic fingerprints as well as improved on sub-atomic info line passage framework strings and matrices for convolutional brain organizations.

4.4. Drug Activity and Property Prediction

The features and development of a pharmaceutical particle are important to understand in order to understand how it will operate in the human body. The natural development, maintenance, movement, absorption, and release features, as well as the physicochemical properties of prescription particles, have been studied using artificial intelligence-based systems. To manage information on a vast number of particles for diverse disease targets, numerous chemical and natural data libraries have arisen. These machine-readable libraries are used to develop AI drug disclosure models. According to M. Aoyagi, K. Nishimori, et. al, the fingerprints of the cerebrum are then utilised to predict new traits for a certain iota. Sub-nuclear qualities such as octanol, dissolvability, mellowing point, and natural development may all be assessed this way. Others can also be utilised to anticipate novel medication compound components. They can also be used with a score limit of the prescription particles to find iotas with beneficial regular development and physiochemical features. Most novel prescriptions discovered so far have a perplexing layout as well as negative features such as poor dissolvability, low security, or poor digesting.

4.5. Design through Deep Learning

For nuclear re-entry, a few DL-based approaches have been proposed. Protein planning, comprising the nuclear organisation of proteins with express confining or functions, is also included. Variational and hostile autoencoders are commonly used in this situation to create new particles in an automated cycle by fitting the arrangement model to enormous datasets of drug iotas. Autoencoders are a type of neural network for independent learning, comparable to the devices used to create representations of fictitious human features. On a variety of drug particle architectures, autoencoders are prepared, and the latent elements are subsequently employed as the generative model. Poorly organised autoencoders can be utilised to create novel sub-nuclear fingerprints and medication plans that include components like dissolvability and maintenance while taking into account predetermined anticancer prescription features. These findings suggest a significant increase in the efficiency of developing new pharmaceutical regimens with unambiguous features.

4.6. Drug-Target Interactions

Pharmaceutical target correspondences must be examined as part of the drug development process. The restricting posture and restricting love between the pharmaceutical molecule and the goal have a substantial influence on the chances of success in terms of the in-silico assumption. Medication new kid on the block undeniable proof by sub-nuclear docking, for assumption and preselection of interesting prescription objective coordinated efforts, is one of the more common philosophies.

The most recent developments in AI applications for drug disclosure and progress include an ever-increasing number of models that use DL movements near. While differentiated from more traditional AI approaches, DL models take the most of the day to prepare because to the massive datasets and vast number of constraints necessary. This may be a big issue when data isn't easily available. As a result, efforts are being made to decrease the amount of data required for DL's planning sets, allowing it to learn with less input. This is similar to how the human frontal cortex learns, and it might be useful in situations where data gathering takes a long time and large datasets aren't instantly available, as is frequently the case with important research and potential therapeutic targets. The use of a single shot learning method or a lengthy ephemeral memory approach, as well as memory increased cerebrum connections like the differentiable brain PC, are all being researched.

V. ARTIFICIAL INTELLIGENCE AND MEDICAL HEALTH VISUALIZATION

It might be difficult to comprehend material delivered in the form of a picture or a video. To acquire the ability to recognise clinical abnormalities, experts in the field will have to plan forward indefinitely. as well as the desire to truly learn new things as additional research and knowledge becomes available. Nonetheless, interest is growing, and there are a scarcity of fundamental specialists in the sector. As a result, there is a requirement for a different strategy and AI commitments to be the mechanical assembly to handle this request opening.

VI. AI AS MEDICAL ASSISTANCE FOR DIAGNOSIS AND SURGERY

PC vision refers to computers' interpretation of images and accounts at or beyond human-level capabilities, including article and scene confirmation. Two areas as per Bohr, A et. al, where PC vision has a considerable impact are picture-based finding and picture-coordinated operations.[26]

Although computer vision has traditionally relied on verified sign processing, the use of artificial mind networks as a learning mechanism is becoming more popular. DL is used to prepare PC vision estimations for gathering pictures of wounds in the skin and other tissues in this scenario. Video data is analysed to see how much data from important standard suggestive images, such as CT, it contains on numerous times and might therefore provide a greater data respect for a long time. Video examination is now uncomfortable, but it has enormous promise for clinical decision support.

Profound Learning and Medical Image Recognition

The term "profound" refers to the complicated concept of AI, and CNNs have shown to be the most promising DL approach in the field of image recognition.

Because picture recognition begins with the detection of the image's distinct highlights, the human visual cortex has an impact on CNNs. Furthermore, CNNs require a significant amount of data preparation, which comes in the form of clinical pictures and image nomenclature. Based on the available preparation information, CNNs may adapt the applied loads and channels at each hidden layer of preparation to work on the display.

As shown in Fig 3, a convolutional layer, the exhibition of convolving an image with varied loads and producing a heap of isolated photos is given, where an image effectively changes into a store of filtered pictures as per A. Shehab. Pooling is then used to this massive collection of separate images, resulting in the initial heap of images being transformed into a more modest representation of themselves with chevalier traits eliminated.[18] This large number of exercises is then stacked on top of one another to create layers, a process known as deep stacking. This cycle can be repeated on several occasions, with the picture becoming increasingly isolated and, for the most part, inconspicuous. The final layer is meant to be a completely interconnected layer in which every value assigned to all levels contributes to the final outcome. If the system transmits a blunder in this final reaction, the inclination plunge may be used to view how the mix-up alters in relation to the appropriate reaction of interest by adjusting the features all over. This may be accomplished using a spread calculation that indicates "acquiring from bungles." Following the acquisition of more capacity from ongoing data, the structure may be applied to fresh photographs and the photos can be organised in the proper order.

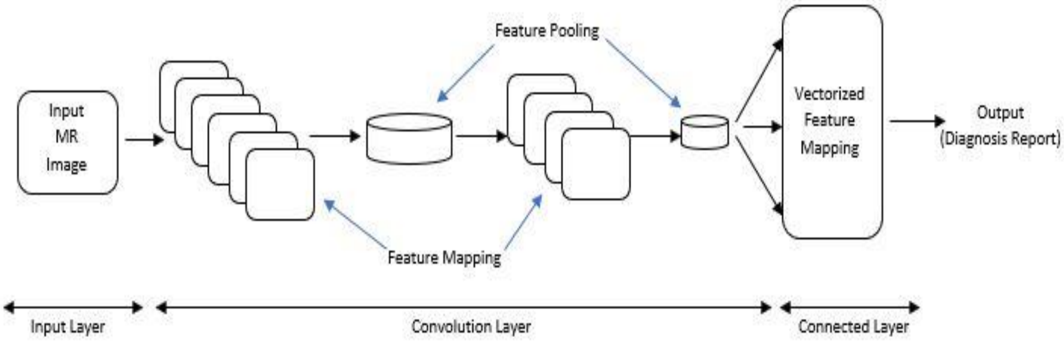

Fig 3. Stages of CNN at work.

[Extracting the input via images, selecting specific areas of interest, extracting the features, pooling, doing feature mapping and diagnosis using CNN and then providing the report]

VII. CHALLENGES AND RISKS

Challenges in IoT related Medical Consultation

IoT related medical consultation has several challenges.[10] Some of them are given below:

a. *Muddled Policies*

Since innovation is developing at such a high speed, it has been challenging for policymakers to keep up with the business.[25] There is incredible vulnerability with respect to matters like repayment arrangements, security insurance, and medical care regulations. Furthermore, telemedicine regulations fluctuate from state to state.

b. *Lesser Face-to-Face Interactions*

A few doctors also, patients are finding it hard to adjust to telemedicine, particularly more seasoned grown-ups. Doctors are extremely worried about patient fumble. While propels in medication have made it more productive to utilize innovation, there are times at the point when framework blackouts happen. There is additionally the potential for blunder as innovation can't necessarily catch what the human contact can.

c. *Expensive Technology*

Medical care systems that use telemedicine may attest to the fact that they take a lot of time and money. [25] Using a different framework necessitates preparation, and some employees find it difficult to accept this transition. Practice directors, medical caretakers, physicians, and others must learn how to apply the framework in order for practises to realise the benefits is as stated by B. Crispo et. al, in their work[14]. Despite the fact that telemedicine is initially pricey, medical care systems should experience a positive return on investment in the long term as a result of more patients and less employees.

Challenges of Machine Learning and Artificial Intelligence in IoT Healthcare

Here, the significant limits and difficulties of ML and AI in IoT medical services are predominantly listed and examined.[11] Fig 4 depicts a relationship between IoT, AI (ML) and individual healthcare. There are many examinations that express the applications of AI in IoT and PH.

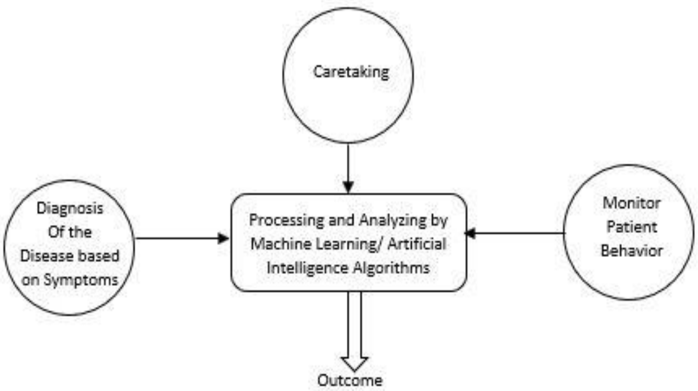

Fig 4. Relationship between IoT and AI

[A very crucial relationship in between the internet of things and artificial intelligence based on the process flow]

The figure shows that IoT creates information that takes care of ML calculations and afterward the results give answers for PH like illness determination, patient ways of behaving investigation, and assistive consideration guidance. ML and IoT-based assistive PH administrations have proactively mainly affected people groups' lives because of innovative headway. Be that as it may, assistive PH will expect to confront testing issues like ease of use and reasonableness. Furthermore, protection and confirmation issues in IoT gadgets can stand out for programmers and cause issues as they will be hacked while possibly not accurately gotten

According to S. Hallur, et. al, study, using ML-based PH organisation urges us to use a perceptive evaluation strategy to help us release patients from healthcare facilities who may need to be readmitted. The purpose of judicious inspection is to use a risk-gathering technique in which patients who are at higher risk are handled with more effort and helpful thinking, such as by spending more time looking at IoT devices/sensors and giving regular (steady) follow-up and review. These models are built using historically accurate data and information. The superior PH system that would enhance re-insistence avoidance drives should also take dynamic data from the patient and store it in memory to foresee future possibilities and initiate an action plan to avoid entanglement. Though A. Abdelaziz, et. al, has stated of so many solutions to improve the efficiency of the image analysis using Machine learning[20], Selvaraj, S et.al, in his paper states some of the challenges as mentioned below[4].

a. Challenge 1: Outdated Data

There have been numerous assessments focuses on working on uses of AI (ML) in IoT clinical benefits. The ML computation's structure logical models integrated into grouped clinical consideration organization applications and clinical canny frameworks[31]. These models are based on data collected from IoT devices to see direct and different clinical conditions of patients, such as recognising the patient's redesigns, affinities, and irregularity exercises in normal timetable activities, and different approaches to acting of resting, stomach related, drinking, and eating plan. With those models in hand, the clever unique systems advise patients on explicit lifestyle suggestions, care programmes, and unusual therapy. Experts may also be included in thinking plan collaboration in order to review and promote lifestyle insight and care plans. Clinical data, such as clinical, lifestyle, and direct data, are quite sensitive, and it's possible that there will be a variety of different forms of unequal busy with the data combination process.[9] and that the end result of managing all conditions may not be the same. Furthermore, the noisy, fragmented facts may cause a decreased chance rate to identify and forecast a prosperity-related evaluation, as well as a cautionary warning. Furthermore, whether or if we had a rich model, it would not be powerful any longer if the readiness dataset and built model were old. Using old and old models and information, we arrived at an incorrect conclusion based on the magnificent structures. This challenge can be addressed by the solution proposed by M. S. Sreekutty et. al, which indicates security enhancement of the medical image via steganography[21]. The same solution was being proposed by M. I. Khalil in their works too.[22]

b. Challenge 2: In Assistive Care

ML calculations are astonishingly linked to genuine relationships and deductions, in which the ML computations pick and forecast based on prior and present experience (planning dataset). The ML-based approach will screen and dissect what is happening based on the arrangement dataset when a patient is checked. As a result, during the test stage, the planning dataset is critical for identifying the continuous model and anticipating future occurrences of a given new issue. This dataset is inconsistent at times and isn't as diversified as it might be to cover a wide range of circumstances. Furthermore, PH can use IoT and ML to make a choice for assurance or assumption. There are a few scenarios where ML-based choices can't be trusted, and it's impossible to explain why a conclusion was reached. The procedure for assessing an AI system's conclusion when solitary machine learning computations were employed is the main topic here. This might lead to an ethical question of who can be trusted in the case of a fake attestation, as well as how to detect or repair such inadequacy throughout the time spent on the trip and understand how should solo AI calculations perform. These difficulties would restrict the use of machine learning calculations.

c. Challenge 3: Confidentiality and Accurateness

F. A. Alaba, et. al, in their paper state the transactions and examinations use AI computations to provide exceptional services like progress tracking, presenting the number of advancements, consumed calories, rest noticing, travelled distance, and vital signs assessments like heartbeat, electrocardiogram (ECG)[13], skin temperature, and electroencephalogram (EEG) as states by K, Jaswal et. al, in his work[5]. As a result, assessing data provided by IoT devices and exchanging it with a server through a linked connection poses security, trust, and order considerations. Server data and communication networks are both subject to failure. As a result, data security and insurance are important factors to consider. There are basic courses of action that can be taken to boost data security by using encryption calculations and preserving the data. K. Zhao et. al, in their paper state however, if a software developer discovers the method into the unscrambling estimation and exposes the message, then the private information will be everywhere.[17] Furthermore, while encrypting, it is possible to lose some information, and if the decryption estimates fail to recover each and every unique datum, the encryption and unscrambling process is no longer relevant.

d. Challenge 4: Monitoring Patient Activities

Different investigations focus on using data from developing sensors to depict dynamic work in real-world settings for a grouping of context-oriented exams in a specific situation of observing patient behaviours. According to research, the development sensor type is one of the most effective tools for assessing long-term human real work for explicitly threatening development patients while they are in treatment groups. Regardless, acquiring data from clinical IoT sensors/devices for clinical consideration application is extremely vulnerable due to IoT contraptions characteristics. Late online advancements and long-distance correspondence/change continue to develop the social event data process and long-distance progressive noticing. However, the chaotic work cycle of combining clinical data raises security concerns and insurance risks throughout the data collection process, including data aggregation and transmission, as well as data management and storage. The difficult issue in the activity confirmation procedure employing mobile phones rather than wearable devices is concluding the data that can preserve client security when it is vital and enormous for AI endeavours. One of the most significant challenges of using IoT for clinical consideration checking is security, particularly in the AI assessment process. Super genuine record customer's methodological data and organisations are ensured by a beneficial client affirmation structure. As a result, the problem is data transparency for clients, which is too delicate for software developers to handle. It will be interesting to share data from IoT devices as is.

VIII. CONCLUSION

The usage of Machine Learning Algorithms to train the models repeatedly enables the systems to be more accurate and specific to the function it is intended to do. Combining with the Deep Learning Algorithms, efficiency of the algorithms can be increased depending upon the choice of the Criterias used. Data generated for processing or after the processing/analysis of the data is huge. So, to handle the data accurately, various security and privacy measures are put in place. The usage of high-end hardware and faster processing software enable the processing of the data more quickly and generate results as soon as possible. The usage of IoT enables to transfer the data remotely for detailed investigation. Also, usage of artificial intelligence and machine learning together facilitates autonomous decision making and solution imparting which reduces the dependency on the medical practitioners, thus, making the society smart and independent.

Case Study: Epilepsy Detection using Sensor Technology

A study by S Hallur, et. al, states deaths are sometimes caused because of extreme epileptic seizure and heart failure due to hypertension.[23] The majority of such deaths are caused by the inability to obtain therapeutic assistance during times of scarcity. This part illustrates a development that examines a remedy for such concerns employing remote correspondences and artificial cognizance via IoT, which includes an enabled RFID backwoods in which the loss' authentic region is tracked for supplying basic therapeutic sorts of aid. This piece also shows how distant correspondences systems and less powerful sensors, such as RFID uninvolved Tags, interact to receive transmissions and transfer all of the data, such as a person's fundamental body-work signal data, EEG, ECG, and GPS data, to the nearest ground station.[24] As a result, both the data plans and the clinical state and area of the patient must be considered. illnesses are somewhat examined, thus outfitting emergency rescue units with the positive region of the person. Also being explored is an algorithm for dealing with the patient region, prosperity status, and rescue. A similar study conducted by S. Hallur depicts the alertness of the patient medical condition to the medical hub based on his pulse status.

Sensors Used: EEG Sensors, RFID Sensors, GPS Sensors, ECG Sensors, Pulse Oximetry sensor, etc.

The Mobile Unit to monitor and alert the occurrence of Epileptic Seizure consists of the following components: RFID Tag and Readers, ECG and EEG Sensors, Oximeter, GPS and Rescue Units

Process:

Any sensors attached to the casualty's body, such as ECG, RFID, Oximeter, and EEG, capture the signs from the casualty's body in a basic structure, which should then be switched over to a discrete structure[31] whose computation and pseudocode is as shown in Fig 5.

Algorithm for Sensing High/Low Pulse Rate:
Step 1: The RFID tag continuously senses the body for determining the Heart Pulses and sends to the receiver upon the command.
Step 2: The bits obtained from the tag are compared every time to check whether a BIT=LOW or a BIT=HIGH has occurred.
Step 3: If consecutive five BIT=LOW is observed in the sequence, the tracking and locating base station is alerted. Else the counter is reset to 0.

Fig 5. Process Algorithm and Pseudocode.

[A calculation to momentarily portray of the patients ECG due to random variations of EEG causing hypertension, the method for the cycle stream from finding the loss' prosperity signs to its transmission and dealing with. A pseudocode of the identical is written in C language]

The signal receiver (such as an RFID receiver) in the surrounding equipment gadget, such as a PC or a PDA, must evaluate the received bits from the sensors put on the human body with care. Observing pulse oximetry, mental symptoms, and monitoring the respiratory system become critical when COVID19 is present. The gatherer continuously changing the sensors until the data is supplied through the input as voltages. The threshold is being set, and the components are being scrutinised. A counter is set up to keep track of how many high and low pulses there are. High signifies that the individual is insignificant. whereas Low indicates that the person is important. One such circumstance that screens the loss' pulse rate is as depicted in the Fig 6 below.

```
Pseudocode for Sensing High/Low Pulse Rate:
/*Piece of Code for detecting a Weak Pulse */
ALERT ()
{ if (bit==LOW)
{ counter++; }
else
{counter=0 ;}
if(counter==5)
{ Alert Locating &Tracking System");
counter=0; } }
```

Fig 6. **Algorithm and Pseudocode for Pulse Value Count.**

[The counter is liable for counting the amount of bits that are allocated with regard 1 and worth 0. This depicts the patient's condition regardless of whether strong.]

Region and Tracking gets a stand-out RFID ALERT message with features like Auto-sending, Auto-Resending, and Auto Messaging via a nearby equipment device beneficiary setback. These connections are provided by the Cellular Network Service Provider via Data Services. The Locating and Tracking Station sends an ALERT message to the Mobile Rescue Unit and informs the Global Positioning System of the exact position of the Radio Frequency Identification Reader implanted into the Cellular Phone. The Mobile Rescue Unit receives an Inform message from the Locating &Tracking Station through IoT, alerting the Doctors/Rescue pack in the Mobile Rescue Unit who are experiencing an epileptic seizure. Meanwhile, the Global Positioning System locates the Victim's exact location, leads the Mobile Rescue Unit to the target on time, and provides immediate clinical assistance to the Victim.

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Chapter - 6

Know-Your-Plate: An Application for Diet Analysis through Artificial Intelligence

Dr. Shaneth C. Ambat[1], Hezekiah John V. Rizan[2], Rom Braveheart P. Leuterio[3], John Patrick G. Chua[4], Chrys Uoie A. Salazar[5], Dr. Hadji J. Tejuco[6], Anthony D. Aquino[7]

[1] College of Computer Studies and Multimedia Arts, Program Director, FEU Institute of Technology
[2] FEU Institute of Technology, 3780 Blk. 9 Lot 17, Durian St., Centennial II, Pinagbuhatan, Pasig City, 1602, Philippines
[3] FEU Institute of Technology, Samson Apartment Unit B, Pagasa Subd., Anabu, 1-B Imus, Cavite, Philippines
[4] FEU Institute of Technology, Blk 21 Lot 7 Pearl Street Citation Homes Barangay Bahay Pare Meycauayan Bulacan, Philippines
[5] FEU Institute of Technology, 469 Block 27-A Brgy. Addition Hills, Mandaluyong, Philippines
[6,7] College of Computer Studies and Multimedia Arts, Faculty, FEU Institute of Technology
[1]scambat@feutech.edu.ph, [2]hezekiahjohnrizan@gmail.com, [3]romleuterio@gmail.com, [4]johnpatrickchua05@gmail.com, [5]biz.salazarchrys@gmail.com, [6]hjtejuco@feutech.edu.ph, [7]adaquiuno@feutech.edu.ph

Abstract— *With the advent of the current health situation upon the world, the public has promptly heeded health professionals' advice on strictly keeping a healthy lifestyle. Our diet and nutrition mainly factor our lifestyle. In this study, the researchers aim to develop an application aligned with this objective by providing the Filipino public a means to monitor, assess, and visualize their health through their diet. The development of the application was employed with artificial intelligence through K-means clustering and Image Classification using ResNet architectures for diet and nutrition analysis, Cloud technology for storing diet records, and Augmented Reality for visualization. The development of the application yielded these results; diet analyses were done through the K-means algorithm yielded that diet of individual Filipinos can be divided into three clusters, where each posed health risks and diseases, and a ResNet-18 classifier yielded an 81% accuracy in classifying 15 different Filipino foods.*

Index Terms— *Diet, Filipino foods, K-means algorithm, Image Classification, ResNet architecture*

I. INTRODUCTION

1.1 Introduction and background of the study

Having a proper and well-balanced diet is often neglected as an essential part of our lifestyle. Despite being aware of health consequences, satisfaction is not always a solution. Eating a healthy diet is only a part of achieving a healthy lifestyle, and this study would want to focus on keeping that awareness. According to an international statistic from the United States, calories, sugar, fat, and grains intake in the American diet are often lacking or exceeded (President's Council on Sports, 2017). The Center for Disease Control and Prevention (2021) also notes that lesser than 1 of 10 American adults and adolescents consume vegetables and fruits regularly. Such data and statistics in the Philippines are not yet present due to the lack of research and study.

The advancement of mobile technologies allows more people to access and develop innovations at hand. Integration of emerging and developing technologies such as Artificial Intelligence (AI), Image Processing, Augmented Reality (AR), and Cloud Technologies has more room for discovery and implementation. This study would like to explore these and develop a software relevant to the topic introduced – health and proper diet.

The possibility of the emergence of new health hazards and new forms of existing ones can now be easily predicted due to the rapid development in medical technology. However, it is a concern that these technologies alone are not the primary response to the health risks that may pose to the public; it is often the population's responsibility. In response to the current health situation, more households responded by tracking their members' diet, creating activities that improve immunity, overall health-conscious, and maintaining a healthy lifestyle. Even before the pandemic, in the Philippines, according to Limos (2019), research by a RunRepeat listed the country as 13th of the most health-conscious countries among 89 others. Moreover, the Philippines ranked 13th regarding diet consciousness and 14th in physical activities and workouts.

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Health monitoring and maintaining healthy routines can now be quickly done through the increased frequency of accessible applications, promoting health consciousness. However, a survey by Meng, Guo, Peng, Zhang, and Vogel (2019) showed that using these applications is not related to how the subjects were conscious of their health but used them for their credibility. eHealth Applications through mobile devices are now prevalent. It has been used by the general public and used by healthcare professionals to aid their operations. The portability of the devices makes it possible for accessible communication and access to relevant information (Ventola, 2014).

Since the COVID-19 pandemic hit worldwide, health professionals have constantly reminded the public to keep a strict healthy lifestyle under these conditions. Most people invested in eating a well-balanced diet; however, the researchers wondered, "What diet is well-balanced for an individual?". This study aims to quantify what people eat and determine if it should be insufficient, enough, or unhealthy, and with powerful technologies today, the team thought it would be possible to accomplish it.

The pandemic allowed households to reflect on their current lifestyle that could impact their health. Maintaining that consciousness is the motivation for developing an application. Early prevention is done through early observations, and this application will be built with that objective to create a quantification of what people eat and determine if it should be insufficient, enough, or unhealthy and prevent possible health risks patterned to the type of food the user intake through self-monitoring.

Diet and nutrition are major risk factors in acquiring dangerous diseases (World Health Organization, 2002). These are the main factors that would be investigated to generate results from the application. Another important reason is that an average Filipino's diet and nutrition data is lacking; the availability of this data could generate relevant and better research in improving the health response in the Philippines, significantly in addressing nutrition issues.

The general objective of this study is to develop and implement an application that could predict possible diet-related diseases an individual might have.

1.2 Scope and limitations

In the study's scope, the nature of data only includes individual diet/nutrition components (e.g., macronutrients – carbohydrates, protein, fat) for pre-processing and analysis. The data used in the pre-processing would originate from the 2008 and 2013 National Nutrition Survey of Individual Dietary Component public use file provided by the Food and Nutrition Research Institute's (FNRI) e-Nutrition webpage. The data was then filtered and limited to only include records of individuals aged 20-50 years only and for male and non-lactating females. Due to this, the researchers limited the study's objective only predicting possible diseases of an individual that are heavily influenced by diet/nutrition, described by (Weininger, 2020) as nutritional diseases (e.g., cardiovascular disease, hypertension, diabetes mellitus). The researchers would not further investigate the prediction of possible diseases wherein diet could also be one of the factors, but only where diet/nutrition is the leading indicator.

Furthermore, the prediction of diseases does not consider the BMI of the users. The application does not include individual consumption of fruits and snacks, and it only includes typical Filipino food consumption, which is a dish/viand eaten with rice. It also does not include the overall fat content that comes from other ingredients like oil and butter, and it only considers the fat coming from the meat, fish, or beef. Additionally, because of time limitation in training and developing the food classifier model, the researchers limited the food classes to fifteen (15): *Bicol Express*, *Bulalo*, *Chicken Adobo*, Filipino Spaghetti, *Kaldereta*, *Kare-kare*, *Laing*, *Lechon*, *Lumpia*, *Pansit*, *Pinakbet*, *Sinigang*, *Sisig*, *Tapa*, and *Tinola*.

The researchers were also keen on investigating and analyzing these data using the *K-means* clustering algorithm. The study does not discuss or compare results using other unsupervised clustering algorithms. In addition, the study does not discuss comparisons of configurations in the implementation of *K-means* (i.e., algorithm used for cluster center initialization). As for the external tools, algorithm, and Application Program Interface (API) used in the study, the researchers were not involved in its construction but only utilized them to develop the application. Specifically, the ResNet Architecture, Augmented Reality, Cloud platform APIs, and the *K-means* algorithm implementation.

II. LITERATURE REVIEW

With the advancement of technologies, new habits form. It is common for individuals to take photographs of their food before eating it and post it to their social media like Facebook and Instagram. Researchers can use this habit because it provides users an easy way to record their diet consumption. Based on Casperson, Sieling, Moon, Johnson, Roemmich, amd Whigham (2015), mobile technologies are proving to be valuable tools for collecting and assessing nutritional consumption. Because teenagers rapidly embrace and adapt to new technology, a food record app may be a beneficial tool for better understanding adolescents' nutritional intake and eating behaviors. They conducted a usability study to measure the amenability of adolescents in recording their food intake through a mobile application, which resulted only in a minority of their respondents fully accomplishing the tasks, concluding that applications that are to be developed are user-friendly to increase participation.

Mobile technologies with better hardware and computational capability are now coupled with applications leveraging the power of technologies such as Artificial Intelligence/Machine Learning. Pouladzadeh, Shirmohammadi, and Al- Maghrabi

(2014) ascertained that there had been a growth in personal mobile technology such as smartphones or tablets, which users nearly always carry with them. That is why they proposed a food calorie and nutrition assessment system that can assist patients and dietitians in measuring and managing daily food consumption. The approach uses deep convolutional neural networks to classify food images and employs a camera nutritional information table. Concerning the quantification of food consumption through mobile cameras, the application developed by Zhu et al. (2010) instead quantifies and estimates the nutrition intake using images of food taken before and after consumption than just simple food image classification.

In another application developed by Villalobos et al. (2012), the objective of their study is to help people who are suffering from obesity and overweight to measure the daily calories they consume. They used a mobile device with a camera; like Zhu et al.'s methods, Villalobos et al. incorporated a unique technique to measure calorie intake through the images taken before and after meal consumption. Their study is a doctoral thesis by Al-Maghrabi (2013), which aimed to find solutions to eliminate the problem of misreporting and the inability to estimate the calories and nutrient intake for people who suffer from obesity being overweight through their Food Recognition System (FRS). Similarly, the system uses a smartphone's camera to record food taken before and after consumption, which Al-Maghrabi concludes to have yielded a less than 15% error in food classification and value quantification through unique approaches.

These studies have things in common; regardless of their objective, each records data related to food and diet. Based on many factors and trends, it was also decided that the most convenient and effective way of recording the nutritional data is using a mobile phone's camera. Lastly, their approach in analyzing the food components is through image processing and deep neural networks.

Advancements in technology greatly affected people's lives, from work to small habits. One notable change is how people eat; before, most used to thank for the food and then eat quietly; but, at present, many take pictures first then post them on social media before eating. This habit can be observed in adolescents and adults but is much more common in the former. The researchers similarly focused on a mobile application that records diet consumption through the camera, with the difference of presenting possible diet-related health risks given the data obtained. With this approach, users will quickly identify the food components and obtain the necessary nutritional data. The convenience of this approach can motivate users to record their diet daily, resulting in more consistent monitoring of their health and increasing their engagement with the application.

III. THEORETICAL FRAMEWORK

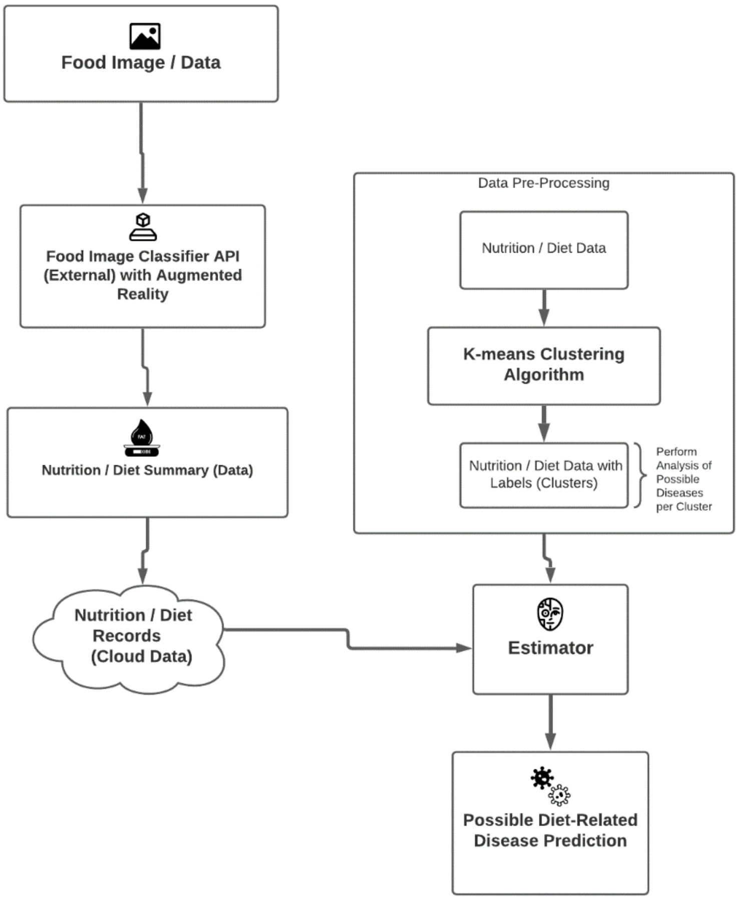


Figure 3.1 – Pipeline of the input and output data of the study

Figure 3.1 shows the pipeline of the input, processes, and output in the conduct of the study. It elaborates how food image data is transformed and recorded as nutritional components, collated as diet records until used for prediction or classification. The focus of this study is to predict possible diet-related diseases through an individual's nutrition/diet records.

The first and critical process in the pipeline is pre-processing a large amount of diet data by individuals, extracting the features targeted to be measured, and then feeding into an unsupervised clustering algorithm to generate groups that could be analyzed. The analysis would then be used as the estimator for prediction.

Subsequently, the development of an application that could take food images as input, visualize the then output data into a user interface through Augmented Reality, and store output data to cloud storage, would be done. Additionally, the application can interact with the estimator, feeding the stored output data from the cloud into it, and showing the prediction through the application's user interface.

IV. METHODOLOGY

4.1 Evaluation and testing of the k-means implementation

The K-means algorithm implementation is one of the initial requirements before the application's development. Since K-means is an unsupervised learning algorithm, pre-implementation optimization and initialization are done first before feeding the algorithm with unlabeled data. As mentioned, the data would come from the 2008 and 2013 National Nutrition Survey of Individual Dietary Component public use file provided by the Food and Nutrition Research Institute's (FNRI) e-Nutrition webpage.

During the pre-implementation of the algorithm, determining the optimal number of clusters would be done through two methods – The Elbow Method and Silhouette Method.

4.1.1 Elbow Method

Mahendru (2019) describes this method as the most used approach in determining the optimal number of *k* clusters. In further explanation, this is done through calculating the Within-Cluster-Sum of Squared Errors (WSS) for different values of k (number of clusters) and choosing the k where the decrease of the value of the WSS can be observed. Mahendru further explains what WSS is as –

- Each data point has a Squared Error, the square of the distance (e.g., Euclidean, Manhattan) of the point to its predicted cluster center.
- WSS is the resulting sum of these Squared Errors of all the data points.

This method would be more visible in Figure 4.1.1.

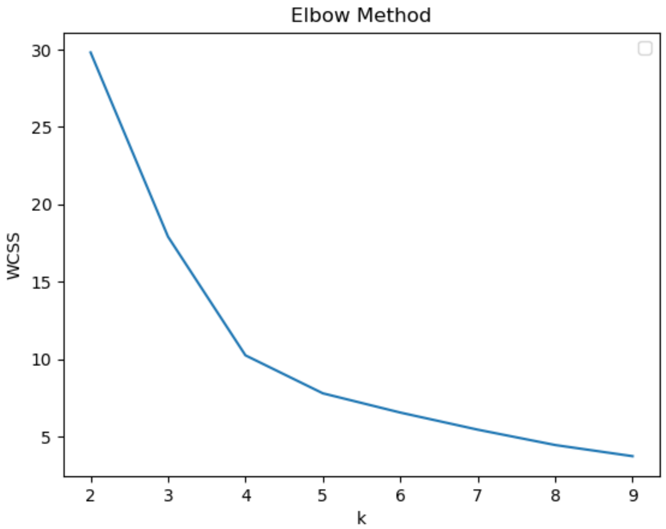


Figure 4.1.1 - An example of the Elbow Method plot

The WSS values are plotted against their respective values of k; at the value of k = 4, an 'elbow-like' figure can be observed from the plot, thus, called Elbow Method; k = 4, is the optimal number clusters. Further explanation of this method will not be discussed as this method has already been available to the machine learning framework (i.e., Sklearn) used in this study.

4.1.2 Silhouette Method

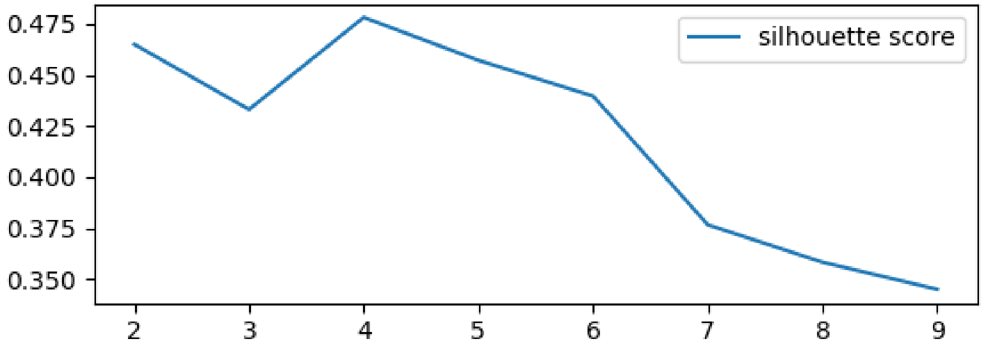


Figure 4.1.2 – An example of the Silhouette Method plot

The silhouette Method is another alternative in determining the optimal number of clusters during pre-implementation. This method validates the consistent data points within a cluster (Rousseeuw, 1987). Each data point would have a silhouette score ranging from -1 to +1, in which a higher value proves that a data point is at the correct cluster. At which k clusters have the highest score deemed the optimal number of clusters (Mahendru, 2019). This method is usually used whenever the Elbow Method does not present visible indications.

Figure 4.1.2 shows an example of how the process is evaluated through a plot diagram. The Silhouette scores are plotted against their respective values of k; the value of $k = 4$ clearly shows where the Silhouette score peaked, indicating the $k = 4$ is the optimal number of clusters.

After these pre-implementation procedures have been done and the acquired data has been fed to the unsupervised algorithm, a consultation with a professional and registered dietitian/nutritionist would verify and validate the results obtained. The insights of the consultation would then become the basis for the application's estimator.

4.2 Evaluation and testing of the food image classification

Fortunately for the researchers, a food image classification model of Filipino foods using the ResNet-34 architecture has already been implemented, then used as a base reference for implementing the classifier. In the implementation by Hatfield (2020), the image dataset used for training, validation, and testing were collected through Google image searches of different categories of Filipino food; the same method would be employed in this endeavor but was limited only to 15 food classes, using 100 images per category, totaling to 1500 images for training and validation of the classifier and about 1000 images for testing.

In addition, the researchers used two ResNet architectures, namely the ResNet-18 and ResNet-34 architectures. These two were compared through their resulting accuracies, and the architecture with the highest result was integrated into the application. To ensure the implementation's accuracy, the researchers employed a multi-class confusion matrix during the training and validation, as illustrated in Figure 4.2.1.

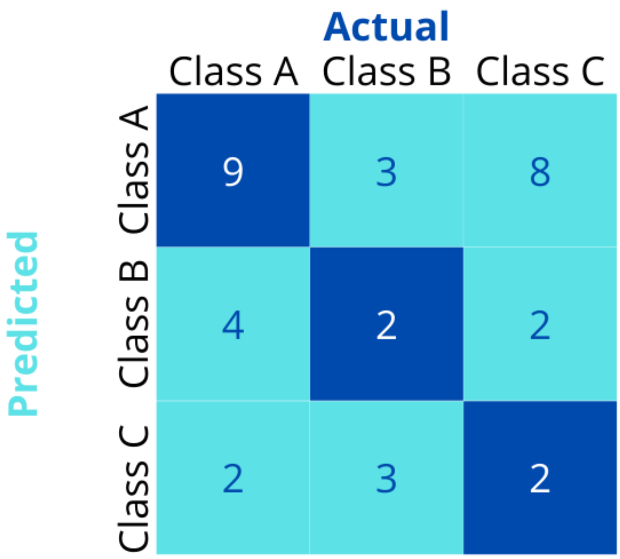


Figure 4.2.2 - An example of a Confusion Matrix for Multi-Class Classification

To assess the training and validation of the classifier, three metrics were used – Accuracy, Precision, and Recall. For the testing, only the Accuracy metric was considered. The values for Precision and Recall are computed using the values of True Positive (TP), False Positive (FP), False Negative (FN), and True Negative (TN) taken from the resulting confusion matrix.

The precision and recall of each class (food) were computed separately to assess how the classification model performs for each. Meanwhile, the researchers utilized the framework's built-in functions to provide the metric for accuracy.

$$Precision = \frac{TP}{TP + FP} \qquad (1)$$

As mentioned, the researchers would evaluate the precision for each class which reflects how well the classification model can predict each class. It is calculated by taking the ratio of a correctly identified positive sample of a class (TP) over the total identified positive samples (TP + FP); its equation is as shown in (1). (Tharwat, 2021)

$$Recall = \frac{TP}{TP + FN} \qquad (2)$$

Meanwhile, each class (food) recall reflects how well the model correctly identifies True Positives from the samples of a class. The recall is calculated by getting the proportion of correctly identified positive samples (TP) and the total positive samples (TP + FN) as shown in (2). (Tharwat, 2021).

This study's Precision and Recall metrics were only used to provide more details for the classification model's performance. The model would be mainly assessed through its resulting accuracy.

V. STATISTICAL ANALYSES AND RESULTS

5.1 Diet Prediction through k-means algorithm

For this section, the results were derived from the outcome of applying the K-means algorithm to the compiled individual diet dataset and the data analyses and interpretations of the researchers from that outcome.

5.1.1 Elbow Method

As explained before on how to execute the Elbow method and its purpose, it is done by computing the WSS values of each cluster in a trial. The researchers observed the computed WSS values up to 10 clusters and then used a scatter plot to visualize its values better.

Table 5.1.1 – Within Sum Squared Table (Elbow Method)

No. of Clusters	WSS
1	283.288207
2	164.150810
3	128.021281
4	101.738704
5	85.568221
6	75.820306
7	67.778540
8	62.465122
9	57.755075
10	53.579361

Table 5.1.1 shows the WSS values from one to ten clusters. It can be observed that each cluster's resulting values are just gradually decreasing and that there is no evident sharp decrease. These values can be expected from the pair plot of the dataset's features (macronutrients) and the 3D plot of the data points since there was no observed correlation between the features and there are no visible clusters on the 3D plot.

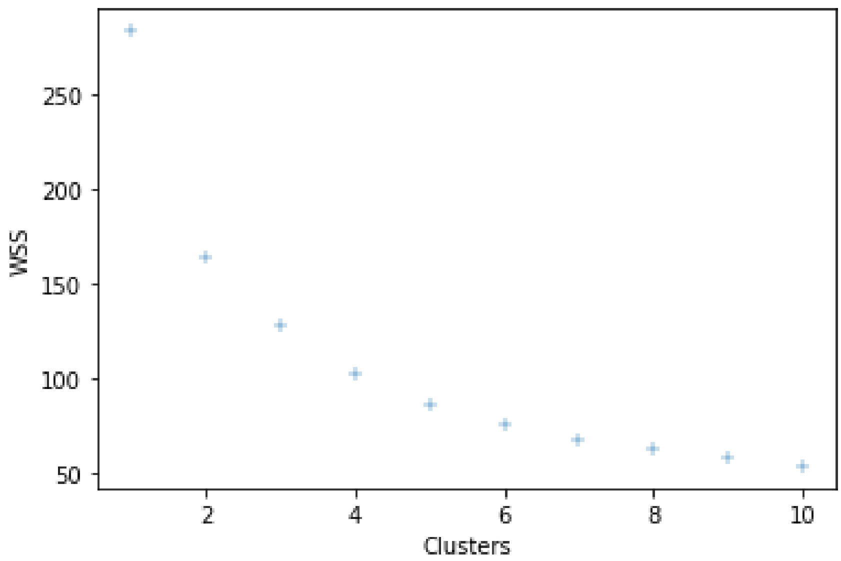


Figure 5.1.2 - Plot of the WSS for the Elbow method

The scatter plot in Figure 5.1.2 supports the findings from the previous table visually, wherein the WSS values are plotted against their respective clusters. As the name of the method implies, the point in which there is an ‘elbow-like’ feature in the plot is the optimal number of dataset clusters. Although choosing the number of clusters would not be validated; thus, another method was employed.

5.1.2 Silhouette Method

Another method used was the Silhouette method since the Elbow method did not produce convincing results for optimal clusters. The researchers again plotted the silhouette scores from the range of three to ten clusters. The highest value among the scores would be the number of clusters.

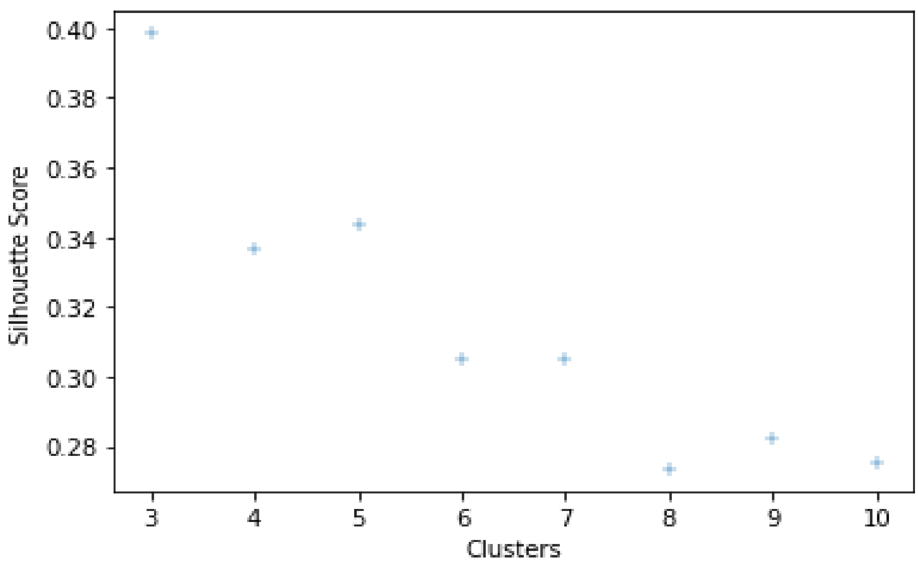


Figure 5.1.3 - Silhouette Score scatterplot

To better visualize the silhouette method, the researchers plotted the silhouette scores against their respective clusters using a scatterplot. Figure 5.1.3 shows that the cluster with the highest silhouette score comprises three clusters. It would also be notable that having 5 clusters could be acceptable as its score is the second-highest. However, for this instance, the researchers used three clusters to group the data points, resulting in the highest silhouette score.

Table 5.1.2 - Cluster centers of the dataset and its observations

Cluster	TOTAL_CHO (g)	TOTAL_PROT (g)	TOTAL_FAT (g)	Observations
0	250.035500	45.286496	22.187317	Low CHO, Below AVE Protein, and Fat
1	481.191680	76.751556	27.621369	High CHO and Protein, Below AVE Fat
2	415.050259	101.943498	86.178201	All High

After determining the number of clusters, the following values in Table 5.1.2 shows the observations from the clusters formed after the algorithm processed the dataset.

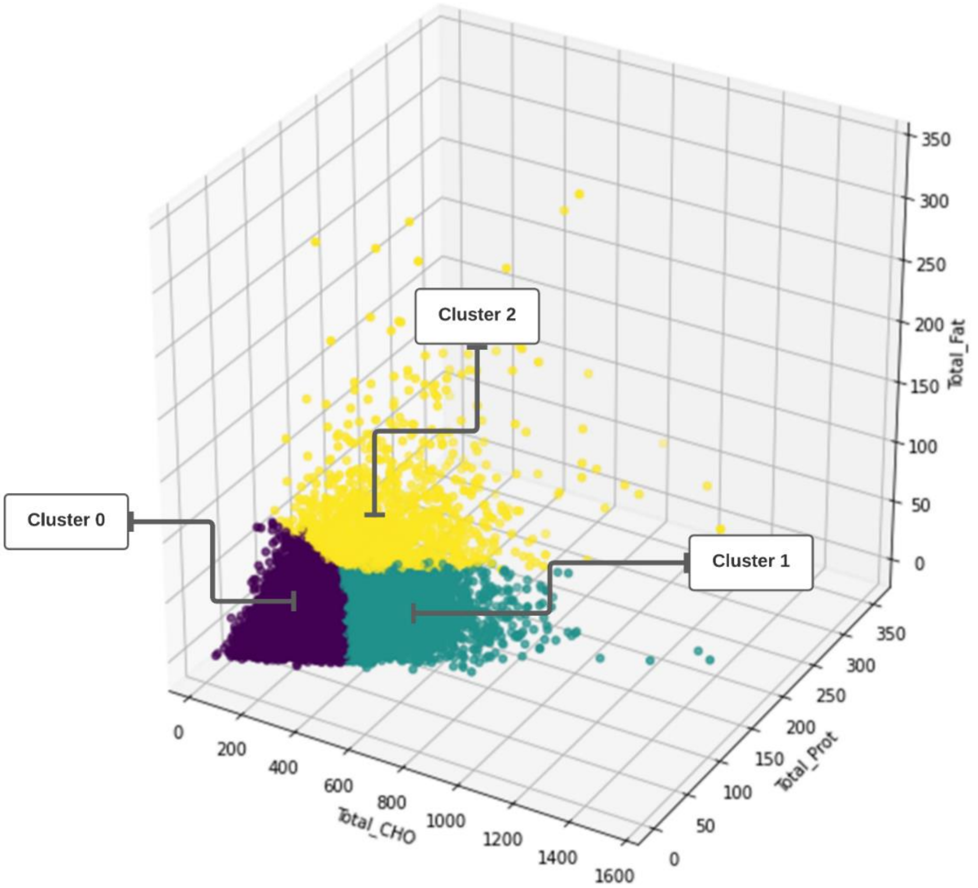


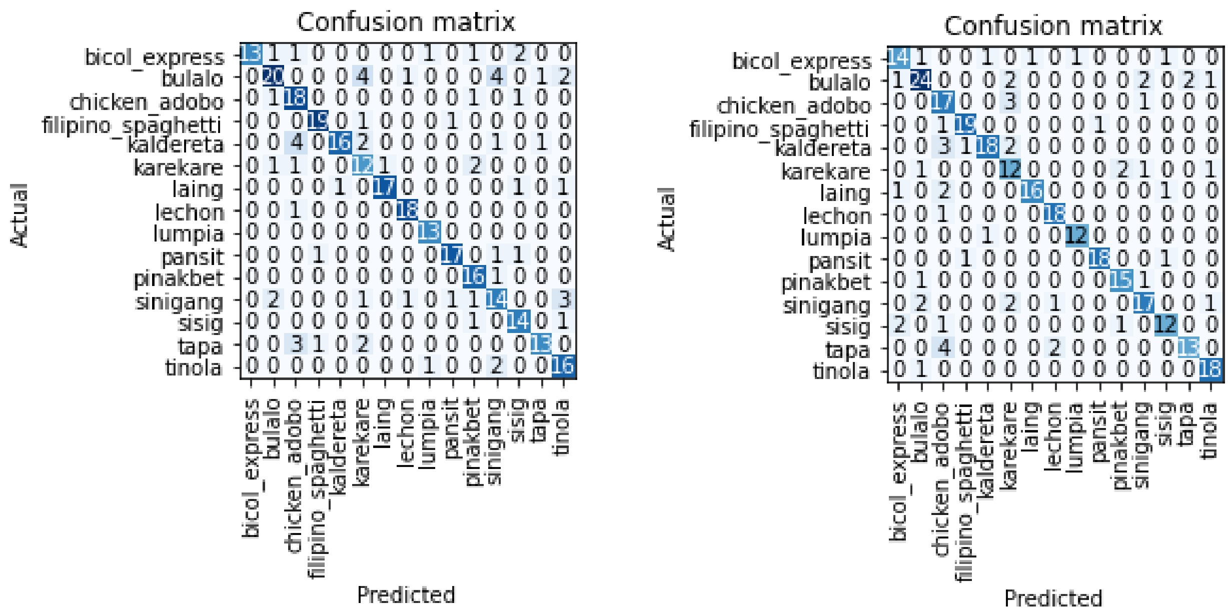
Figure 5.1.4 – Labeled 3D plot of the dataset and its cluster

The 3D plot in Figure 5.1.4 visualizes how the dataset has been divided into three clusters through the different colors of each data point – 0 (dark violet), 1 (blue-green), 2 (yellow). It is noted that even though the Silhouette method determines the number of clusters, the clusters from the 3D plot are still not conclusive enough to provide differentiation from one data point to another.

5.2 Image classification

In this process, to determine what Convolutional Neural Network (CNN) structure, specifically the ResNet architecture, would be suited to be integrated into the application, the researchers compared the performance of two architectures, namely the ResNet-34 ResNet-18 architecture, in classifying Filipino food images. These architectures are already pre-trained using ImageNet images and have been widely used for image classification.

As the name of these architectures implies, the number attached to it indicates the number of layers the CNN has; ResNet-34 has 34 connected layers, meanwhile 18 for ResNet-18.



(a) (b)

Figure 5.2.1 – (a) Confusion Matrix result for ResNet-34; (b) Confusion Matrix result for ResNet-18

After each ResNet CNN architecture has undergone cyclic training, Figure 5.2.1 is the resulting confusion matrix for each. Meanwhile in Table 5.2.1 shows the precision and recall of each class (food) per ResNet architecture derived from the confusion matrices in Figure 5.2.1.

Table 5.2.1 - Precision and Recall of each class (food) per ResNet architecture and its macro-average

Class (food)	**ResNet-34**		**ResNet-18**	
	Precision	Recall	Precision	Recall
Bicol express	100%	68.4%	77.8%	73.7%
Bulalo	80%	62.5%	80%	75%
Chicken adobo	64.3%	85.8%	58.6%	81%
Filipino Spaghetti	90.5%	90.5%	90.5%	90.5%
Kaldereta	94.1%	66.7%	90%	75%
Kare-kare	54.5%	70.6%	57.1%	70.6%
Laing	94.4%	85%	94.1%	80%
Lechon	90%	94.7%	85.7%	94.7%
Lumpia	86.7%	100%	92.3%	92.3%
Pansit	89.5%	85%	94.7%	90%
Pinakbet	72.7%	94.1%	83.3%	88.2%
Sinigang	60.9%	60.9%	77.3%	73.9%
Sisig	73.7%	87.5%	80%	75%
Tapa	86.7%	68.4%	86.7%	68.4%
Tinola	69.6%	84.2%	85.7%	94.7%
AVERAGE	80.51%	80.29%	82.25%	81.53%

For the ResNet-34 architecture, among the food classes that it can classify, the class for Bicol express followed by *laing* has the highest precisions of 100% and 94.4%, signifying that the ResNet-34 classifier can mostly predict these classes of food. Meanwhile, in terms of recall, *lumpia* is the highest with a value of 100%, followed by both *Lechon.* This signifies that the classifier could correctly identify and label samples of these classes. This classifier poorly predicted samples in the class of *kare-kare* with only a 54.5% precision. While, in terms of recall, the class of 'sinigang' was mostly misclassified as other classes with only 60.9%. Thus, this classifier performs worst among these classes in terms of prediction and identification.

Meanwhile, for the ResNet-18 architecture, *pansit* is the class with the highest precision followed by *laing*,with values of 94.7% and 94.1%, respectively, predicted by the classifier. The classes with the highest recall values are 'Lechon' and *tinola* 94.7%. Like the results from the ResNet-34 architecture, the classifiers can predict samples of *laing* well. The worst precision is predicting samples of *kare-kare* with only a value of 57.1%, while *tapa* has its recall value being the worst with a 68.4% value only.

Table 5.2.2 – Comparison of the accuracy between ResNet-34 and ResNet-18 architecture

ResNet Architecture	Training and Validation Accuracy	Testing Accuracy
ResNet-34 classifier	78.67%	78.34%
ResNet-18 classifier	81%	80.44%

Table 5.2.2 shows the resulting accuracy of the two ResNet architectures based on the researchers' metrics gathered from the training, validation, and testing. The ResNet-18 classifier yielded better results than the ResNet-34 classifier. Even though the ResNet-34 has more layers than the ResNet-18, it outperformed by a margin of 2% during training and validation and about 2% during testing. This result can be attributed to the difference in the number of epochs the researchers trained on each classifier.

VI. CONCLUSIONS

6.1 Diet prediction through K-means algorithm

To provide conclusions for the diet prediction using the K-means algorithm, the researchers provided observations of the results and validated them to a registered nutritionist/dietitian. These findings were then used and integrated into the application developed.

Table 6.1.1 – Mapping of each cluster and its corresponding list of diseases

Cluster	The intensity of Physical Activity	Diseases/Risks	Probability
0	LOW	Low to no risk of Malnutrition	LOW/NONE
	MODERATE	- Risk of Malnutrition (Protein-Energy Malnutrition, Underweight/Wasting)	LOW
	VIGOROUS	- Risk of Malnutrition (Protein-Energy Malnutrition, Underweight/Wasting)	HIGH
1	LOW	Overweight	LOW
	MODERATE	Nutrition-Related Health Risk	LOW
	VIGOROUS	Micronutrient Deficiency - Fat-Soluble Vitamins	LOW
2	LOW	- Cardiovascular Diseases - Renal Diseases - Obesity	HIGH
	MODERATE	- Cardiovascular Diseases - Renal Diseases - Obesity	LOW
	VIGOROUS	Low to no risk of diseases as mentioned above	LOW/NONE

Table 6.1.1 shows the validated findings and mapping of the general groups of disease per cluster and probabilities from the registered nutritionist/dietitian. It must be noted that each cluster was then subdivided into three more categories indicating the person's intensity of physical activity. As discussed in the previous chapter, the algorithm's results do not present convincing results; thus, the researchers concluded that the K-means algorithm is not the proper algorithm to be used for analyzing the macronutrients of the diet data of a person.

6.2 Image classification

Based on the resulting values from Table 5.2.1 and Table 5.2.2, in terms of the macro-average for precision and recall, the ResNet-18 architecture proved to have performed better in identifying 15 classes of Filipino foods, with resulting values of 82.25% and 81.53% respectively. Furthermore, its accuracy, performed 2% better than the ResNet-34 architecture. The researchers then concluded that the ResNet-18 classifier would be integrated into the mobile application.

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Chapter - 7

Image Processing Modalities & Principles Involved in Disease Diagnosis and Prognosis

Dr.S.Rajalaxmi

Associate Professor & Head, Department of Biomedical Engineering, Mahendra College of Engineering, Salem. Tamil Nadu.

Abstract— Image Processing is a prominent tool which supports medical experts to probe in effectively with their diagnosis and prognosis procedures. Imaging human body have been developed prominently in the last two decades and had aided many decision support systems. This had also proved in curing multiple diseases which was a challenge in the past. Imaging is done in human body at various modalities and is categorized based on images produced. Ultrasound Imaging, Magnetic Resonance Imaging, X-Rays, Computed Tomography, Positron Emission Tomography and Single Emission Photon Emission Computed Tomography are the mostly utilized medical imaging modalities. They play a vital role in supporting medical experts with high precision accuracy in visualizing the internal organs and tissues. In imaging, artefacts are a major issue in capturing the expected image and position of the organ or tissue or a cell in the human body. For accurate diagnosis, lucid imaging details of the region of interest are required to read the minute details of the affected organ/cell/tissue. Researchers have contributed multiple noise filtering algorithms and some of the algorithms are accommodated with the imaging system. This will provide a filtered image thereby aiding the medical experts with clear picture in diagnosing the disease from the region of interest. The boom of Artificial Intelligence is a dominant support in future medical imaging modalities as it is surpassing the critics in the current time. It has the capability to process enormous quantity of medical images with high precision and accuracy and with fine details that are invisible in naked eyes. The roaring development of Artificial Intelligence in medical imaging will provide medical experts with value added task and will thereby enhance patient interaction times.

Keywords— Medical Imaging, Radiology, Artefacts, X-Rays, CT, PET, Ultrasound, MRI, fluoroscopy, Imaging modalities, Artificial Intelligence in medical imaging

Medical Imaging dates back to its primary discovery from X-rays 120 years ago. Today's technology and researches had supported medical experts with intricate details of the area being diagnosed with trivial imaging. The invention of X-rays followed by other imaging modalities has shown a cease to surgeries just for the purpose of diagnosis. The evolution and development of different imaging platforms have proved themselves in their own significant means in predicting the diseases at an early stage and thereby concentrating on sustained prognosis.

I. ECCENTRIC HISTORY OF MEDICAL IMAGING

The concept of imaging the internal organs began in the year 1895 by Wilhelm Rontgen who produced images on photosensitive plates by passing ionizing radiation inside the human body. This was indeed a great discovery as it penetrated the tissues with different densities and produced results of abnormalities in the regions of interest [1]. With further thirst of research in peeping inside organs and blood vessels, a pharmaceutical contrast agent was developed in 1900's. Moving organs were visualized with the passage of radio opaque dye and this was another evolution in radiology. This gave rise to Fluoroscopy [2]. Pathology diagnosis further evolved with the infusion of radio nucleotides in the pathway of interest into the organs or group of cells. This was pictured by gamma cameras in the year 1950's and provided still more better results and aided medical experts with fine details. The usage of sonar in World War II had drawn its attraction in the medical field where, high frequency sound waves are made to be penetrated through probes inside human body. These waves are reflected back on the intervention of objects in the path way and are collected with different frequency electric pulse which are produced as Ultrasound images on screen. A sparkling revolution in the history of medical imaging was created with the development of a series of cross-sectional views of soft tissues which are reconstructed with computing algorithms to frame an image. This was the invention of Computed Tomography (CT) in the year 1971 which is remarkable to be noted as the first digital imaging technology based on X-ray [3]. To create further lucidity in imaging and with the utilization of magnetic resonance, there came the astounding development of Magnetic Resonance Imaging (MRI) which incorporated super conducting magnets for performing functional imaging of the tissues [4]. This embarked a new path in the journey of medical imaging modalities and in the handling of pathology diagnosis in still better notion.

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II. IMAGING MODALITIES

The imaging techniques are governed by the principles that are utilized along with the energy sources and it is where the principle lies in imaging / spanning the cells, tissues and organs.

2.1 X-Ray Imaging

X-Rays – claimed to be the key basis for the innovations in medical imaging was an accidental discovery by Wilhelm Rontgen in the year 1895. This was started when he tested penetration of cathode rays in glass. He discovered some unknown rays and hence named them as X-Rays which had the capability of passing heavy objects and leaving shadows of solid objects. His discovery was trailed by the penetration of X-Rays into human bones and soft tissues. The discovery of X-rays had proved to be a salient tool for medical experts as this had lead to non-invasive and painless diagnosis procedures. This was dignified as an era in medical field that had made doctors to plan their surgical procedures, blood clot treatments, tumour treatments and others more precisely which incurred more time and risks prior to X-rays. Figure 1 shows the process of image capturing from a patient.

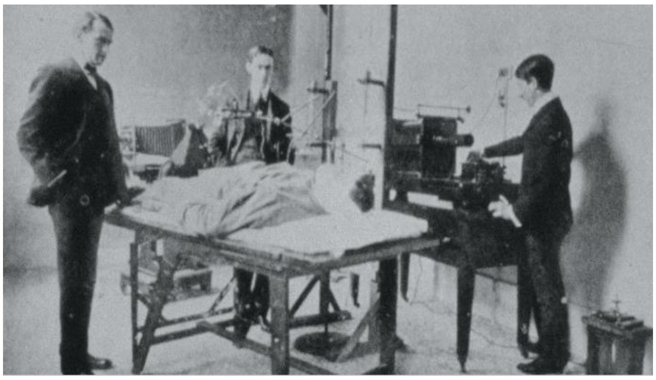
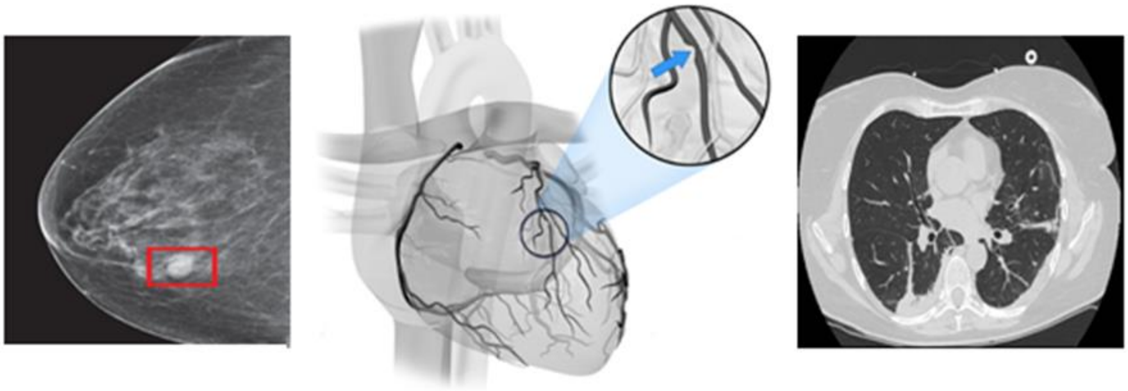


Figure 1: X-Ray Machine capturing Images from a patient (Image Courtesy: Johnson & Johnson Archives)

There are some imaging techniques which utilize ionizing radiations for producing images from the regions of interest. Radiography, Fluoroscopy and Computed Tomography are the imaging techniques which utilize ionizing radiations. These imaging techniques work on the principle of passing X-ray beam into the area of focus where some rays are absorbed and the remaining are scattered to an image capturing film. Based on the purpose, the imaging technique differs with the number of X-rays and the strength of ionizing radiation passed inside the area of interest.

Mammography is radiography based imaging technique where gamma rays are utilized for capturing single static image for future evaluation. Fluoroscopy is a continuous projection of beam of X-rays on the region of interest in real-time where a dyeing agent will be passed for continuous monitoring of the region. This will be procured during placement of implants or stents in cardiac or intestinal areas. Coronary angiography is an example for fluoroscopy which implements a balloon type catheter to blast blood vessel blockages. Computed Tomography utilizes a series of X-ray beams around the human body to capture slices of images pertaining to blood vessels, tissues and bones. These images are entitled to reconstruction via mathematical procedures for getting detailed screen of the affected area. This will provide more intricate details to support the diagnosis procedure. The main drawback of the utilization of X-rays in the human body is that continuous exposure to these radiations will perk the patient towards cancer in the future.



(a) (b) (c)

Figure 2: Images obtained via Mammography (a)[x], Fluoroscopy (b) & Computed Tomography (c)

It has been faceted that high energy radiations including gamma rays, X-rays, alpha rays, beta rays and nucleotides exposure on patients will cause damage to their DNA provoking possibilities to cancer [5]. This depends on factors like patient's age, sex, organ exposed to radiations and the quantity of radiation. However the benefits obtained from X-ray imaging and other ionizing radiation based imaging outrages the minor disadvantages caused by the radiation exposure. Figure 2 shows the images obtained from mammography.

2.2 Ultrasound Imaging

Ultrasound imaging is yet another remarkable evolution in the field of medical imaging which utilizes sound waves of frequency more than 20 kHz. This is a non-invasive imaging technique that overcomes the drawbacks wrapped by ionizing radiations. Nowadays, the transducers incorporated in ultrasound imaging utilize sound waves with threshold values in the range of Megahertz [6]. The jellied transducer probes are placed on the patient's skin in the region of interest to transmit the ultrasound waves. The waves are reverberated from the objects in the transmitted pathway of sound waves. For improving the quality of image the transducer probes may be placed inside blood vessels, vagina or gastrointestinal tract. Ultrasound imaging is a very useful diagnostic procedure for predicting the growth of foetus in the mother's womb. Figure 3 shows the cross-sectional view of a Foetus in the mother's womb.

Figure 3: Ultrasound Image - Cross-sectional view of Foetus
(Courtesy: Philips Healthcare-iu22xMatrix System)

The sound waves that are reverberated are formed as images which are used for diagnosis and examinations of the affected region. Kidneys, liver, gall bladder, heart, blood vessels, intestine, uterus, ovaries, brain in infants are some of the examples which are examined with the help of ultrasound imaging. Conventional ultrasound imaging was available only in 2D form and now, to improve the details captured, 3D and 4D ultrasound imaging have been developed.

2.2.1 Ultrasound

Ultrasound - being the high frequency waves that are above the frequency of human hearing was first predicted by an Italian Biologist, Lazzaro Spillanzani during the 16th century. This prediction was made by him from bats which navigated in nights for search of its prey with the help of its high frequency sound and this is shown in figure 4. During its navigation the prey was identified based on reflection of the high frequency sound waves which was discovered as Ultrasound [7].

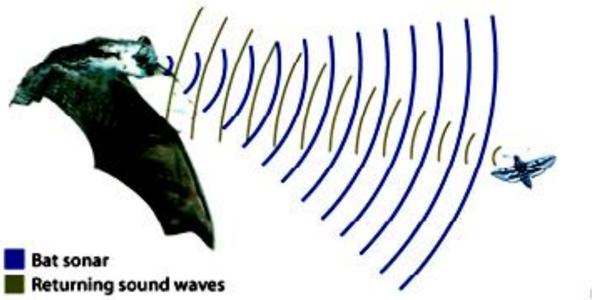


Figure 4: Prey Identification by Bats using Ultrasound [7]

Karl Dussik and his brother can be known for their first ever diagnostics using ultrasounds in the year 1946 to predict brain tumour and their corresponding cerebral ventricles. But the authoritative procedure for visualizing human organs was done by George Ludwig in the year 1949 who witnessed gall bladder stones.

2.2.1.1 Transducers – Ultrasound Imaging

Ultrasound is an acoustic energy with a frequency greater than the human hearing capacity. This principle is utilized to generate non-invasive medical images without the intervention of ionizing radiation. The technique is used for the purpose of imaging and therapeutic diagnosis. The required ultrasound waves are produced by piezoelectric transducers. These transducers work on the principle of converting electric potential into mechanical pulses and vice-versa. The ultrasound transducer can detect the reverberated ultrasound waves and also transmit ultrasound waves. When a transducer probe is placed on the skin in the region to be monitored, the transducer will transmit the ultrasound beam. Partial beam is attenuated by the tissue boundaries and are reflected to the transducer. The transducer will capture the echoes in the form of electric pulses and are transmitted to the ultrasound scanner [6]. Based on the time taken by the echoes to return to the transducer, the scanner will calculate the distance to the tissue boundary. The distances are calibrated in the form of 2D echo images. Usually a sterile gel is used on the skin when the probe is placed on the human body to transmit the ultrasound waves effectively without blockage by air sacks.

2.2.1.2 Categories of Ultrasound Imaging

Ultrasound plays a major in diagnostic and therapeutic procedures. Diagnostic Ultrasound is the general procedure used for scanning the internal organs non-invasively with the help of transducer probes. Current evolution in the medical field had developed the scanners to operate at higher frequencies in the range of megahertz. Based on diagnostic procedure, sterile probes can also be placed inside the body to enhance the image quality. Diagnostic ultrasound is further divide into anatomical ultrasound and functional ultrasound. Anatomical Ultrasound is designed to produce the images of internal organs with a scanner arrangement. Functional ultrasound will image the functions of tissues based on the movement of blood in the tissue, physical characteristics, and texture of tissues which will provide intricate details on the changes related to functioning of an organ.

Therapeutic Ultrasound will utilize ultrasounds for the purpose of therapy and is not entitled to produce images. The applications are wide-spread to move a tissue location, destroy a tissue, dissolve blood clots, heating a tissue and for drug delivery. The core purpose also stands to destroy dead cells with the help of high-intensity beams for curbing tumour cells from the expected region. Ultrasound scanning stands with its merits of being a non-invasive technique with no exposure of patients to ionizing radiations.

2.3 Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging is a non-invasive pervasive imaging technique which utilizes strong magnetic field and radio waves for the construction of images of the internal organs and tissues. Raymond Damadian, an American physician is the father of Magnetic Resonance Imaging who discovered that Nuclear magnetic resonance could be used to differentiate the cells in the body.

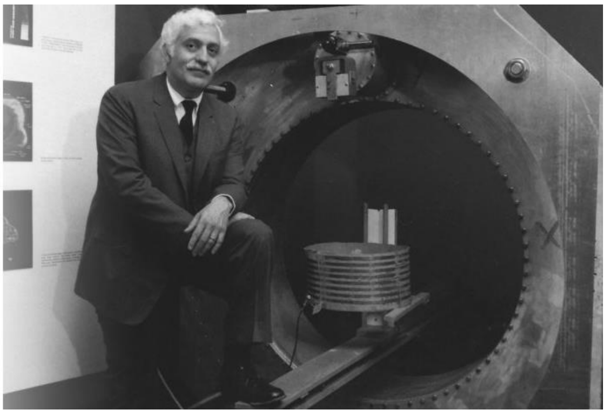


Figure 5: Dr.Raymond Damadian with his early prototype MRI machine [8]

He discovered that magnetic signals are visualized differently in normal cells and cancerous cells. This paved a path for the discovery of Magnetic Resonance Imaging with the principle of aligning hydrogen atoms in the human body. The first ever MRI scan was performed by Dr.Raymond Damadian in the year 1977 and the prototype model shown in figure 5 is available in the Hall of Medical Sciences, Smithsonian Institution, the United States [8]. MRI scanning machine is made of a big tube arrangement placed with strong magnets that are responsible for producing magnetic field. The images formed with MRI scan are used for diagnosis and prognosis of diseases. The scanner could be utilized to examine any parts of the body including brain, bones, pelvic region, breasts, uterus, joints, heart, blood vessels, liver, prostrate glands etc. This is a significant imaging technology which constructs 3D images with anatomical facts [9].

2.3.1 Superconducting Magnets in MRI

The images produced by an MRI scanner primarily depend on the static magnetic field produced by the magnet. Initially resistive magnets of 0.3 Tesla were used and it was subsequently replaced by superconducting magnets with field strengths ranging from 0.35 Tesla to 0.6 Tesla. The utility of superconducting magnets proved to suppress fat homogenously in the images and provide more intricate imaging of spine and liver [10]. Currently Cryogenic Superconducting magnets operating in the ranges of 0.5 Tesla to 1.5 Tesla are used for diagnostic purposes. The magnets are usually cooled to absolute 0 Kelvin with the help of immersion of magnets in liquid helium to enhance the conductivity nature of magnets. Researches are being carried out for utilizing 3 Tesla magnets for improvising the image quality with better signal to noise ratio, spatial and temporal resolution, spectral resolution and quantification [11].

2.3.2 Working Principle – MRI

As the human body is composed of 70% water, the protons present in the water molecules are aligned to the strong magnetic field exerted by the superconducting magnets in the MRI scanner. Followed by the alignment of the protons with the magnetic field, a radiofrequency pulse is responsible to stimulate the protons and pull against the magnetic field. The MRI sensors bedded inside the scanner captures the energy released by the protons when the radiofrequency pulse is turned off. The time taken by the protons for the realignment with the strong magnetic field and based on the amount of energy released during alignment of protons is characterized as images [9]. To acquire brighter images, patients may be injected with contrast agents like Gadodiamide which will increase the speed of realignment of protons with the magnetic field. This will improve the quality of image.

2.3.3 T1, T2 Relaxation Time

The Magnetic Resonance image has varied signal intensities. The signal intensity determines the image quality and provides with diagnosis features for the medical experts. The signal intensity depends on the density of the protons in the region of interest, T1 relaxation time, T2 relaxation time and flow. Proton density refers to the quantity of protons present in the tissue which encompasses water molecules and fat. The relaxation time taken by the protons to revert to thermal equilibrium in order to realign with the magnetic field immediate to radiofrequency pulses are termed as T1 and T2 relaxation times [12]. Flow is an artefact resulting in loss of signal which is due to the rapid flow blood. Figure 6 shows the sample T1 and T2 weighted images affected by hypertensive intracranial haemorrhage.

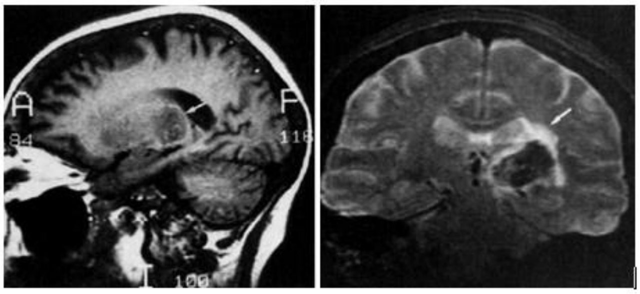


Figure 6: Sagittal T1-weighted MR Image (left) & Coronal T2-weighted MR Image (right) of Hypertensive Intracranial Haemorrhage [12]

This relaxation which is longitudinal or transverse are designated as Spin Lattice Relaxation (T1) and Spin Relaxation (T2) respectively. Lattice represents the environment of the nucleus and the removal of radiofrequency pulse results in energy dissipation inside the lattice. The time taken by the protons to release and attain 63% of the thermal equilibrium after the removal of radiofrequency pulse is represented as T1. The time required to image water and cerebrospinal fluid is around 3000 to 5000 ms and this appears dark on T1 weighted images. The image acquisition for fat requires around 260 ms and this short timing makes them appear brighter on T1 weighted images. The spin lattice relaxation (T1) timing could be modified by varying the radiofrequency pulse durations. When the radiofrequency pulse is relaxed, there is an energy transfer process among the nuclei causing reduction in the field direction with arbitrary changes in the alignments in the transverse vector. This gives rise to T2 relaxation time [11].

The pulse sequences are characterized by T1 weighted and T2 weighted sequences. A T1 weighted image is obtained with short (<1000 ms) repetition time (TR) and short (<30 ms) echo time. A T2 weighted image is obtained with long (>3000 ms) repetition time and long (>80 ms) echo time. Figure 7 shows the pulse sequences required for T1 and T2 weighted images.

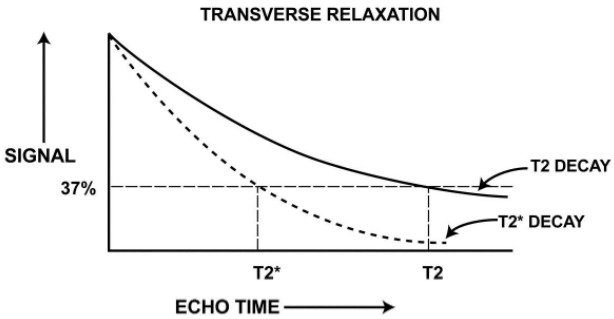


Figure 7: Pulse Sequences of T1 & T2 Weighted Images [12]

Brain related pathologies and intracranial diseases suspected are clearly screened with the help of T2 weighted images. T1 weighted images are required for the prediction of haemorrhage, lipoma and dermoid [12]. Table 1 shows the Magnetic

Resonance image intensities in T1 and T2 weighted images. It indicates the image intensities that are obtained on pathologic lesions.

TABLE 1: T1 & T2 WEIGHTED IMAGES – MR INTENSITIES [12]

Feature	T1 Weighted Image	T2 Weighted Image
Solid Mass	Dark	Bright
Cyst	Dark	Bright
Subacute Blood	Bright	Bright
Acute and Chronic Blood	Gray	Dark
Fat	Bright	Dark

2.4 Computed Tomography (CT)

Computed Tomography – being an important decision support system for medical experts was first designed in the year 1974 by Godfrey Hounsfield. The imaging modality utilizes ionizing radiations as already mentioned in section 2.1. With further developments in technology, mathematical calculations had allowed it evolve into 2D informative images. The CT scanner produces image slices by positioning the patient inside a round tube where X-rays are allowed to penetrate surrounding the body [13]. The dominant advantage of CT imaging modality is that the cross-sectional view of the region of interest is clearly portrayed whereas a plain film of image is obtained in X-ray modality. The amount of ionizing radiation on the patients becomes a threat as it may lead to cancer in future. But it is authorized that cumulative dosage of 100 milli Sieverts (mSv) on a patient is not advisable and the medical team is responsible to maintain reasonably low radiation exposure for the welfare of the patients [14]. The giant requisite of this imaging modality to visualize and diagnose diseases, nullifies the meagre throwbacks set on the technique. It has been a dominant tool in decision making by the clinicians, treatment of cancer, trauma, and treatment of cardiac diseases, injury and stroke and has the impact of allowing the medical experts to perform authenticated decisions on the findings. This imaging modality had reduced the need of many probing surgeries for just the need of decision making from 13% to 5%.

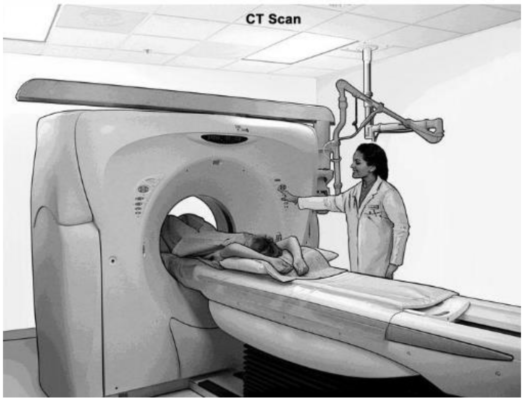


Figure 8: Abdominal CT Scan performed on a patient [13]

The high spatial resolution and minimal scanning time has attracted the utility of CT scan to a major level. From its inception the growth of CT scan requirement is oozing in millions and a report notifies that around 279 candidates per 1000 inhabitants undergo CT scanning in the United States which sums to be the largest count as per the year 2019 and Korea with the second largest count of 249 per 1000 inhabitants [15]. Figure 8 shows the CT scanner performing abdominal scanning on a patient with a clinician.

2.4.1 CT Scanners

With the enormous development of technology, the scanning time taken by the CT scanner has hardly reduced to minutes and even seconds in recent evolution. Also the spatial and temporal resolutions of the images are greatly enhanced in recent times.

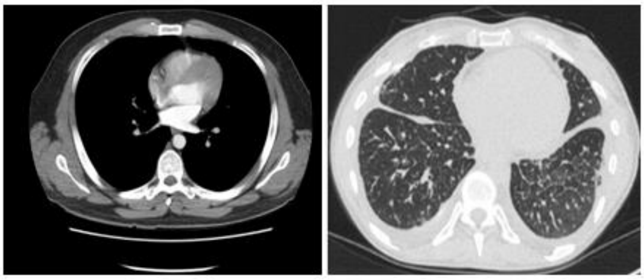


Figure 9: Normal CT Chest (left) and Abnormal CT chest (right)[16]

Figure 9 shows the CT images of normal and abnormal chest scan. Helical scanners are developed using slip ring technology and multi slice scanners are available nowadays with instant imaging facilities and improved resolution standards [16].

2.4.1.1conventional CT Scanner

In the conventional scanners, the patient is made to lie on a tube arrangement and the tube will produce a narrow beam of X-rays. These rays will probe the patient and the output is collected with the help of row of detectors. The tube and the detectors are made to rotate round the patient in clockwise and anticlockwise directions one second each. Each rotation is responsible of capturing an image of slice thickness 1 cm. After scanning a particular portion, the patient is made to move to the next segment of the tube for scanning the next slice of image [16]. In this method of conventional scanning, the scanning time is much slower and is affected by artefacts due to movement of patient. Also this scanner is lacks contrast of image and there is a possibility of missing small lesions in between slices. Conventional scanners find their utility in non-contrast examinations of vascular imaging as it does not require speed in imaging.

2.4.1.2 Helical/Spiral CT Scanner

This type of CT scanner incorporates slip ring technology which enables the tube rotation in a single direction. This simple change in technology had made CT scanning with an outraging importance in the medical field.

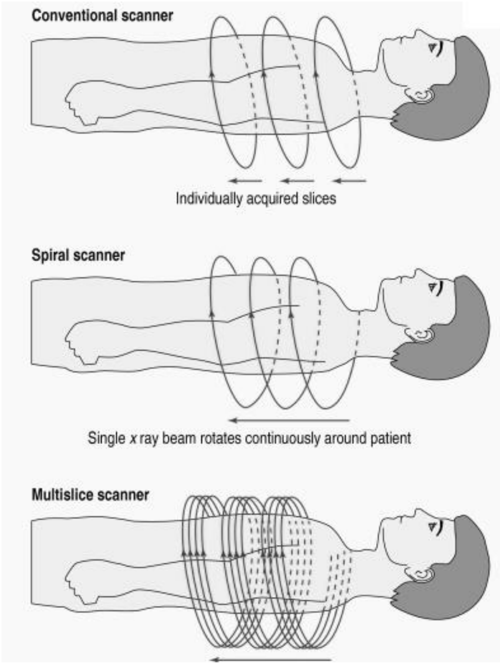


Figure 10: Evolution of CT Scanners[16]

In this scanner, voluminous tissue regions are scanned rather than slice by slice scanning. Axial slices of images are produced after mathematical reconstruction of slices in all planes including sagittal, oblique and coronal planes. Spiral or helical scanning requires short period for scanning when compared to conventional scanners. This allows good quality scanning and image reconstructions in all possible planes and the possibility of missing small lesions between slices are avoided. Figure 10 shows the scanning in the different types of CT scanners.

2.4.1.3 Multislice CT Scanner

Multislice scanner is a multi detector scanner and is explained as a turbocharged spiral scanner. Single row of detectors are employed in conventional and spiral scanners whereas multi rows of detectors are utilized simultaneously in this scanner. Currently, scanners with 8 rows of detectors are available and the images produced via these scanners are with high efficiency and reliable by the clinicians. GE Medical Systems is to produce scanners with digital detectors on flat panels [16]. This increase in the number of detectors will facilitate the coverage of volume of tissues at much faster rates and provide good resolutions. These multislice scanners owns the merits of faster data acquisition with precise slice reconstruction, low movement artefacts, slice reconstruction in all planes, improved imaging viability and good spatial resolution. Figure 11 shows the CT images of the Chest acquired from a multislice scanner, spiral scanner and a conventional scanner. The images could easily differentiate the quality of details that needs to be acquired by medical practitioners.

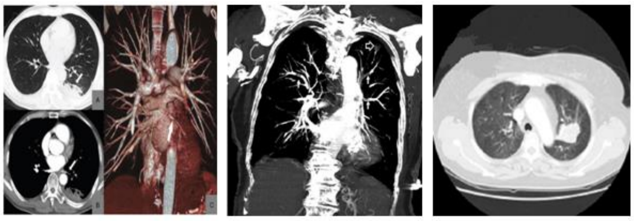


Figure 11: Multislice CT Image of Chest (left), Spiral CT Image of Chest (middle), Conventional CT Image of Chest (right)[16]

The images are constructed by a CT scanner in terms of pixels which are directly related to the radio sensitivity. The pixel intensity differs based on the tissue content and density. These measures are denoted using Hounsfield units [13]. Iodine is used as a contrast agent for clear identification of blood vessels, tumours and other infections. Table 2 shows the varied Hounsfield units that are interpreted by the tissue contents [17]. Hounsfield scale is defined on the ratio between difference of attenuation of X-ray in the given voxel and attenuation of water to the attenuation of water multiplied by 1000.

TABLE 2: TISSUE DENSITY IN HOUNSFIELD UNITS [17]

Tissue Density	*Hounsfield Units(HU)*
Water	*0*
Air	*-1000*
Bone, Calcium, Metal	*1000*
Haemorrhage	*60 to 100*
Fat	*-30 to -70*
Muscle, Soft Tissue	*+20 to +40*
Gray Matter	*35*
White Matter	*25*
Punctuate Calcifications	*30 to 500*
Iodinated CT Contrast	*100 to 600*

2.5 Positron Emission Tomography (PET)

Positron Emission Tomography is used to analyze the metabolic activity and the biochemical analysis of a cell or tissue or organ on suspicion of defects. According to Berkley Lab, around 2 million PET scans are performed every year [20]. This nuclear medicine based process is used to visualize the chemical changes taking place in a particular region of interest. A radionuclide or a radioactive tracer will detect the metabolic condition of a tissue prior to the identification made by other scanning procedures including Computer Tomography, Magnetic Resonance Imaging and other imaging modalities [18].

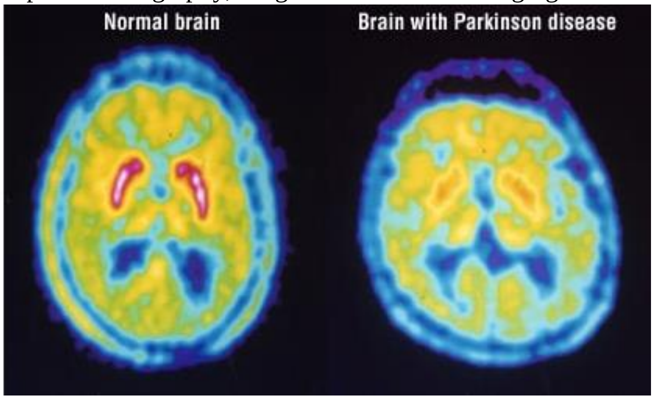


Figure 12: PET Scans of Normal Brain & Brain with Parkinson Disease [19]

This modality is majorly used to diagnose pathology in heart, brain and cancer diagnosis. PET is mostly used in conjunction with CT or MRI for providing a authoritative study of the pathology conditions. Currently, PET is combined with CT as PET/CT for potential diagnosis of cancers, Alzheimer, epilepsy and heart diseases. The metabolic activity of cancer cells are found to be more chemically active when compared to noncancerous cells. These cells are visualized as bright white spots in PET scan [20]. Initially the technique was availed only in PET dedicated centers that are combined with radio nuclides labs. This has been progressively modified with the attachment of Gamma camera systems in the PET imaging system and this has increased the speed of scanning with nominal cost. The PET scans of normal brain and brain with Parkinson disease is shown in Figure 12 as a sample [19].

2.5.1 Positron Emission Tomography – Procedures

Positron Emission Tomography is an imaging modality that analyses the function of a particular region of interest based on the metabolic rate, chemical reactions, blood flow, neurotransmitters and reaction exhibited on the radionuclide drug. The radioactive dose is injected via peripheral vein and is named as oxygen-15, fluorine-18, carbon-11 or nitrogen-13 [21]. The procedure takes around 40 minutes and is similar to Computer Tomography in many aspects. The procedure is completely painless and it measures the quantity of glucose consumed in different parts of the body and this is done with the help of 18-fluorodeoxyglucose (FDG). The use of FDG clinically stands to classify benign and malignant tumours which are identified based on the glucose metabolic consumption. The different stages of cancer are notified with the help of whole body PET scans. Other clinical importance of PET is in the analysis of blood flow and oxygen consumption by brain in stroke, Alzhemier disease and Parkinson disease. Dopamine is used as a neurotransmitter to track the metabolic issues in brain. PET scans also play a major role in differentiating tumours caused by radiation necrosis and scars from surgery in cardiac defects.

2.5.2 Image Formation with PET Scans

When the radiotracer is typically injected via peripheral vein, the decay of the radionuclide produces annihilation photons and this is detected with the help of back to back 511 keV photons.

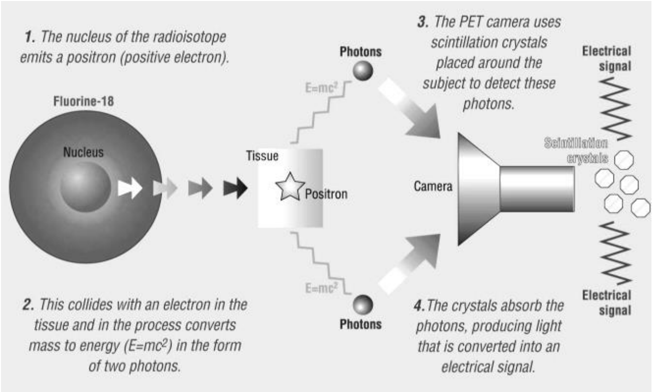


Figure 13: Image Reconstruction Process in a PET Scanner [22]

The PET scanners use a scintillation detector made of thick scintillation crystal coupled with a photo detector. The decay events around 107 to 108 events are collected by detectors that are surrounded by the patient. This is used in the reconstruction of PET image that are based on the reflection of distribution of radionuclide.

During the process, loss of energy could occur due to the scattering of one or both annihilation photons and these are described as scattered events. Random events may also take place when both the photons from the decay of radionuclide strike the detectors simultaneously. Random events and scattered events are the most important phenomena which must be reduced to enhance the PET image quality. The two annihilation photons have to travel towards the detectors at different time and this time difference is calculated as time of flight PET. This event is utilized in the image reconstruction process and is mainly used to localise the event with good image quality. This forces the requisite of image reconstruction algorithms taking into account of the line segments of scattered events, random events and time of flight. The effective reconstruction process will produce quantitative image with the image intensity depending on the radioactive tracer acting upon per tissue volume [22]. The image reconstruction process via the movement of annihilation photons to the scintillation detector is shown in figure 13.

III. ARTEFACTS IN IMAGING TECHNIQUES

In imaging, artefacts are a major issue in capturing the expected image and position of the organ or tissue or a cell in the human body. Artefact refers to the fact that a portion or part of the image does not represent the expected anatomical structure that is focussed. Feeble exposure to lighting conditions and external disturbances may cause noise in the images acquired. These may curb the efficacy of diagnosis of details/diseases from the region of interest of the patient which may probe to wrong diagnosis and prognosis. Hence eradication of various noise levels is mandatory to filter the noise present in the images. Gaussian, Poisson, quantum, speckle and impulse are some the dominant varieties of noise identified in the imaging modalities.

3.1 X-RAY Artefacts

X-Ray artefacts are caused mainly due to failure of hardware, technician error, movement of patient and software issues and these problems contribute to formation of abnormal shadows in the output image. X-Ray artefacts are contributed mostly by common artefacts, film radiography artefacts and computed radiography artefacts. Figure 14 shows the artefacts from an X-ray machine.

The common artefacts results to a distorted image occurring due to patient movement, compositing of image due to superimposition of different structures resulting from double exposure of films and formation of trapezoidal regions caused by debris accumulation in the collimator tube [23].

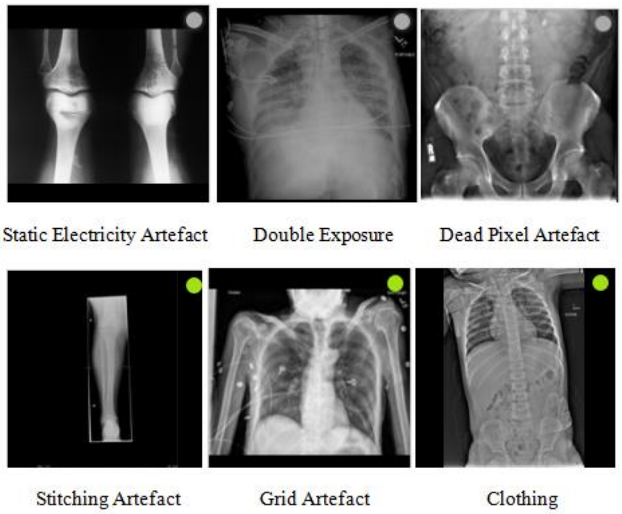


Figure 14: Common X-Ray Artefacts [23]

Grid cut-off is a common artefact issue in X-ray imaging caused due to absorption of unwanted X-rays by radio opaque objects like jewellery, clothing and hair. Grid cut-off leads to diminution of optical density and occurs based on the type of grid used. Parallel grid cut-off and crossed grid cut-off are mostly used and problems created via these stationary grid cut-off are rectified by oscillating grid cut-off [24].

Film Radiography artefacts are caused by improper handling of images contributing to finger marks, film placement in the machine prior to developer solution causing clear film, unwarranted flexing of the film contributing to lightning marks, fingernail pressure on the film causing black lines of crescent shape, intensifying screen causing white lines of crescent shape, black film caused by full exposure to light and clear spots contributed by air bubbles while film processing and debris on the intensifying screen.

Computed radiography artefacts are chipped in by signal dropouts, dead pixel artefacts, lag of detector image, back scatter, stitching artefacts, formation of radio opaque spots, detector offset problem, failure of electronic shutter, mid grey clipping and grid line suppression failure [23].

3.2 Artefacts in Ultrasound Imaging

The common artefact issues that are represented by ultrasound imaging include missing of anatomy or incorrect positioning of the anatomy structure or improper imaging of the size of the expected region. The main drawback of artefacts incurred in ultrasound imaging is that there is a misconception of artefact as a wrong diagnosis. The radiologists are ultimately responsible for differentiating the artefacts from the organ or tissue structures. The common artefacts in ultrasound imaging are shown in figure 15.

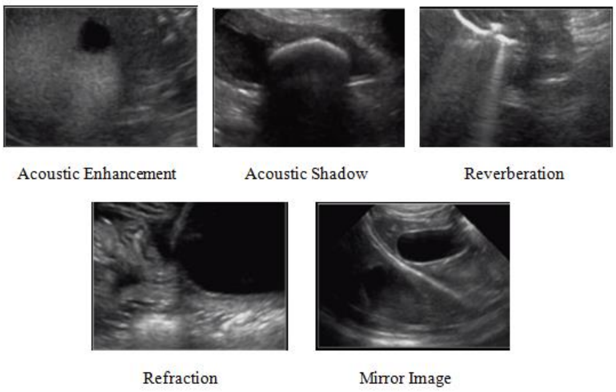


Figure 15: Common Artefacts in Ultrasound Imaging [25]

In clinical practice the common artefacts that are encountered in ultrasound imaging includes speckle noise, acoustic enhancement and shadowing, anisotropy, blooming artefact, comet tail artefact, colour bruit artefact, aliasing artefact, double aorta artefact, reverberation artefact, side lobe artefact, ring down artefact, refraction artefact, speed displacement artefact, multiple echoes artefact and twinkling artefact [25]. Hence artefacts are very common in ultrasound imaging modality and the ability to identify the artefacts will support in image enhancement.

3.3 Artefacts in Magnetic Resonance Imaging

Magnetic Resonance images that are produced from magnetic fields and radio waves suffer from artefacts which mimic to produce false anatomical structures. This may lead to wrong diagnosis and treatment procedures. Physiologic artefacts, inherent physical artefacts and hardware and software artefacts are the types of artefacts that are experienced from MRI scanning.

Physiologic artefacts are caused due to movement of patient while scanning and this may lead to ghosting or blurring of image in the direction of phase-encoding. Respiration, heart beat and blood flow are unavoidable in MRI scanning procedure and the artefacts produced due to such mandatory reasons could be eliminated via fast sequences and respiratory ordered phase sequence. Flow artefacts are produced due to blood flow and this may be eliminated with saturation bands and gradient echo sequences [26].

Inherent Physical Artefacts are classified as chemical shift artefacts and magnetic susceptibility artefacts. During the frequency encoding process, the fat and water molecules vibrate within the magnetic field and are presented differently as bright edges in the anatomy which may be misinterpreted as pathology. This artefact can be minimized by improving the bandwidth, minimising the fat frequency signal and matrix size. Magnetic susceptibility artefact is produced due to medical implants and ornaments in the patient. It is the degree of magnetization a tissue may exhibit in response to magnetic field. This artefact is more dominant at 3 Tesla. This artefact produces voids at tissue interfaces during diffusion sequences [11]. This creates bright spots in the image obtained which may be misinterpreted as disease.

Hardware and Software artefacts are caused by the machinery component in the scanning room and related surroundings. This will create noise in the produced MRI image and hence the MRI scanning rooms are prohibited from environment interferences and devices that will curb the quality of image [26].

3.4 Artefacts in Computed Tomography

Artefacts in CT scans will curb the image details and will lead Computer Tomography as a diagnostically unstable modality. The radiologist must be trained to distinguish artefact from image detail in order to provide efficient diagnosis. Physics based artefacts, scanner based artefacts, helical and multislice artefacts and patient artefacts are more common in Computed Tomography.

Physics based artefacts include beam hardening, partial volume, under sampling and photon starvation artefacts. Cupping artefacts and appearance of dark bands are the cases that arise due to beam hardening. The X-ray beam which contains photons becomes harder when it probes through a patient as low energy photon particles are absorbed more rapidly than high energy photons. This causes beam hardening effect in CT scanners.

Ring Artefacts are more common in scanners that occur when one of the detectors is not calibrated effectively. This will cause rings to be produced in the images misleading the diagnosis process. Periodical detector calibrations and software implementations will minimize ring artefacts.

Helical artefacts occur in the axial plane and multisection scanning. This type of artefact is enhanced when the anatomical structures are liable to change in the z-axis orientation. This artefact becomes nullified when the z-axis orientation is reduced with low pitch of 180 degree interpolator and having thin section acquisistions. In multisection scanning, the helical artefact is represented as cone beam effect and multiplanar reformation. Stair step artefacts and zebra artefacts are more common in this multisection scanning [27].

IV. STATE-OF-THE-ART IMAGE DE-NOISING ALGORITHMS

For accurate diagnosis, lucid imaging details of the region of interest are required to read the minute details of the affected organ/cell/tissue. Researchers have contributed multiple noise filtering algorithms and some of the algorithms are accommodated with the imaging system. This will provide a filtered image thereby aiding the medical experts with clear picture in diagnosing the disease from the region of interest.

Poisson noise, additive noise, speckle noise, Gaussian noise and salt-and-pepper noise are the commonly witnessed types of noise artefacts in medical imaging modalities. These noise artefacts found in various imaging techniques will curb the image details if left unprocessed or not removed. Effective de-noising techniques are available in the literature which has contributed its own merit in maintaining the image quality without disturbing the intricate image details. Among them Median, Gaussian and Wiener filters are mostly used with higher efficacy.

Median filter is an order statistic filter which is better utilized for de-noising of salt and pepper noise. This type of noise is noticeable in X-ray images and other radiological images. This filter has proved to have good efficiency in de-noising and the process of de-noising is done by replacing each pixel in a pre-determined window with its median value. The size of the window is cautiously chosen as there is a possibility of replacing fine details of the image. Hence the process of de-noising is executed and accomplished at the expense of losing the original data present in the image [28].

Weiner filter is an optimal statistical filter utilized for removing different types of noise available in medical images. The filter is designed such that it does as a trade-off between noise smoothening and inverse filtering [28]. The usage of the filter for curbing noise requires prior knowledge of spectral properties present in the image. The filter depends on the minimum mean square error and is hypothetical in considering the additive noise to be inactive.

Gaussian filter is used to remove noise present in ultrasound images and MRI images based on Gaussian distribution. The noisy pixel is replaced by the average value of the surrounding pixel. This is a linear smoothing type of filter and has higher efficiency for normal Gaussian distribution.

V. ARTIFICIAL INTELLIGENCE (AI) IN DIAGNOSTIC APPLICATIONS OF MEDICAL IMAGING

The boom of Artificial Intelligence is a dominant support in medical imaging modalities and is rendering a helping hand to radiologists. Artificial Intelligence is circumventing pseudo-diagnosis prevailing in medical field due to lack of experience. It has the capability to process enormous quantity of medical images with high precision and accuracy and with fine details that are invisible with naked eyes. The roaring development of Artificial Intelligence in medical imaging is providing medical experts with value added task and is thereby enhancing patient interaction times. AI investigations take keen interest in assessing the diagnostic accuracy based on sensitivity and specificity. AI has also established its importance in diagnosing advanced diseases and the cases that require long term prognosis. The utility of AI will completely replace the existing methodology by its strong dominance in disease diagnosis, modified treatment analysis for a specific case, precision, and improvement in mortality rate and enhancement in the quality of life [29]. Figure 16 shows the model impact of artificial intelligence in diagnostic medical imaging.

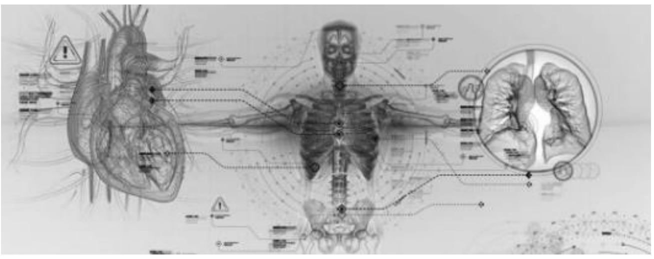


Figure 16: Artificial Intelligence in Diagnostic Medical Imaging (Image Courtesy:ESR)

Artificial Intelligence has the incredible capability of identifying pattern changes in the images that are not assessable by humans. Analysis of brain MRI with the help of machine learning has proved to diagnose ischemic stroke at the very onset very sensibly that is consented to be impossible by human readers. Artificial Intelligence had started its reign in medical imaging with the advent of machine learning algorithms utilized for analysing histograms of pixels, shapes, location and area expended in the images. Machine learning algorithms utilize part of the data entries for training the system while the remaining data are used for testing applications. Commonly used machine learning algorithms include Principal component analysis, Support vector machine, supervised learning algorithms, radial basis neural networks and many more [30]. Tensor processing unit has been developed for enhancing neural networks based machine learning and this seems to have great potential in medical imaging.

Artificial Intelligence is joining hands with radiologists in order to improve the image quality and efficiency of diagnosis and is not emerging to replace radiologists [31]. Artificial Intelligence will take the role of augmented intelligence rather than self autonomy. Artificial intelligence is still in the era of supervised learning which insists that human supervision is mandatory. The data with machine learning produced in diabetic retinopathy showed major inter observer differences and hence the data given as input requires to be effectively fed. Deep learning algorithms have demonstrated great improvements compared to machine learning algorithms. It has the capability to compare a patient's history with the current report and forecast on possible outcomes. It has accomplished a promising choice in CT, MRI, Ultrasound and PET scans as it handles the specific chosen data with the meta data and does not depend on the medical expert. This naturally predicts the significance of AI and deep learning algorithms in medical imaging and related researches.

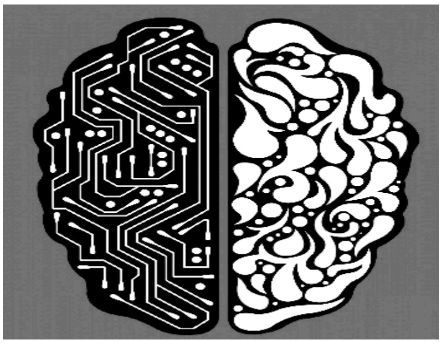


Figure 17: Augmented Intelligence Support for radiologists (Image Courtesy: American Medical Association)

Artificial Intelligence is a boon to radiologists in the field of medical imaging with the case that it will be a superior supervised decision maker still in the hands of humans and this is enunciated in figure 17.

VI. CONCLUSION

Image Processing is a prominent tool which supports medical experts to probe in effectively with their diagnosis and prognosis procedures. Imaging human body have been developed prominently in the last two decades and had aided many decision support systems. This had also proved in curing multiple diseases which was a challenge in the past. Ultrasound Imaging, Magnetic Resonance Imaging, X-Rays, Computed Tomography, Positron Emission Tomography and Single Emission Photon Emission Computed Tomography are the mostly utilized medical imaging modalities. Each imaging modality is specifically unique in the aspects of its contribution in discrimination of enormous diseases in the human body. They play a vital role in supporting medical experts with high precision accuracy in visualizing the internal organs and tissues. The imaging techniques are governed by the principles that are utilized along with the energy sources and it is where the principle lies in imaging / spanning the cells, tissues and organs. Analysis of medical images for the process of diagnosis and prognosis is very essential and many algorithms are in existence for supporting the medical experts with artefacts free image. This is additionally enhanced with the augmented support of Artificial Intelligence. It is circumventing pseudo-diagnosis prevailing in medical field due to lack of experience. It has the capability to process enormous quantity of medical images with high precision and accuracy and with fine details that are invisible in naked eyes. The roaring development of Artificial Intelligence in medical imaging is providing medical experts with value added task and will thereby enhance patient interaction times.

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Chapter - 8

Internet of Everything based big data journey for medical industry

Piyush Gupta[1], Dr Bhupendra Verma[2], Dr Mahesh Pawar[3]

[1] Research Scholar, Department Of CSE, UIT RGPV Bhopal
[2] Department of CSE, Director TIT Bhopal
[3] Associate Professor,Department of IT, UIT RGPV Bhopal

Abstract— Health is considered as the global challenge for human kind. According to World Health Organization (WHO), constant patient monitoring is said to be the highest standard in hospitals. The developing amount of data in healthcare industry has made predictable the big data techniques adoption in range of enhancing the healthcare delivery quality. Big data plays a significant role in medical industry by governing numerous amount of data, such that the information is maintained and gathered from various platforms. These are possible by performing big data analytics to analyse and capture every information, by resulting patient's entire history and appropriate information at right time. Therefore, the present study reviews the dimension of big data and significance of IoE (Internet of Everything) in medical field and the application and challenges of big-data in Health care System are also reviewed. The study highlights the IoE based Big-data journey in Medical Industry.

Keywords— Medical Industry, Internet of Things, Internet of Everything, Big Data.

I. INTRODUCTION

Internet of Everything (IoE) is considered the intelligent means of connecting people, data, processes and things. IoE applications comprise digital sensor tools utilized for remote applications that have recently emerged to be more automated and intelligent [1]. Currently, the health care industry is considered one of the great desperation. Even the service provided in healthcare is more expensive than others because the entire population worldwide has increased in the number of chronic diseases.

IOT (Internet of things) combines various communication devices and smart electronics that sense and communicate with each other. In recent years, IOT devices brought a revolution in the field of biomedical applications by looking at several challenges and complications faced in the past [2]. These IOT devices can generate a significant amount of biomedical data and play a vital role in developing existing automatic medical-data collection systems. When IOT devices are integrated with advanced Machine Learning (ML) algorithms, big data is essential for improvising these health systems in diagnosis, decision making, and treatment. Advanced ML are used for both categorical variables and continuous variables. And some of the commonly used algorithms are,

- Linear Regression
- Linear Discriminant Analysis
- Logistic Regression
- Naive Bayes
- Classification and Regression Trees
- Learning Vector Quantization (LVQ)
- K-Nearest Neighbors (KNN)
- Random Forest
- Support Vector Machines (SVM)

In addition, IOT in biomedical applications has developed research areas in IOE, such as symptomatic treatments, observation of patients, and monitoring [3].

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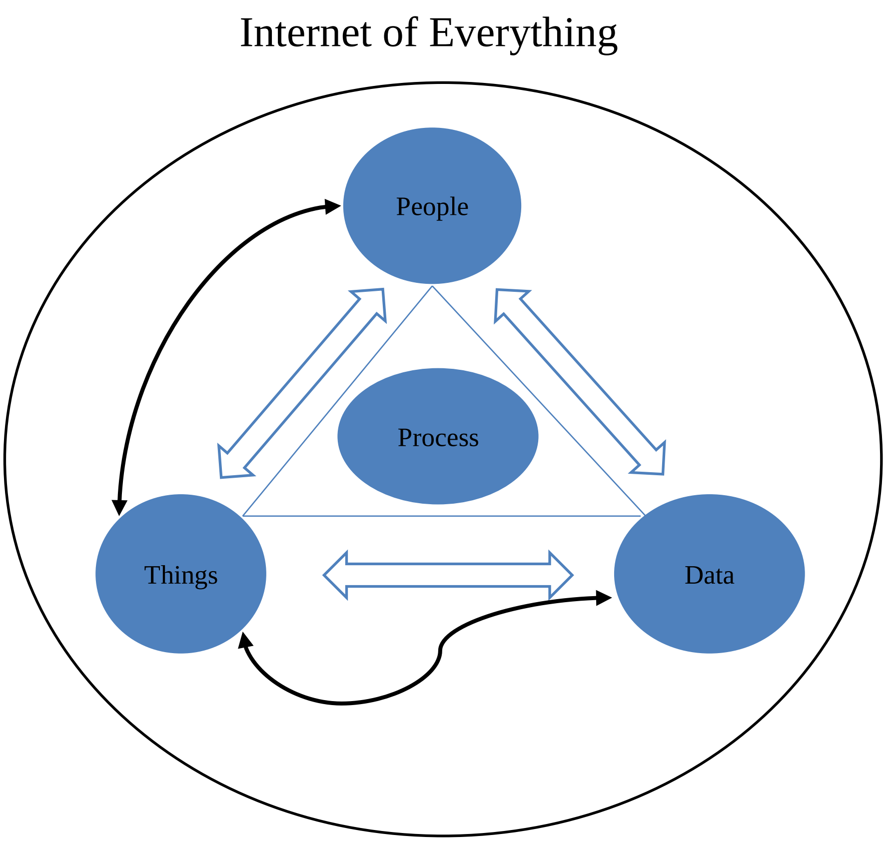

Figure 1 Frame work of Internet of Everything

The framework for the IoE is shown in fig. 1. Generally, IoE depends upon the process, people, data and things interconnected to the internet. This influences people's lives, business and also their industrial processes. Further, the real-time information collected from multiple sensors is interconnected and implemented into a people-oriented automatic process [4]. Additionally, the internet of everything helps to accomplish environmental sustainability and socio-economic goals. Also, IoE is utilized in fossil fuel mining, remote monitoring, E-learning, automation, traffic controls, smart grids and several other industries. The internet of everything will generate enormous data through the sensors implanted in the physical objects in the environment. As generating and monitoring information is a constant process, keeping these devices connected and active to the internet is essential. This ensures uninterrupted data updates to servers.

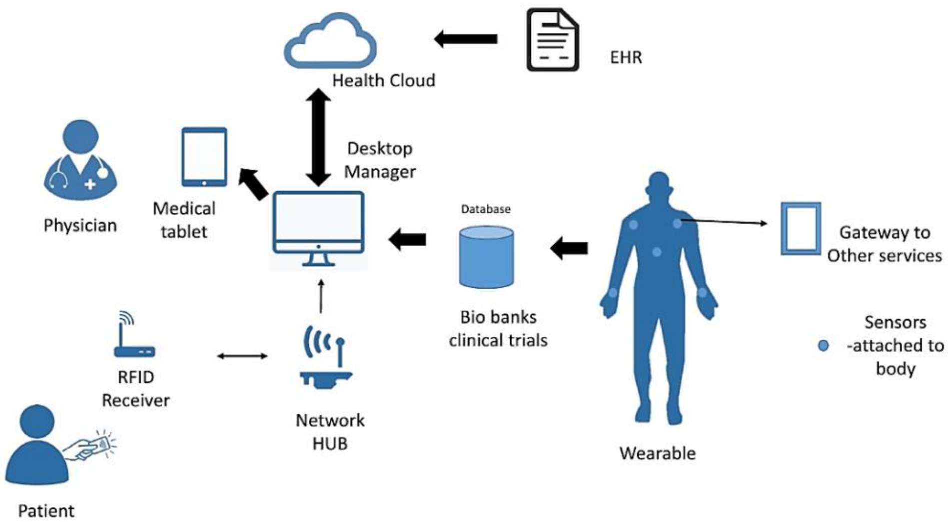

Figure 2. Revolutionary features of IoE in the hospital environment [5]

Figure 2 represents revolutionary features of IoE in a hospital environment. Patients with diabetes will be given ID cards, which will be scanned and linked to the cloud that stores the EHR (Electronic Health Records) and actual laboratory results, prescriptions and medical history records. Such that the nurses and physicians can access these records on a desktop or laptops, or tablets in an easy manner.

EHR implementation of EHR will significantly change the health care sector. Managing the hospital records by ink-paper systems i.e. conventional pen and paper records will be replaced with digital systems. The conventional ink-paper system has various limitations, and it also can be missed at times. However, EHR reserve all the essential information in one place and facilitate sharing that information for doctors and physicians. Thus EHRs can eliminate numerous inefficiencies and also saves a life. However, one of the huge drawbacks of implanting IoE is communication. Even though various devices possess various sensors for collecting data and information, they cannot communicate to the server. Further, each manufacturer has its protocols, such that the sensors by other manufacturers cannot communicate with each other.

Big data analytics is a predominant technology, particularly in digital transformations. Further, big data has covered different sectors such as healthcare, geospatial communication systems, sensor networks, mobile applications and E-commerce in a short period. Also, the data arrival rate will be in EB (Exabytes). When considering healthcare sectors, apart from being massive and distinct, the high-speed data arrival seemed to be highly challenging because of its heterogeneous nature. Moreover, the patient's data are available in enormous numbers, including disease origination, clinical history, post and pre-treatment process, treatment duration, diagnostic and postoperative data such as EEG, MRI reports, X-rays, and US (Ultrasound) reports and CT scans. Big data entered this sector because of its multi-dimensional methods, techniques and solutions for health care sectors. By using this advanced technology, every healthcare system will be easier to access, and it will also be significantly cost-effective. In modern healthcare system, there are several issues that requires big data to resolve, such as maintenance of health care data, mobility of the data, accessibility which is necessary to improve the hospitality for the patients.

II. DIMENSIONS OF BIG DATA

Big data is huge amount of data, which is endangered by several websites like social media sites such as twitter, linkedin, Facebook and blog sites, and diverse instruments such as sensors for different applications. This big data needs a new architecture, various techniques, complicated algorithms as well as powerful analytics for managing high scale data and to extract information from complex algorithms. As the data magnitude has increases a particular point, qualitative issues will be considered as important problem than the quantitative issue while capturing the data, storing the data, processing the data, data analysis for the processed data and visualizing the data. Moreover, big data possess several dimensions like volatility, viscosity, virality, value, visualization and variability.

Variety: Big data collects variety of data such as EHR, ECG (Electrocardiogram), and sensor data for various applications, audio, social websites and digital photos.

Velocity: The data speed will be calculated based on the big data that are releasing from the various fields such as machines, sensors, network as well as smart phones. Moreover, the flow of data is constant, that integrates the structured and unstructured format of data.

*Visualization:*The data that was collected need to presented in the reasonable manner, and even there are different characteristics like volume, velocity etc. this becomes more challenging. Thus, by visualization, it is feasible for providing a complete and clean picture of data.

*Volatility:*Volatility refers to speed, which helps in movement of data across the networks. Besides data, time also plays a major role in data analytics.

III. SIGNIFICANCE OF IOE IN MEDICAL FIELD

In today's world, the healthcare providers are facing many consequences. Internet of Everything increases medial IQ by providing right information at right place. Firstly, it allows to streamline the workflow by eliminating simple things, thereby substantially reducing service cost, and also provides more quality doctor/patient time. Moreover, the scores of higher patient satisfaction and patient outcomes like HCAHPS could rise revenue by increasing third party payments. Additionally, IoE improvises both patient and business outcomes. In accordance with IMS institute, the cost of medical in 2012 was over 200 billion dollars. The increased IQ in medical field significantly reduces risks in clinical mistakes. The recent advancements in biometrics and sensors provides immediate feedbacks to the doctors. Instead of waiting for 14 days for patient's response, with the help of IoE, instant actions can be obtained. When integrated with Big data, additional benefits can be obtained like lowering errors and providing good patient care. Most importantly, Internet of everything provides the necessary information, which are required by the healthcare sectors by maintaining wellness[1].

IV. APPLICATIONS OF BIG DATA IN HEALTH CARE

The following are the applications of big data in health care environment.

- *Big data and Medical Imaging*
- *Telemedicine*
- *Predictive analytics in healthcare sectors*
- *Big data could cure Cancer*
- *Informed strategic planning by utilizing health data*
- *Enhancing the patient engagement*
- *Real-time alerting*
- *EHR (ELECTRONIC HEALTH RECORDS)*
- *Patient prediction*

4.1 Patient prediction

Big data plays a predominant role in predicting patients for improvised staffing. Several articles have discussed the strategy of big data in predicting patients, in which, it has been stated that the data from different source were integrated so that daily and hourly predictions of patients, who are visiting hospitals. Further, the data scientists implemented the techniques of time series analysis in hospital's admission records. This has helped in predicting the patient admission rates as well as the rate of staff availability. Thus, improvising the performance staffing[2]. Additionally, various ML algorithms act as essential tool for analysis and prediction of admissions trends for the future patients. When prediction was performed, correspondingly, more staffs will be available, which helps in decreasing the patients waiting time and also improvises the method of caring provided for the patients.

4.2 EHR-Electronic Health Records

The general form of utilizing Big data analysis in the health care sectors are EHR. These Electronic health records stores the patient's reports like lab test results, medical histories and demographics digitally[3]. Moreover, a secured information system has been employed for making these EHR available for private and public sector. Since every records are digitized and it contains updated files for each data, there is no need for paper works and data duplication.

In addition to that, Electronic health records could generate remainders for tracking the prescriptions of patients and warnings for conducting the required lab tests. Even though implementing EHR is worthier, several countries still struggles in implementing.

A study suggested that, in US (United States), a system named Health-Connect has been implemented, which was easy to share and utilize data[4]. McKinsey who framed the report regarding the integration system of big data with the health care domain presented that around one million dollars have been saved due to the reduction of office visits as well as the pathology tests for the cardiovascular disease.

4.3 Real-time alerting

By utilizing big data, real time alerting provided health care analytics is considered predominant functionality. Generally, in hospitals, real time CDS-Clinical Decision Support system helps health practitioners and doctors with prescriptions and advice given on the spot to the patients. However, these real time systems are costly, hence the doctors or health practitioners prefer their patients to stay away from their hospitals. In recent years, Personal analytics design was utilized, in which the health data of patients will be constantly observed by wearable devices such as smart watches and shares the information via cloud[5].For instance, if there was a rapid increase in blood pressure of a particular patient, his personal doctor will receive an alarm, such that corresponding actions will be taken for reducing the blood pressure. Moreover, in an Asthmapolis system, the inhaler has GPS access, used for finding asthma trends at individual level and huge population. These data will be aggregated from clinical decision support, thus resulting in better treatment plans for patients suffering from asthma.

4.4 Enhancing the patient engagement

As people are becoming more health conscious now a days, as a result, they smarter devices for monitoring their own pulse rate, blood pressure, sleep, and also recording their day to day routine. Such that, by utilizing these any kind of health risks could be identified and treated. Moreover, heart diseases can also be predicted by chronic insomnia and increased heart rate in future. Ultimately by using smart devices, patients will also be involved in every kind of health monitoring activities[6]. Also, specific health trends are identified by system and uploaded cloud, from which they will be used by the physicians. By doing so, there will be a significant reduction in number of visit to the hospital and moreover, the patient will feel that they are independent.

4.5 Informed strategic planning by utilizing health data

In today's world, strategic planning in healthcare sectors is very essential, which can be provided by the big data analytics. A study suggested that, an application was introduced by Google Maps for illustrating different real time problems. Such that, spread of any chronic disease and population can be represented in the form of heat maps[7]. Medical services availability in intense area has been compared to real time data, and their decisions were taken with respect to healthcare strategies, which were augmented by several healthcare units.

4.6 Big data could cure Cancer

By utilizing big data, a system named, Cancer moonshot[8]was developed to cure cancer. This programs aims to cure cancer within short timer period in contrast to the conventional curing period of time.Several researchers from medical field were utilizing huge amount of data for accomplishing better results and also to identify useful trends. The results of this system will provide good recovery rates as well as treatment plans. Furthermore, the tumor samples that are stored the bio-banks are linked to the treatment records. These data is referenced in order and the interactions as well as mutations among the cancer proteins, such that the treatment plans are mapped[9]. This results in obtaining better outcomes. This also sometimes gives surprising results such as, presence of desipramine, which cures lung cancer.

Additionally, these researches demands in interconnecting different hospitals, institutions as well as non-profit organizations, in which the treatments records are available. The samples of cancer tissues of trial patients are sequenced genetically and added to worldwide cancer database. Nevertheless, big data analytics in identifying a cure for cancer possess some limitations, which reduces benefits. Firstly, because of incompatible data, these datasets cannot interface each other.

4.7 Predictive analytics in healthcare sectors

In recent years, the predictive analytics is exploited for application related to business, and it will be further explored. A recent study suggested that, research project in US has gathered data from thirty million people, from which the study observed a good quality of delivery care[4].

These kind of intelligent tactics assists the health practitioners and doctors in making decisions on the basis of available datasets, and obtaining improvised and better patient treatment. For instance, if a patient possess complicated medical history, and also suffers from critical health disorders, these tactics will be more helpful. Moreover, there are some new tools, which can predict heart disease, blood pressure as well as diabetes. Such that, the patients could be advised to possess regular physicals and medical advices, and also making use of dietary plans or weight management programs[10]. For example, the air quality index prediction system has effective usage in the treatment for Obtrusive sleep apnea[11].

4.8 Telemedicine

For more than 40 years, the telemedicine has been in industries, which now has entered various technology such as smartphones, wireless devices, online VC (video conferences) and wearable. The remote medical services incorporates medical professionals, healthcare education and monitoring remote patients. Further, the tele-surgery, another kind of remote medical service performed by utilizing skilled robots with higher speed and precision, and also utilizes real time data from remote location as illustrated in Figure 3.

Moreover, telemedicine offers personalised treatment plans, in which it prevents readmissions or hospitalizations. The healthcare data analytics assists the doctors in predicting any critical medical events in the life of the patients, and also prevents the health of patients.

With the help of telemedicine, the admission costs in hospitals were significantly decreased, as well as the QoS (Quality of Service) was incremented. Since the conditions of patients can be monitored from anywhere and consulted at any time, the hospital visits are not needed, thereby significantly reducing the waiting time.

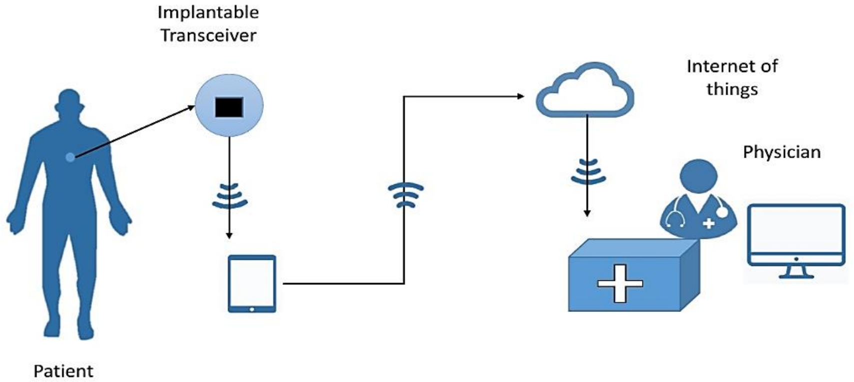

Figure 3. Remote patient monitoring[12]

4.9 Big data and Medical Imaging

Big data has major contribution in Medical imaging, such that, several radiologists individually investigates every medical image, analyse them and store them for many years that will be accessed by the healthcare sectors. However, this method consumes more time and cost.

Moreover, the carestream, a medical imaging provider consisted of products, which were developed by utilizing big data analytics. The carestream algorithms analyse numerous images and finds the specific patterns in medical-images pixels and convert it to numbers. These numbers plays a vital role in diagnosis, thereby helping doctors in treating diseases. This concept saves doctors from remembering numerous medical images with their lot of information. Therefore, Carestream algorithm has a positive impact towards skillset, experience and education in the field of medical industry.

V. CHALLENGES OF BIG DATA IN MEDICAL INDUSTRY

The issues that faced by the healthcare domain is because of huge number of disease and their crucial conditions, various results, different types of treatment, analytical techniques and the gathering of different methodologies. Further, in healthcare sectors, there are various sources of big data such as biometric data, web data, and medical-images, reports of outpatients, electronic records, clinical data and case records. Combining these information sources generates massive dataset with large dimension. Several studies have addressed the characteristics of big data in medical field and compared with traditional medical epidemiological information[13]. However, collecting these data involves several protocols, and since this process uses costly instruments and well-trained professionals, it is expensive. Moreover, it is prone to various uncertainties like coding errors, missing values as well as measurement fails. The general features of the big data integration with medical repeatedly makes the change in the treatment process and the characteristic of patient with respect to time.

5.1 Missing values

The big data analysis in healthcare sector manages the data that are gathered from various resource for many reasons. However it agonises from missing values of variables as well as incompleteness in the datasets. Further, the easiest way in handling the missing values is adding data value or removing case from datasets. In addition, several data mining algorithms are capable for handling the missing values while pre-processing. Missing data represents various relations with the prevailing unobserved and observed data values, which are the depicted as the following.

- ***NMAR-Not missing at random:*** missing data is related to unobserved data.
- ***MAR-Missing at random:*** The missing data is not related to the unobserved data, but it is related to observed data.
- ***MCAR (Missing completely at random):*** The missing data is not related to the unobserved and observed data. Here, the missing data wouldn't impact the analysis process. Moreover, Stata, SAS, R, WinBUGS are the automatic tools for handling the missing values. If the missing values are below 10%, these tools provides similar outcomes. Whereas, if the misplaced values were greater than 60 percentage, the tools will fail to provide appropriate outcomes. However, the tools may provide other suggestions, for the missing values between 10 and 60%.

5.2 Challenges in Health Care Big Data

Even though the big data analytics has vast potential in different fields mainly in the medical sector. There are various issues while implementing the big data analytics in the medical domain, which considered as the crucial and they face difficulty while outlining the process. Since big data is considered as the emerging technology, their real time advantages are very low in evident[14]. Also, the big data suffers from the intrinsicoperational problems such as heterogeneity, timeliness, privacy, data incompleteness, data inconsistency, data quality, legal issues, analytical issues, instability as well as limitation to observational studies. Moreover, the quality of data must be improvised, particularly in EHR, as it is sensitive. Thus, dramatic changes are needed for solving technical issues for acquiring better outcomes. Finally, the big data analytics and clinical integration can provide several benefits, however it takes at least few years to obtain the expected integration and outcomes. Additionally, big data analytics provides efficient, improvised patient care as well as quicker response[15].

VI. SUMMARY

Health is considered as the global challenge for human kind. According to WHO (World Health Organization), constant patient monitoring is said to be the highest standard in hospitals. Since their heartbeat and ECG's are constantly observed, there is a chance of losingdata or data mismatching. In order to avoid these issues, cloud is a predominant infrastructure for electronic patient records as well as tele-helath video consults with nurses and physicians. The patient's data like ECG, last position, heart rate and temperature will be measured frequently and stores in the server. Additionally, it also offers connection across insurance companies and health care providers, which allows them to buy resources which are required. This results in maintaining the patient's expenses and keeping them under control. Further, mobility serves a significant role in end to end experience of healthcare, which keeps the patients and doctors connected when they are at hospital. Since the patients are connected with devices through their hospitalization, the healthcare professionals could easily access the data through their mobile applications, thereby substantially boosting the agility and efficiency of patient care. Big data plays a vital role medical industry by governing numerous amount of data, such that the information is gathered and maintained across different platforms. These are possible by performing big data analytics for capturing and analysing every information, thereby providing entire history of patients and delivers appropriate information at right time.

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Chapter - 9

NUTRIFY: A Meal Planner App for Diabetics

Dr. Shaneth C. Ambat[1], Justine Rose R. Cale[2], Czarina G. Castillo[3], Oliber M. De Leon[4], Royce Christian N. Esguerra[5], May Florence D. San Pablo[6], Dr. Hadji J. Tejuco[7]

[1] FEU Institute of Technology, Program Director, P. Paredes St., Sampaloc, Manila
[2,4,5] FEU Institute of Technology, Student, P. Paredes St., Sampaloc, Manila
[3] BSCSSE Student, FEU Institute of Technology, P. Paredes St., Sampaloc, Manila
[6,7] FEU Institute of Technology, Faculty, P. Paredes St., Sampaloc, Manila
[1]scambat@feutech.edu.ph, [2]jstnrosecale@gmail.com, [3]castilloczarina@gmail.com, [4]oliber.deleon18@gmail.com, [5]royceesguerra@gmail.com, [6]mdsanpablo@feutech.edu.ph, [7]hjtejuco@feutech.edu.ph

Abstract— The Philippines has a high rate of diabetes cases that is sometimes caused by bad eating habits and poor lifestyle. A good eating practice is to have three meals in a day and two snacks between each meal to properly distribute the needed nutrients. The researchers have developed an application entitled "Nutrify" to help people diagnosed with Type 2 Diabetes (T2D) in planning their meal. The meal plan contains the calorie and macronutrient distribution. The decision-tree algorithm is responsible for the changes in the meals computed by the application, appropriately distribute the macronutrients, and optimize the plan's validity. The survey conducted shows that for all the participants' responses, the respondents are very satisfied with the application having a score of 4.62. However, results from the paired t-test could not prove the effectiveness of the application in managing the user's weight due to the short period to produce statistically significant results. In conclusion, the researchers have developed an application that will generate a meal plan and create a dietary goal for the user in order to help the user to stay healthy and avoid their existing health conditions becoming worse.

Index Terms— Diabetes, Decision-tree Algorithm, Macronutrients, Nutrify, Type 2 Diabetes (T2D)

I. INTRODUCTION

Nutritional requirements are an essential component of one's life that must be taken into consideration, and in order to maintain a healthy body, one must consume the appropriate number of nutrients. However, the lack or excess of these nutrients that an individual takes on every day may cause health problems in the future.

According to an article by Sun Life Philippines, How Better Nutrition Can Prevent Diabetes (2020), the Filipino diet consists mainly of rice, which gives off carbohydrates that contribute to an individual's daily energy intake [7]. It is suggested that calorie intake from rice and other foods must be taken into account to maintain the right amount of nutrients in the body. However, the wrong dietary intake may lead to many non-communicable diseases. One of them is the global public health issue, diabetes, and its prevalence in the Philippines has increased throughout the year (Angeles-Agdeppa, 2020). Furthermore, the Food and Nutrition Research Institute (n.d.) reported in their 8th National Nutrition Survey that the age range of 60-69 years old had the highest diabetes prevalence (12.6%). The right amount of nutrients may be needed to maintain and regulate the blood sugar level. Moreover, many health and nutrition field professionals study how to prepare a suitable meal plan for individuals based on their health, hence the dietary recommendations for people with diabetes apply to everyone [5].

Every meal is categorized into an individual's recommended nutrients, such as carbohydrates, protein, fats, and other micronutrients. Managing blood glucose levels is a big responsibility for diabetic people. Therefore, it is advisable to have three meals per day. In addition to the article of Alberta Diabetes Link (2018), consuming high-fiber carbohydrates is good to maintain glucose levels as it is being digested at a fast rate [1].

Every individual needs to balance their intake that depends on their body needs. Not everyone has the same health condition, but knowing the recommended nutrient intake will benefit anyone.

II. LITERATURE REVIEW

2.1 Local Related Literature

To take on the daily activities, it is necessary to consume the right amount of nutrients recommended in a day. How one person uses the energy stored in the body may vary depending on age, gender, and the type of food they choose to eat [2]. The most common combination of a meal in a Filipino household consists of their source of carbohydrate, which is rice, partnered with fish and meat, and adding some fruits and vegetables to this diet.

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This type of diet is the "Pinggang Pinoy," one of the Food-Based Dietary Guidelines suggested to meal planners. The 2015 Updating Survey of Nutritional Status of Filipino Children and Other Population Groups data was used in a study by Lopez-Madrid, Orense, Duante, and Capanzana (2018) to determine the percentage of meal planners who are aware of the four FBDGs, namely, the updated 2012 Nutritional Guidelines for Filipinos (NGF), the Kumainments, the Pinggang Pinoy, and the Daily Nutritional Guide Pyramid (DNGP) [9]. The most known FBDG is the Daily Nutritional Guide Pyramid (DNGP), having 35.8% of meal planners that are part of the data gathered. These four FBDGs provide information and messages on eating right and maintaining a healthy lifestyle. It shares suggestions on diversifying a meal while containing the body's three nutrients: carbohydrates, protein, and fats. These suggestions must be considered, especially when consuming carbohydrates that are most likely to be found on rice. Micronutrients can also be found on rice, but the soil where it is being cultivated in the Philippines lacks these essential micronutrients. In an article by Palanog, et. al (2019), one of the common problems in the Philippines is micronutrient deficiency, and one of the reasons it exists is the unfortified rice [11]. This rice also contributes to diabetes because refined sugars can be found. These sugars can make the glucose level rise and eventually disrupt the regular insulin production in the body. Different methods are suggested to avoid this issue, such as Plate Method, Hand Guide, and the Food Exchange List [12]. With different resources and information available, it will be easier for meal planners to create a meal that will give the body its needed nutrients.

2.2 Foreign Related Literature

Diabetes mellitus is a chronic health condition caused by high levels of glucose. A person with this health issue cannot utilize or produce enough insulin. This deficit can lead to many life-threatening health complications. According to Saeedi, et al. (2019), an estimated 463 million people had diabetes in 2019 [13]. Furthermore, over 4 million people were estimated to die from diabetes in people aged 20 to 79 years. These statistics show how severe diabetes is. In addition, different health complications may arise from diabetes: microvascular and macrovascular [6]. Causes of diabetes have been determined in a literature review by Wanjiru, J.M. (2018) in wherein Type 1 reasons are genetic susceptibility, autoimmune destruction of the beta cells, environmental factors, viruses and infection, and infant feeding practices; and Type 2 causes are high BMI, hypertension, smoking, and physical inactivity [14]. A consensus report by Evert et al. (2019) stated that a Diabetic diet is not a one-size-fits-all [4]. Thus, individualized nutrition therapy should be a component of diabetes care and management. With technological advances, artificial intelligence (AI) algorithms to create personalized meal plans are no longer impossible. A paper by Li and Cao (2017) about MOGA argues that "users' accumulated intake of nutrients in the past period should be added to the recommended strategy" (p.2) [8]. MOGA considers the user's existing dietary records, physiological needs, and cumulative long-term effects on them. On another algorithm, Mohammed and Hagras (2018) stated that "There is a need to employ technology to help diabetics and doctors to control the disease and reduce its complications." (p.56) [10]. Their proposed meal plan algorithm focuses on a diet plan recommendation system for diabetes using type-2 fuzzy logic. The proponents hoped that the recommendation system would help diabetics and doctors manage diabetes with this technology.

III. THEORETICAL FRAMEWORK

The 90/10 theory supports this study by registered dietitian Joy Bauer. This theoretical framework can be applied to the study to make sure that the user remains motivated in following his or her meal plans. It is vital to allow a small percentage of meals for foods that the user craves because if the users consistently deny the food they want to eat, it is likely that they will lose all their willpower in following the meal plan. Everyone's body and lifestyle are different. Rather than making their life fit around a strict diet plan, the 90/10 allows for food flexibility and freedom. However, for this theory to be successful, it is crucial to give the user a general idea of what 10% of the meals mean. Eating three meals per day translates to two cheat meals per week [3]. The mobile application will create a meal plan that allows 10% of what the user wants to eat automatically so that the user does not need to think and calculate that 10%, all they need to do is follow the meal plan. Hence, the user does not need to develop a mindset to make sure they are doing the 90/10 plan.

3.1 System Design

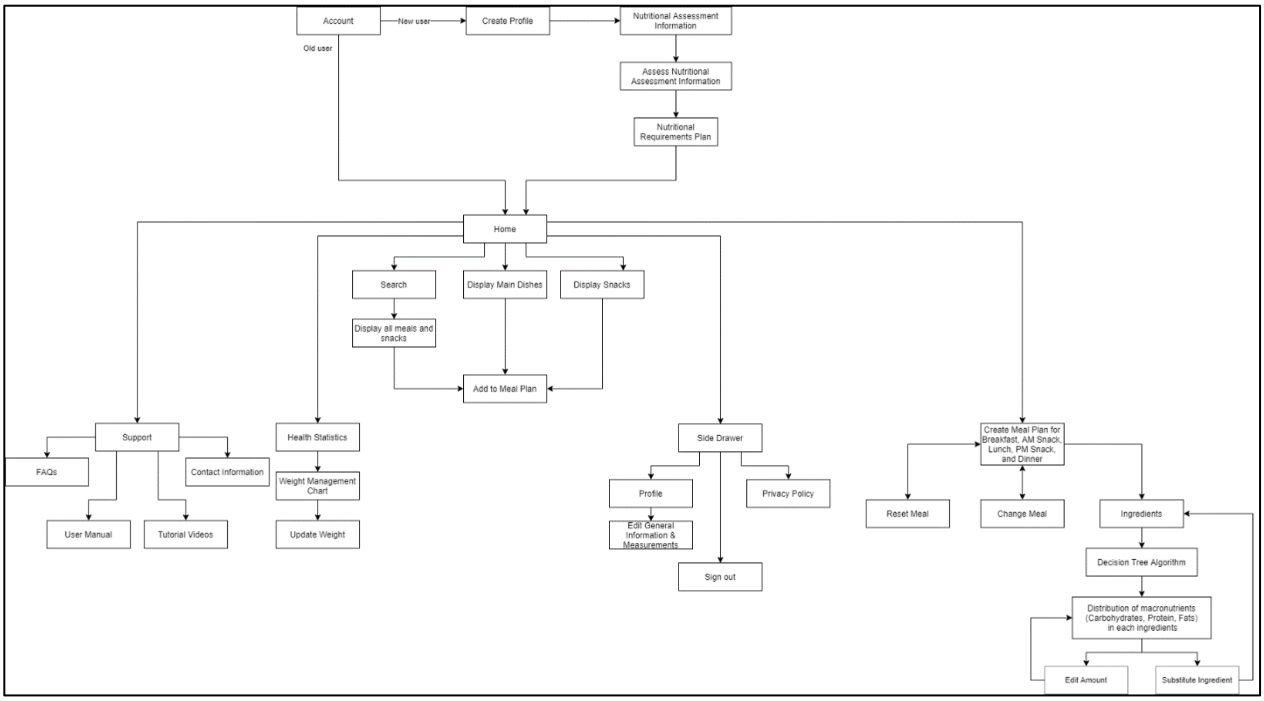

Figure 1. System Design

The diagram on Figure 1 shows how the system will achieve its purpose. After the user sets up their profile and information, the system will assess it and create the user's plan for their goal, calorie count, and macronutrient intake. The home page shows different icons to navigate to explore all application pages. The user can see all the meals in the search bar or the main dishes and snacks list. They can add the meals they like to their meal plan. The Decision-Tree Algorithm is used to choose the best meal to fit the user's nutritional requirements. The algorithm is applied to the ingredients of each meal, and this is one of the reasons why the application can detect if the changes in the meal and its ingredients are still valid for the user or it needs to be improved.

Tracking their weight on the Health Statistics page will help them have a clear vision of their progress to see their improvement. The user can also get their answers to their questions on the Support Page.

IV. STATISTICAL METHODOLOGY

After the collection and data gathering, computer software such as Microsoft Excel will be used in tallying the data. The result will determine the effectiveness of the meal planner in providing a meal plan for diabetic persons. It will be based on the questionnaires and interviews by the respondents.

The researchers will utilize the following statistical treatment to interpret the data of the study effectively:

4.1 Mean

It will be used to identify the respondents' evaluation based on their provided data. In order to get the mean, the sum of all the data entries must be divided by the total number of entries.

$$X = \frac{\sum x}{n} \qquad (1)$$

where:

x – mean,

Σx - the sum of all scores or values in the distribution,

n - total number of scores in the distribution

4.2 Weighted Mean

Weighted Mean will be used to evaluate the overall value of the responses made by the participants in a certain group. In weighted mean, a certain weight is assigned to each value to determine its relevance to the observation. The weighted mean can be obtained by getting the sum of all the products of the weight and the value then dividing it by the sum of all the weights.

$$\text{Weighted Mean} = \sum_{i=i}^{n}(x_i \ * \ w_i) \ / \ \sum_{i=i}^{n} w_i \qquad (2)$$

Where:

$\sum_{i=1}^{n}$ - the sum of all the number

w – weights
x – value

4.3 Standard Deviation

This method will be used in the computation of Paired T-test wherein the differences of the weights of the users from the initial and final output of testing will be computed. The significant differences would be determined by comparing this method and the mean of two matched groups.

$$sd = \sqrt{\frac{\sum(x-y)^2}{(n-1)}} \quad (3)$$

$\sum$ - the sum of all the numbers
x - the initial weight of the user
y - final weight of the user
n - total number of participants

4.4 Paired T-Test / T-Statistics

It mainly focuses on the "before and after" type of testing where the same participants are measured both before and after to see the changes in the output within the given time. This method is also the final computation where the mean and the standard deviation are compared from a group of samples tested twice within the procedure.

$$t = (\bar{x} - \mu)/(sd/\sqrt{n}) \quad (4)$$

$\bar{x}$ - mean of the pre - BMI
μ - mean of the new BMI
sd - standard deviation

V. Statistical Analyses and Results

5.1 Respondents

The researchers have tested the mobile application several times before releasing it for testing. The testing is done to ensure that all the functionalities and features of the application will serve their purpose and will not fail the expectation of its users. After thorough testing, revisions, and improvements, the researchers searched for respondents that would qualify to test the application. These respondents must belong to people with diabetes, Endocrinologists, Registered Nutrition dietitians (RND), and CS/IT Professionals. These people answered the survey on how satisfied they were with the mobile application. A separate group of people with diabetes have tested the application for seven days. The data from the survey questionnaire is measured from 5 having very satisfied remarks to 1 having very unsatisfied remarks.

5.2 Paired T-Test

The data accumulated from the tester participants for the past seven days that they have used the application is computed using paired t-test. The participants are divided into groups based on their weight goals. The researchers compared the tester's BMI before using the application and the BMI after using it for several days. This data is used to test the hypothesis.

Table 1. Weight Maintenance and Weight Loss Paired T-test Computation

WEIGHT MAINTENANCE			**WEIGHT LOSS**		
	pre-BMI	post-BMI		pre-BMI	post-BMI
Mean	21.64	21.5260	**Mean**	27.64	27.4380
Variance	6.023	6.1844	**Variance**	2.288	2.5892
Observation	5	5	**Observation**	5	5
Pearson Correlation	0.9998		**Pearson Correlation**	0.9995	
Hypothesize	0.0000		**Hypothesize**	0.0000	
Degree of Freedom	4.0000		**Degree of Freedom**	4.0000	
t-statistics *t*	4.6118		**t-statistics *t***	4.2098	

P(T<=t) two-tail	0.0099	**P(T<=t) one-tail**	0.0068
t Critical two-tail	2.7764	**t Critical one-tail**	2.1318

In order to know the hypothesis, the researchers used the values given in table 1. With the values of these variables, the researchers got the t-statistics and determined the p-value and t-critical value of the gathered weight maintenance and weight loss data.

In conclusion, since the p-value in the weight maintenance is less than 0.05, the null hypothesis is rejected. In addition, the p-value of weight loss is 0.007 and is less than 0.01, and the null hypothesis is also rejected. Therefore, there is no significant change in the BMI of users after using the Nutrify application for a week.

5.3 Survey Results and Interpretation

The following table shows the participants' rating on the Functionality, UI/UX, Reliability, and Efficiency of the application. The researchers computed the weighted mean and mean of the tester participants' responses to determine how satisfied the participants to the application.

Table 2. Summary of Tester Participants' Data

SUMMARY OF DATA AND INTERPRETATION		
	Mean	Interpretation
Functionality	4.72	Very Satisfied
User Interface/ User Experience	4.62	Very Satisfied
Usability	4.68	Very Satisfied
Reliability	4.70	Very Satisfied
Efficiency	4.88	Very Satisfied
Total	4.88	Very Satisfied

Table 2 shows the satisfaction value in each category and its interpretation. The Functionality, Reliability, Efficiency of the application have a 'Satisfied' rate from all the respondents. The User Interface/User Experience and Usability have a 'Very Satisfied' rate. Even though three categories gained a 'Satisfied' rate, the overall satisfaction of all respondents gained a value of 4.62, which is interpreted as 'Very Satisfied' remarks.

VI. CONCLUSION

The Philippines has a high rate of diabetes cases, and its prevalence will still increase as long as a poor diet is still present in a person's lifestyle. Rice is one of the reasons why Filipinos are always at risk for diabetes. According to the American Diabetes Association, consistency in carbohydrate intake helps blood sugar levels throughout the day. For people with diabetes, eating snacks in between meals is a good practice to prevent blood sugar spikes. Furthermore, weight management will help people with diabetes avoid obesity, which highly correlates with the disease.

The researchers have proposed a study to create a meal planner application called Nutrify for people diagnosed with Type 2 Diabetes (T2D) to help manage their disease risks. The application generates meal plans according to the user's daily nutritional needs. Further, Nutrify features meals for the whole day encompassing breakfast, AM snack, lunch, PM snack, and dinner for which meal recipes are provided, including every ingredient's macronutrient and a link for the video tutorial in cooking the meal. The meals presented to the users include Filipino dishes that have readily available ingredients in the market.

Nutrify uses the Decision Tree Algorithm as the application's underlying technology. User's nutritional requirements and meal plans are correctly calculated based on the formulas used by Nutritionists. Features such as the edit recipe and substitute ingredients are helpful for the user's adaptability and personalization. Furthermore, the algorithm is efficient in its time complexity. Data shows that the application is efficient in CPU usage, memory usage, battery usage, and network usage. Thus, Decision Tree is the ideal algorithm for the application.

Evaluation of the application is conducted by four groups that qualified as the respondents. The groups are people with diabetes, Endocrinologists, Registered Nutritionist dietitians (RND), and CS/IT Professionals. These respondents answered a questionnaire of which ten agreed to test the effectiveness of the application in weight management for one week.

Paired t-test was used to test the changes in the before and after BMI of the users, and p-value > 0.05 was considered statistically significant. The weight maintenance group has a p-value of 0.01 and shows a significant change in their BMI.

Hence, the application was not as effective in maintaining the weight of the users. This result is maybe due to internal and external factors that the application cannot control, such as metabolism and sudden increase in physical activity. Although there is a change in the mean of the pre-BMI and post-BMI of the respondents, the weight loss group arrived at a p-value of 0.007, which shows that there are no significant changes in the BMI. It shows that the users should have an extended period of testing the effectiveness of the application to produce statistically significant results.

The researchers use the Likert Scale to get the respondents' satisfaction level in each questionnaire category: functionality, user interface/user experience, usability, reliability, and efficiency. With an average score of 4.62, the respondents are very satisfied with the application.

In conclusion, the researchers have developed an application that will generate a meal plan and create a dietary goal to help the user stay healthy and avoid their existing health conditions from becoming worse. Furthermore, users need to use the application for a more extended period to see statistically significant results.

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Chapter - 10

Internet of Medical Things (IoMT) – Medical Applications and it's Cyber Security

A. Varsha Jacqulyn[1], Mrs. R. Thiruchelvi[2]*, Mrs.K. Rajakumari [3]

[1] Assistant Professor, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS) Chennai-600117.

[2] II[nd] year student, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS)

[3]Assistant Professor, Department of Bioengineering, B. Tech Biotechnology, Vels Institute of Science, Technology and Advanced Studies (VISTAS) Chennai

Abstract— The Internet of Things (IoT) is a huge deal all around the world. It can be used in a variety of fields, including industrial, healthcare, agriculture, and the environment. Due to a lack of interaction among patients and doctors in the past, correct diagnosis was difficult to come by, and fatality rates were high. They were incapable of dealing with epidemics and pandemics. The Internet of Medical Things (IoMT) was recently developed to better and improve the healthcare profession. IoMT is a medical gadget that allows for increased patient convenience, price healthcare treatments, improved medical therapies, and more customized care. Wearable gadgets have been on the rise, with several benefits in terms of keeping watch of vitals and healthcare, igniting the growth of the Internet of Medical Things (IoMT). It allows electronic technologies to collect, analyze, and send information to cloud systems. This allows you to examine the patient's health status at any time and from anywhere, including body temperature, pulse rate, hearing beats utilizing ECG sensors, temperature, pressure, and observation. Digital gadgets have been designed and are widely used as a result of these systems. Doctors may keep track of a patient's health status in real time and prescribe medicine, vitamins supplements, and healthcare advice to them through. IoMT aids in the detection of body changes such as the growth of irregular masses of undifferentiated cells, the recognition of neural disorders, the checking of diabetic patients' glucose levels, the detection of psychiatric conditions using heartbeat, the real-time tracking of chronic disease symptoms, the screening of internal organ dysfunction, and the monitoring of cardiac blocks that cause heart attacks. IoMT assisted doctors in identifying and diagnosing COVID-19-affected patients and assisting them in providing appropriate therapy remotely. Clinical decisions were made with the help of IoMT as Artificial Intelligence (AI), telemedicine, and sensor technologies advanced. In the context of smart cities, IoMT introduces a new issue in the healthcare sphere. This chapter provides an outline as to how IoMT operates and how it has improved the lives of many patients through the use of modern technologies. This also includes a design and overview of IoMT, as well as numerous activities in the health-care industry, pop-up technologies, and several IoMT case studies in medical applications. It also lays out the IoMT's cybersecurity rules and indicates issues which need to be tackled at the parliamentary and community sectors.

Index Terms— Internet of Medical Things (IoMT), Artificial Intelligence, Cloud Systems, Digital Gadgets, Sensors, Smart cities, Cybersecurity.

I. INTRODUCTION

The Internet of Medical Things (IoMT) is a Web system of hospital equipment, electronics, and programming that connects clinical IT. IoMT devices can help doctors track patients' activities and behaviors absent from work, enabling them to access to actual data on patient treatment adherence as well as what occurs after a patient goes from a healthcare center. IoMT has the potential to improve the way we care for our elders and to aid with rising healthcare expenses. IoMT devices can monitor vital signs and heart rate, as well as glucose and other physiological systems, as well as activity and sleeping patterns. Seniors frequently fail to take their prescription medicine on time, and IoMT gadgets could assist them remember to do so while also documenting when they took it. Furthermore, portable diagnostic gadgets could enforce strict blood and urine testing easier for our ageing population, a group of people with limited mobility who require such tests more likely than younger patients. Wi-Fi connectivity allows for remote monitoring. The creation of a website for real-time monitoring of medical indicators. To give the doctor warning and notification about the patient's health condition, an open platform transportation protocol is implemented. This method allows you to access the monitoring and recommendations of doctors all over the world. By 2020, Gartner estimates that 20.4 billion items will be interconnected [1]. With an annual growth rate of 16.9%, the global IoT industry will exceed 1.7 trillion USD by 2020, up to 655.8 billion USD [2]. This chapter discusses about how the IoMT works and the applications of IoMT in medical and healthcare.

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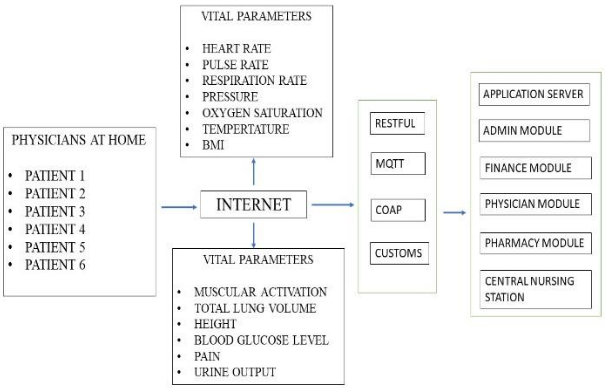

Figure 1 General outline of IoMT devices

II. CATEGORIES OF IoMT:

The IoMT is categorized into 5 parts: on-body segment, in-home segment, community segment, in-clinic segment, in-hospital segment.

2.1 ON-BODY SEGMENT:

The on-body segment is classified into consumer health variables and clinical-grade variables.

2.1.1 Consumer Health Wearables:

Consumer health wearables included activities monitors, wristbands, bands, sports watches, and smart clothing, as well as consumer-grade gadgets for wellness or fitness. Most of these gadgets are not authorized by health authorities, but specialists may recommend them for certain health uses based on unofficial clinical validation and customer analytics. Examples are Samsung Medical and Fitbit.

2.1.2 Clinical-Grade Wearables:

Most of these gadgets are used in combination with professional advice or a doctor's prescription. They are regulated gadgets and systems which have been certified for and by one or so more regulatory or medical agencies, including The US Food and Drug Administration. Examples are Halo Neuroscience's Halo Sport is the first wearable neurostimulation device created exclusively to aid athletes in improving their performance. It speeds movement-based training, makes it easier for athletes to undertake actions by stimulating neurons, and makes it a stronger aid [3] and Muscle memory, strength, and endurance are all controlled by them; and Neurometrix's Quell, a wearable neuromodulation gadget that feeds into sensory neurons to provide chronic pain relief.

2.2 IN-HOME SEGMENT:

The in-home segment is classified into three parts: PERS, RPM and telehealth virtual visits.

2.2.1 PERS:

A Personal Emergency Response System (PERS) integrates smart hardware components with a real healthcare contact center program to help the seniors who are housebound or have reduced movement are becoming more ego. Users may connect and receive urgent medical treatment quickly using this product.

2.2.2 RPM:

Remote Patient Monitoring (RPM) encompasses all smart sensing smart objects used for patients with chronic diseases, which entails constant monitoring of physiological measures to assist long-term care in a patient's home in an effort to slow progression of the disease; acute home monitoring, which entails continuous monitoring of outpatient services to speed recovery and avoid re-hospitalization; and medication management, which entails providing users with medicine notices and information on dose to increase adherence and outcomes.

2.2.3 Telehealth Virtual Visits:

Online consults that allow patients manage their diseases and acquire medications or recommended care regimens are included in telehealth online visit. Video consultations and the examination of illnesses or lesions using live observation and digital diagnostics are examples.

2.3 COMMUNITY SEGMENT:

Passenger vehicles can track health metrics while in travel thanks to mobility services. First responders, paramedics, and hospital’s emergency room care professionals will benefit from emergency response intelligence. Kiosks are structural units with computerized touchscreen display that can distribute products or give services like connectivity to healthcare practitioners.

Medical gadgets used by a practitioner outside the home or regular healthcare environments, such as at a health camp, are known as point-of-care devices. Logistics refers to the transportation and distribution of health-care goods and services, such as drugs, surgical and medical equipment, medical instruments, and other items required by caregivers.

2.4 IN-CLINIC SEGMENT:

IoMT systems that are employed for administration or clinical activities are included in this segment. Moment in time gadgets in this section diverge from others in the public sector with one meaningful area: rather than the healthcare professional directly operating a tool, skilled workers can operate one distantly. Rijuven's Clinic in a Bag is a cloud-based assessment service that allows practitioners to check patients anywhere at site of treatment; Think Labs' smart stethoscope is also another example.

2.5 IN-HOSPITAL SEGMENT:

Asset management keeps track of elevated capital equipment and mobility assets across the hospital, such as implantable devices and wheelchairs. Personnel management assesses the effectiveness and productivity of employees. Patient flow management enhances hospital operations by minimizing bottlenecks and improving the patient experience—for example, patient arriving time from an operating room through post-care to a ward room are tracked. Inventory management reduces inventory costs and improves staff productivity by streamlining the ordering, storage, and usage of medical supplies, commodities, medications, and medical devices. Environment and energy management systems keeps track of how much electricity is used and guarantees that patient spaces and storage rooms are in good working order.

III. APPLICATIONS OF IoMT IN MEDICAL AND HEALTHCARE:

3.1 REMOTE HEALTH MONITORING:

They carry out some normal regular tasks by monitoring the patients. Though the patients are healthy, continuous health monitoring is done to check their health. Instead of paying bills in hospital for normal checkups, we can do it remotely using these advanced devices so that it'll lower the bills. The advancement of IoMT has ultra-low power sensor devices which are easy to carry everywhere, light weight communication agreements. These processes include a Portable Patient Monitoring Unit (PPMU) which includes sensors and circuit design that quantify pulse rate, heartbeat, oxygen saturation, systolic and diastolic blood pressure, body temperature, Mass index, blood sugar level, respiratory rate, muscle activation, and much more. This aids in genuine monitoring and judgement at the hospital. Patients' status can be monitored in a periodic surveillance system that relies on their conditions.

3.1.1 Heart-Related Diseases:

ECG stands for Electro CardioGram, which is the way of documenting and analyzing the patient's heart rate. It aids in the acquisition of the voltage differential that is being recorded. P wave, QRS wave, and T wave are the three types of waves. Atrial depolarization is indicated by the P wave. This P wave has an intensity ranging of the less than 2.5 mV and a length from less than 0.12 seconds. A greater P wave indicates right heart expansion, whereas a smaller P wave indicates hyperkalemia. QRS wave indicates right and left ventricular depolarization. A QRS wave normally lasts 0.060.10 seconds. The wave has a 3.5 mV amplitude. The repolarization of a ventricular is represented by a T wave. A low T wave implies ischemia inside the coronary arteries. Because it specifies ventricular repolarization, this waveform gives additional details than a P or QRS waves. The ECG was previously assessed by inserting sensors on the patient body and watching their rhythm signals. Arrhythmia, which is described as an irregular cardiac rhythm, can be detected with these remote devices. They reveal a wide range of previously undiscovered illnesses. Signals filtering, digitization, and packetization, as well as transferring these signals to the main server, are now required to validate heart rate. The Internet of Things has developed to the point that wirelessly sensor-based remote monitoring equipment are being recommended for evaluating individuals' ECG readings. A wireless connectivity point in the home transmits the Electrocardiogram of various patients to a central server. The physicians ensure an informed decision at the proper moment after processing the signals.

The scientists devised a technology that oversees the entire the Electrocardiogram to use a wireless instrument that is portable. The signals are measured in the phone app or on the PC and wirelessly transferred to the physician via the Bluetooth connection [4]. Using mobile phone technology with an elevated recording with an alert system and notification system, designers develop a low, portable, mobile ECG acquisition system [5].

Simple-link sensor web monitoring of inputs from millions of patients and connecting it to the medical servers is one of the best solutions for monitoring the heat rate. It is divided into two sections: 1. the patient's residence 2. A medical facility.

Patient's home:

The patients house program contains a WPSU and a residential router. WPSU has an ECG sensor in the shape of an inclusion of additional that detects heart activity, as well as an instrument amplifier that boosts low-amplitude signals, active noise cancelling to filter out unwanted frequencies, and a microcontroller that analyses the Electrocardiogram signal, it delivers the findings to the intended recipient. The data is subsequently transmitted to the clinic via the web.

Hospital section:

The hospital gets regular data from the home via greater Wi-Fi. The ECG application server collects the ECG from the patient's home via the web. The patient's data stores private information such as DOBs, gender identities, blood types, locations, and illnesses. Heart rate monitoring software is used to view and evaluate ECG signals. This entails storing patient records, charting data both online and in person, and providing the most current information for all patients. It can identify node that are not operational due to various of reasons, including network access difficulties or sensing malfunction [6].

The [7] proposed MSSO-ANFIS enhances search capability while using the Levy flight approach. The conventional learning method in ANFIS is diffusion and prone to being trapped in local minima. MSSO-ANFIS is being used to classify and identify the heart status from incoming sensor data. Through simulation and analysis, MSSA-ANFIS has been shown to be useful in disease prediction. The MSSO-ANFIS prediction algorithm surpasses the other methods in terms of accuracy, according to the simulated findings. The MSSO-ANFIS predictive algorithm has a precise of 96.54 and a precision of 99.45, which is significantly higher than the other techniques.

For sensor identification, a hybrid logit analytics with enhanced ant colony optimization (HLDA-MALO) method was chosen, while for echocardiogram classification tasks, a hybrid Faster R-CNN with SE-ResNet-101 architecture was applied. Both classification methods were used, as well as the results were integrated and verified in terms of their ability to forecast cardiovascular disease. The HLDA-MALO methodology accurately detected regular sensor information 96.85% of the times and unusual sensor information 98.31% of the times. With 98.06% accuracy, 98.95% recollection, 96.32% sensitive, a 99.02% F-score, and maximum consistency of 99.15%, the based hybrid Accelerated R-CNN with SE-ResNeXt-101 transfer active learning significantly excelled in spotting echocardiography pictures [8].

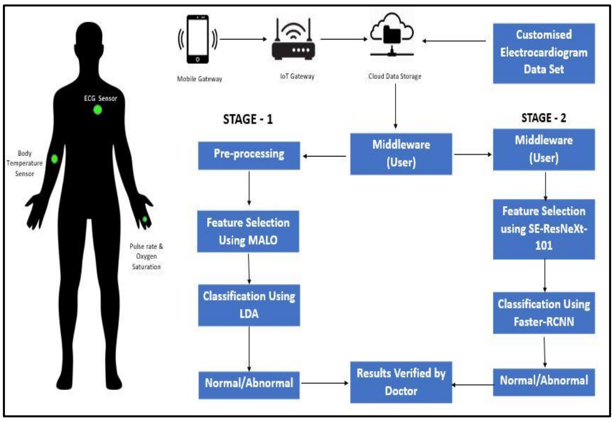

Figure 2 Identification of heart rate using HLDA- MALO method [8]

The [9] demonstrates that the people's clinical data, including such pulse rate, temperature, and oxygen availability in the cylinders, are wirelessly communicated to the doctor's area and stated when the doctor demands them, via a display system. In addition, in the case of emergency, this system contains a way for delivering medications to patients. The title of the medication will be displayed on a LCD (Liquid-Crystal Display) in the patients' area, which will be reviewed by staff nurses on a regular basis. This helps to reduce the death rate by acting fast.

The [10] detects heart rate using a readily available sensor the Pulse Sensor AMPED. It blends a simple cardiac detector with sound and amplification techniques to obtain reliable heart pulse readings quickly and effectively. This sensor was chosen because of its dependability, convenience of use, and outstanding performance. It's also reasonably priced and comes in a small packet. The sensor can be worn by clipping it to the touch of a finger and connecting it to a microcontroller. Power consumption is an important consideration when employing sensors. The fitted sensor is energy efficient, using only 4mA at 5V and operating throughout a voltage range of 3V to 5V. In addition, the sensor's lower transmit power is crucial for reducing the sensor's effects on the child's state.

3.1.2 Brain and Neurological Disorders:

Neurological diseases affect both the peripheral nervous system. The nervous system is made up of the cranium, brain stem, central nervous system, peripheral nervous system, sympathetic nerves, nerve cells, and muscular to mention few of. These disorders include epileptic seizures, Alzheimer's disease, and other forms of dementia, cerebrovascular diseases like cerebrovascular accident, severe headache, and other backache illnesses, amyotrophic lateral sclerosis, Parkinson's disease, neuroinfectious, tumors, traumatic central nervous disorders from head trauma, and brain conditions caused by malnutrition. Alzheimer's disease is indeed a neurological condition which causes the brains to shrink (atrophy) causing brain tissue to die. A chronic loss of intellectual, behavioral, and social capacities compromises a person's ability to function freely.

Dementia is a condition where a patient's clarity — logic, remembering, and thinking has worsened to the point where typical tasks and existence have become challenging. Some dementia patients lack emotional control, and therefore, their personality shift. Dementia can fluctuate in complexity from least severe phase, whenever a patient's ability to function is decreasing, to some of the most intense phase.individual is entirely reliant on someone else for basic daily activities.

Parkinson's disease causes shakes, rigidity, and difficulty functioning, balancing, and synchronizing. When cells in the basal ganglia, that portion of the brain is responsible for signal transmission, are harmed or dead, this happens. Dopamine, a particular cognitive neurotransmitter, is generated mostly by nerve cells, or neurons. Parkinson's disease is caused by a lack of dopamine produced by neurons that have died or been harmed.

A variety of ailments can be caused by anatomic, chemical, or electric irregularities in the brains, frontal lobes, or even other nerves. Immobility, tight joints, poor coordination, lack of sensation, convulsions, anxiety, pain and disturbed states of consciousness are some of signs. Dementia manifests itself in a number of ways including

- The inability to recognize things,
- The inability to identify and communicate the urge to pass urinate and faces movements
- A failure to identify a medication schedule,
- Difficulty to recall a person's address and phone number, and
- Incapability to comprehend previous daily activities.

contrasted to the patient's stated previously expected behavior. A comprehensive's operational of diagnosis of the disease in people who live there and don't have anyone to observe their conduct [11].

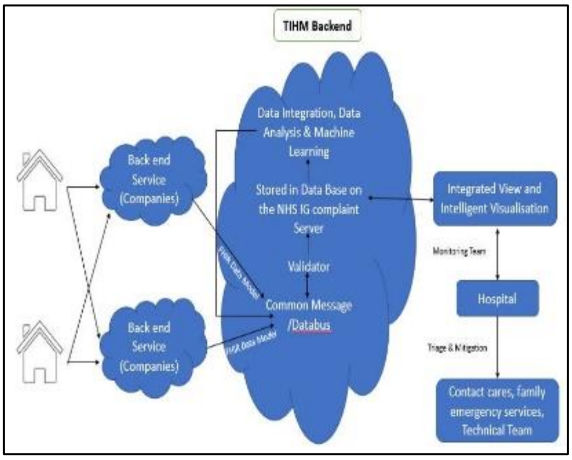

Figure 3: Overview of TIHM backend method to monitor dementia patients [12]

The [12] developed an innovation healthcare management strategy in this investigation. IoT gadgets were used to facilitate TIHM (Time-Hopping Impulse Modulation). To enhance the patient files, a variety of machine learning algorithms were employed. TIHM is capable of working in real-time and informing healthcare providers on the health status of a dementia patient. Although the system can extract critical information in real time and send extra and accurate data to patients and practitioners, it has dependability and trustworthiness issues.

Researchers employed Partial Tree (PART), a hierarchical clustering classifier with advanced feature set, to detect brain tumors according to their class, i.e., grades I through IV. Using 10-fold cross validation, the proposed model is compared to existing methodologies including such CART, Randomized Forests, Naive Bayes, and Random Tree.

Wearable sensors were used to detect abnormal body motions and oscillations, as well as to detect dementia early. The purpose of the system development was to construct a flawless IoT-based platform that could detect dementia and track the patient's status early on, enabling the issue to be addressed before it became worse [13].

Utilizing devices including an RFID-enabled wrist band and an IR room locator, the [14] attempted to track the activities of elderly people in their homes. To establish not whether the person has dementia, three variables were used. Furthermore, sensor data was used to develop a forecast model that used these three characteristics to predict the sickness. The sensors can monitor the patient's state by monitoring gasoline, sink faucets, light switches, and TV switches out again to see how active or passive the patient is.

A thorough examination of dementia earlier diagnosis and post-detection treatment is now underway. A "Demencare" post-diagnosis aged care technique is included in the [15]. This model includes eight detectors that can monitor a dementia patient's daily activities. An edge of the network platform can be used to technique involves observing on a community scale. On their grounds, they have a gadget. Healthcare experts may also keep an eye on the patient's condition for just any signs of unusual behavior. IoMT promotes post-diagnosis therapies for neurological illnesses like Alzheimer and Dementia. The patient's behavior and vital metrics are always accessible, irrespective matter how far away they are. Patients' data can be categorized, and more information can be collected to aid patients be handled more effectively.

3.1.3 Diabetic Patients:

Diabetes, often known as blood sugar, is a condition in which your blood glucose levels is absurdly high. Your primary source of energy is sugar, that originates from food that you eat. Insulin, a pancreatic hormone, boosts glucose uptake into tissues for producing energy. The World Health Organization (WHO) reported 422 million people worldwide had type 2 diabetes in 2014. (T2D). This means that diabetes affects 8.5 percent of adults. The WHO, on the other hand, predicts that just by 2030, the population would have climbed to 500 million.

If diabetic is not well managed, the quantity of sugar in the blood increases. Excess glucose can harm several parts of your body, including your eyesight, heart, legs, nerves, and kidneys. Increased blood pressure and arterial hardening are also side effects of diabetes. To avoid such serious complications, diabetics can be monitored using IoMT technology.

Diabetic patients should have their blood sugars checked on a constant schedule to verify that their diet is appropriate and that their blood sugar levels are within safe limits. On the market, there are several features that enable users to check their blood glucose levels from the comforts of home. However, does not provide genuine supervision by a physician or therapist. IoMT makes it easy by building intelligent, low-power nodes that monitor and manage a patient's sugar levels and make it accessible to doctors via smartphone or online apps.

RHM is a method that continuously monitors health data. This includes physiological monitoring, such as pulse rate, temperatures, and heart rate, as well as physical exercise tracking, diet tracking, medication tracking, and behavior tracking. Wellness data is securely supplied to patients and caregivers via the cloud. This technique receives, evaluates, and monitors a large volume of data.

RHM makes use of the following:

1) Identifying and diagnosing diseases
2) Management of diseases
3) Diseases forecasting
4) The prognosis of diseases
5) Preventing diseases
6) Administering the appropriate medications and treatments
7) Rehab services

As a result, by gathering medical data and sending it to caregivers, RHM may lessen the danger for people who are more vulnerable [16].

This concept includes a user experience, EHR databases, OMDP SWRL methods, conventional, an OMDP level of cognitive, and an inference system. The user audio input primary function is to collect health information without taking up too much of the doctor's time. An proper processing strategy is always necessary because the EHR database contains a huge amount of organized and unstructured medical information. Diabetes mellitus forecasting model, screening, and medication are all part of the OMDP project [17].

DiabetCare is a software app designed exclusively for insulin pumps users by Homecare. DiabetCare is a functionality tool with a blood glucose records, graphical monitoring, and carbohydrate calculations. This app offers three services that help diabetics in their everyday lives: care monitoring with the ability to recall strange events, respondents answered enhancement with configurable notifications and carb calculations, and patient care guidance with the power to call from the app via the incorporated directory [18].

The Internet of Things (m-IoT) presents a new medical networking concept in [19], which combines IPV6-based communications technology such as 6LoWPAN with anticipated 4G technology to facilitate new Internet-based m-health services. It is well known that true measurement could provide medically important data about glucose concentrations and situations, enabling for prompt intervention of any insulin dependent patient's hyperglycemic incidents in real-time, rather than quasi measurement techniques, as is actually the case. In recent years, several non-invasive glucose level measurement devices have been studied. This [20] shows how to set up a home-based Urine-based Diabetes (UbD) monitoring device. It has multiple stages that enable individuals not only to monitor his or her diabetic measurements on a constant schedule, but also to do a prediction technique so that cautious actions can be implemented at an initial point.

3.1.4 Elderly People:

An advancement of IoMT is fall prediction for elderly people who are living at home and undergoing true monitoring systems. A variety of sensors, including gyroscope detectors, accelerator sensors, motion detectors, and single and multi-cameras, make up a data acquisition system. The sensors interface with the appropriate microcontrollers and internet processor to transmit signals to a centralized computer, which creates an alarm method that enables officials to react to a patient's current condition. You may well have mobility issues or chronic health ailments, or you may be isolated from family and friends. Services that are typically provided, such as caregiver assistance, in-home health care, and meal delivery companies, may be inaccessible for a while. That's why IoMT shows up.

The first detection is performed by the Sensor of Movements (SoM) device to disperse the consumers of fast data processing. The Decision-Analysis Device (DAD), a second device with additional computational resources, creates a deeper processing of the sensory input to discern between a present falling event and other sorts of impacts more precisely and reliably. A wireless link is formed between both the SoM and the DAD, which are both worn by the individual being observed, resulting in the creation of a Wireless Body Area Sensor Network (WBSN) [21].

The LAURA system provides the services by using a Wireless Sensor Network (WSN) that is installed all through the nursing institute to gather and transfer the essential data from patients to a central controller [22].

For the City4Age project, the authors developed a behavioral management and risk detection system. A location sub-system identifies interior position of the user, and a locomotion sub-system continuously monitors and detects body activities using a wearable device, are the two components of the suggested system [23].

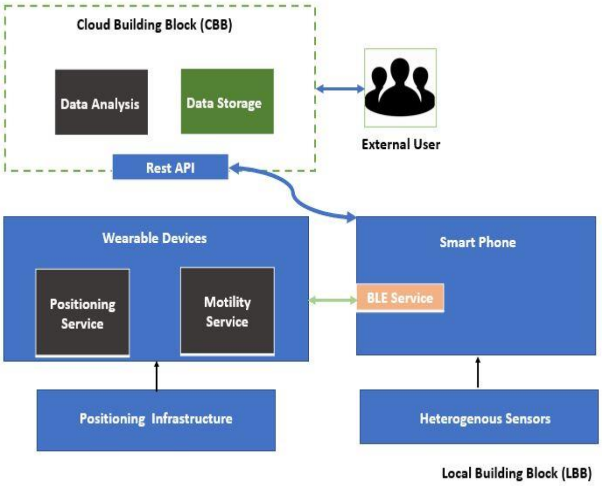

Figure 4: The overall view of City4Age project [23]

The [24] uses phonocardiograph (PCG) or ECG detectors, an Arduino Microcontroller, and a Raspberry Pi 3 to create a unique mobile device design. It was used to remove noise from sensor data, exhibit PCG or ECG signals in web-based media and identify cardiac sound signal components in real-time to show a legible and simple diagnostics heart sound signal.

The [25] presented a wearable system that uses Bt smart beacon sensors and a cloud-based mobile app to have an activity surveillance system for elderly individuals. The device was capable of effectively distinguishing various drinking and toileting actions, which could be useful to caretakers in monitoring elderly patients.

3.2 SMART HOSPITALS:

IoT is critical in transforming the clinic into a digital facility. The first step forward towards a smart hospital has been achieved by establishing mobile phone appointment enrollment based on doctor availability, smartphone application inquiry, and lab results reports, among other things. Developing medical devices that provide real-time signals of blood glucose levels, Electrocardiogram, hypertension, and other parameters to an early proponent for diagnostics is a step forward.

Chronic illnesses are those that cannot be treated but can be managed. To avoid critical conditions, patients with this condition require constant monitoring and acute treatment. With the use of remote access, a stay in the clinic just for the purpose of managing can be avoided. The 5th International Conference on Devices, Electronics, and Systems will take place in 2020. Holter-based surveillance is the most widely used and acknowledged way of tracking individual patients with chronic conditions.

A patient-worn ECG sensor and a distant monitoring station, and a decision - making support system that links these elements, were proposed as part of a smart cardiac surveillance system. The Pan–Tompkin's algorithm is used to detect heart rhythm, and a decision tree is used to classify them by the decision - making support server. Simulations employing information from MIT-BIH arrhythmia dataset show that our system detects heartbeats with a 95.74 percent accuracy and classifies them with an almost 96.63 percent accuracy, all while maintaining confidentiality and safeguarding communication among the involved parties [26].

IV. TECHNOLOGIES USED IN IOMT DEVICES:

The Internet of Medical Things (IoMT) integrates the Internet of Things (IoT) with medical advances to give positive outcomes, better expense medical solutions, quicker medical treatment, and more individualized healthcare. It then goes on to detail the health service's operational processes and how they are incorporated into design and architecture. There have also been several technical advances, such as:

1. PUF,

2. Blockchain technology,
3. Artificial Intelligence (AI),
4. SDN

should be seen as key solutions for solving a number of e-healthcare concerns, including safety, privacy, correctness, and convenience.

4.1. Blockchain Technology:

The blockchain is made up of blocks, or nodes, that are connected by a network. Information passed between nodes in a network is stored and can be used for cross references. This methodology aids in pinpointing the particular source of malcontents in the network because these blocks contain data from earlier blocks. As a response, network nodes which are not identifiable are removed, paving the way for blockchain to be recognized a credible way of sharing information in IoMT platforms [27].

Blockchain enables organizations to communicate with others even when there is no central authority in the system. In blockchain, data entries are saved in data blocks. These blocks, as stated previously, hold data on surrounding blocks in the network and also cryptographic techniques for safely packaging them. Other customer can access those blocks and its data, but the data held within them is safeguarded from alteration. Blockchain also makes it far easier to execute agreements without a central ministry's involvement [28].

While the volumes of information flowing into the health ecosystem is expanding all the time, the value of implementing blockchain technology arrives with a confidence level. The block chain technology has the capacity to discuss the rising demand for data transfers throughout the medical infrastructure. Drug trials are going conducted all around the world as blockchain is being explored in institutions for EHR systems [29].

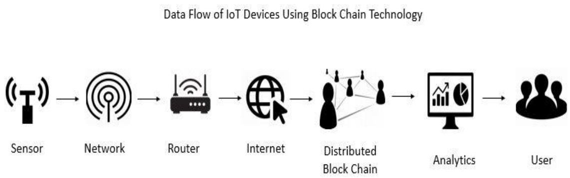

Figure 5 Blockchain Technology

4.2 PUF:

Physically Unclonable Function (PUF) technologies give the IoMT environment's sensitive parts a unique identification. Various distinct fingerprints/signature are the result of differences in the manufacturing of these gadgets. These characteristics can be used to produce cryptography keys to defend the detectors and their information in the IoMT scenario, where smart objects sensors are subject to hardware manipulation efforts. The PUF gadgets are found in the light coating [30] in our mapping. These devices are crucial when it comes to the authentication of IoMT devices within the ecosystem.

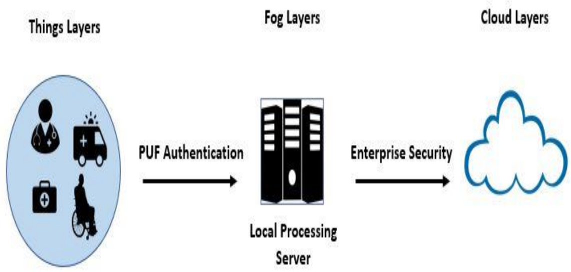

Figure 6 IoMT supported by PUF devices [30]

4.3 AI In IoMT:

Personalized medicine involves attempting to cut investigations and customized treatment delivered on time. By providing realistic solutions for developing specific treatment pathways looking at historical and actual statistics, AI makes a solid case for this. AI-based solutions have the power to change many parts of the healthcare market. These will include AI-based strategies for classification building, including such automate client information gathering, arranging doctor's appointments, determining lab tests, treatment options, medications, and surgical intervention, among other topics.

Such classifications might be enhanced and also used to assist managers make informed decisions. NLP presents a way for collecting information from certain unstructured pieces of data in the network for other categories which aren't properly preserved. Test results, medical examination reports, surgery notations, as well as other patient-related section summarizes are instances [31].

4.4 SDN:

In Software-Defined Networking (SDN), there are two elements to the network:

(1) data plane

(2) control plane.

The data plane is in responsibility of transmitting data towards its target, while the control plane is in responsible of activities that permit the plane makes routing information. SDN (Software-Defined Networking) defines a proactive step for the data plane and control plane. The data plane can acquire a range of sources from just a remote system using the commonly Used network interface since the data plane and control plane connections can be made standardized utilizing a regular SDN protocol. Because they can be placed on the cloud layer, this provides for the development of numerous of e-healthcare applications. The SDN control plane gathers data from IoMT devices and delivers it to an e-healthcare software. A privacy and security tool, a patient diagnosis usage, or a patient care usage are all examples of e-healthcare applications [32].

V. CYBERSECURITY:

Advances in medicine have secured a spot even among the Internet of Things' ever-growing reservoir of portable technologies that manage our society (IoT). This digital age, though, is about more than quantity; it is all about closeness.

What used to be a web of devices has evolved into a network of human devices. Despite its allure, the modern drive for interconnectedness also introduces new security vulnerabilities. A single flaw in these tangled networks might jeopardize critical health infrastructure. Furthermore, with humans actively involved, the risks of cyber espionage are higher than they've ever been. New technology creates new targets, necessitating the development of nimble cybersecurity systems capable of combating these emerging threats in real time.

Any gadget that connects to a network or accesses information is vulnerable to hacking. Cyberattacks range from blatant to subtle in nature, which has ramifications for detection and reaction. Although the word "cyberattack" is most often linked with criminal intent, unintended security flaws may put patient health on the line. Assailants have increasingly targeted the healthcare industry, which has been subjected to several attacks during the lockdown. In fact, according to a survey done by Ponemon Institute in 2020, 54 percent of healthcare providers experienced at least one patient data breach in the previous two years, while 41 percent experienced at least six, if not more. Surprisingly, the average data leak cost $2.75 million and involved 10,000 patient information.

Figure 7 Three crucial aspects of Cybersecurity

5.1 CONFIDENTIALITY:

Unauthorized disclosures of patient data protected under federal law are commonly referred to as "loss of confidentiality." This usually happens as a result of unauthorized users, hardware thievery, or malware attack in the context of external threats. First, an unauthorized actor may utilize a compromised device as a channel to spy on health data. Despite the fact that the Internet of Medical Things is well-protected, the addition of Smarter Environments raises the likelihood of wellbeing IoT becoming novel aggressive channels. Another method of acquiring data or passwords from an equipment would be through IoT burglary, underscoring the importance of physical safety. In the notorious casino cyber heist of 2017, criminals used a Smart fish tank inside the foyer to get access to the casino network and then exfiltrated several gigabytes from high-roller dataset [33]. A phishing attempt in which an unwary patient or medical personnel member clicks on a link that spreads spyware from a laptop to nearby devices [34].

The reality that IoT systems are commonly easy to conceal and often found in regions with unfettered physical access adds to the risk. Outfitting elevated, transportable IoT devices geolocation trackers linked to warnings for suspicious activity could be one method to deter theft [35]. One approach to assist prevents this form of threat is to raise knowledge about cyberattacks.

5.2 INTEGRITY:

A device's integrity is its ability to be trusted. In general, gadget fidelity can be lost owing to data or functionality damage. The explicit weaponization of a healthcare gadget through a reprogram attack is a famous example. This type of attack can result in a variety of consequences based on the phone's medical applications. In 2008, a group of academics were able to tinker with a pacemaker's device programmer to eavesdrop, modify patient information, interrupt connections, cause disruption, and manage the delivery of impulses [36].

In 2016, the Owlet Smart sock, a baby monitoring with a sensor that allows caretakers to check their child's heart rhythm and oxygen saturation on their smartphone, was hacked. [37]

5.3 AVAILABLITY:

The capability of a gadget for use by an authorized people is referred to as availability. This function is limited by speed, storage, and storage capacity. DoS attacks cause a device to become overloaded by flooding a website with traffic. A denial-of-service attack could be used to drain a pacemaker's charge.

The overloading a Smart watch's memory could cause it to become inaccessible or demand a restart. This is merely one of the "Sweyn Tooth" flaws as in (BLE) "system on a chip" that were discovered in March 2020 [38].

DoS attacks also are known for causing process disruptions. This can result in care delayed or financial losses, putting a pressure on the health service. The possibility of a huge DDoS - Distributed Denial of Service assault leveraging the IoMT is of special concern [39]. While most DoS assaults result in short service interruptions, like Sweyn Tooth has experienced, other cases have shown this to be also feasible to "brick" or permanently destroy IoT. Healthcare providers have the responsibility of protecting their devices and staff, particularly when it comes to impact to clinical operations and preventing unauthorized access to vital information technologies (PDoS) [40].

The following presents the current IoT security, organized by the three primary topics described above.

5.3.1 Device Protection:

Each device has its own identification key or security certificate: This key is used by the device to authenticate itself and communicate with IoT gateway.

For connecting the gadget to the IoT gateway, an on-device X.509 certificates and secret key are required. The authentication mechanism must ensure that this secret key is never known beyond the device, resulting in a better amount of safety.

5.3.2 Security Of Connectivity:

Data security and privacy are at risk when IoT computers are connected via the Internet. As a result, it's important to guarantee that all data transmitted between two equipment and IoT hubs, and then to the cloud, is protected.

5.3.3 Cloud Security:

Cloud computing has a lot of security vulnerabilities that, if ignored, might have disastrous effects. The most common security flaws can be classified as follows:

- Technologies that are shared
- Hijacking of an account or service
- Denial of Service (DoS)
- Insiders with nefarious motives

The most basic approach is to employ an encrypted internet standard to secure all data from the origin to the destination throughout the entire journey. SSL & TLS can also be used to encrypt communication and restrict the disclosure of sensitive data.

VI. WAYS TO PREVENT CYBERSECURITY ATTACKS OF IoMT DEVICES:

Healthcare providers must protect their equipment and employees, especially when it comes to clinical procedures and preventing illegal access to sensitive information. One approach for managing IoT in healthcare is to use risk analysis concepts and methods to necessary protection Iot technologies on a larger scale. Healthcare providers can use risk management plans and administration, risk, and accountability (GRC) to quickly develop or modifying their current safety network to approach involving their cyber problems.

Identifying all devices: First and foremost, healthcare organizations must be aware of and identify all devices linked to their network. This will not only aid in the detection of possible threats and strange activity, but it would also allow the business to implement security requirements and updates.

Monitoring devices: In addition to just identifying devices, healthcare institutions should have a proper monitoring procedure in place to provide a benchmark for network activity. This is critical in both the formulation of preventive security policies and the reaction to incidents.

Controlling access: Because some IoMT devices don't permit for software upgrades or fixes, healthcare providers can use security controls or app access controls to restrict access.

Strong password: Passwords on devices should be strengthened. Too often, healthcare companies link IoMT equipment to the internet without altering the production plant users and passwords, which can be fatal. For the most essential devices, medical IT teams must need secure passwords or passcode and consider carried out using two authentications. Gadgets should only be allowed to see it and acquire what they want and need to perform their tasks.

Keep up with known and available patches, especially for devices that are very susceptible: Patch application should be selected and scheduled to enhance the effect while limiting the harm. Organizations should separate gadgets from the network when they can't patch them. Examine your computer for insecure or out-of-date software. If upgrades are available, twice that amount the patching procedures are safe.

6.LAWS AND REGULATION:

The well legislation relevant to patient confidentiality is indeed the Health Insurance Portability and Accountability Act (HIPAA). HIPAA was signed into law in 1996, and it "mandated the adoption of federal laws to ensure critical patient information from being exposed without the patient's knowledge or consent," according to the CDC (2018).

The Privacy Rule protects private health information (PHI), but the Security Rule safeguards electronic PHI (e-PHI) that's also made, kept, accessed, or transferred. The HIPAA Security Rule requires a company managing electronic protected health information (e-PHI) to use important cybersecurity measures such as the ones listed below:

• Protect e-PHI from security breaches or prohibited usage.
• Protect the confidentiality, security, and accessibility of e-PHI.
• Identify cybersecurity threats that might imperil e-PHI and take extra precautions against them.
• Confirm compliance with federal guidelines [41]

VII. CHALLENGES OF IoMT:

There are many obstacles and ramifications that must be solved for IOMT may be widely accepted.

7.1. Interoperability:

The specifications that enable apps made by various sectors differ. The volume of use is also hampered by the heterogeneity of systems and networks obtained from various sources, owing mostly to multi variability. Interoperability is challenging because data sharing between multiple IoMT platforms with different features is hard. As a response, the establishment of multiple connections is critical, especially in systems that allow inter-organizational merge [42].

7.2. Cost Efficiency:

A significant network of interconnected healthcare sensors and devices are part of the IoMT-based network. It has substantial service and upgrade expenses, which impact both the producer and the end customer. As a consequence, combining low-maintenance detectors with minimal startup expenses will help in the creation of further IoMT devices and enhance their utilization on a more daily basis [43].

7.3. Environment:

To fulfil tasks, the IoMT devices include a variety of biological devices incorporated in. These are constructed by combining multiple semiconductors that contain rare earths as well as other harmful substances that could pollute the environment. As a reason, government regulators oversee and oversee the biosensor manufacturing operations. More study into the design and manufacture of detectors made of biodegradable materials are needed [44].

VIII. CONCLUSION:

The Internet of Medical Things (IoMT) is a technology that links medical IT by integrating Web medical products, hardware resources, and software applications. In hospitals, IoMT, also called the internet of Things, allows remote and distant sensors to safely communicate via the internet, allowing very efficient and easy health information analysis. They're key to preventing, detecting, curing, and recovering ailments and conditions in a safely manner, thus the advantages devices may provide are rising. Clouds and computing, machine intelligence, virtual / mixed realities, big data analytics, and blockchains have facilitated the rapid and efficient deployment of IoMT. Remote monitoring technologies and tech gadgets, telehealth platforms, robotic, and drone have all greatly contributed to sickness prevention by providing testing, early identification, treatment, and eased living. The efficiency with which these gadgets can be used for patient monitoring has overtaken the necessity for just a visit to the doctor. However, the related issues must be solved in order to attain universal support of cost-effective, versatile, and reliable medical systems. This chapter evaluates and summarizes IoMT, its classifications, and multiple uses such as chronic illnesses, cardiovascular problems, central nervous system and neurological diseases, monitoring systems of elderly patients, as well as the technological aspects used in IoMT devices, legislation and rules, cybersecurity, and ways to prevent cyberthreats.

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Chapter - 11

Artificial Intelligence in Healthcare Analytics

Krishna Priya Kumar[1], Padmashree Baskaran[2], Anitha Thulasisingh[3]

[1] Industry Academia Cell, National Institute of Food Technology, Entrepreneurship and Management- Thanjavur (NIFTEM-T), Thanjavur- 613005, India.
[2] Department of Biotechnology, Rajalakshmi Engineering College, Chennai- 602 105, India.
[3]Associate Professor, Department of Biotechnology, Rajalakshmi Engineering College, Chennai- 602 105, India.
[1]priyarajinela@gmail.com, [2]210411010@rajalakshmi.edu.in, [3]anitha.t@rajalakshmi.edu.in

Abstract— The evolution of lifestyle had eventually turned down the hale and health statement of humans. This led to the gradual upsurge of various diseases in humans irrespective of their age. On the other hand, innumerous healthcare data generated from the wide range of medical sectors challenged the human brains. To combat those human setbacks in data handling there arose the revolutionary solution through machines using mathematical algorithm entitled as Artificial Intelligence (AI). The employment of Artificial Intelligence is traced in medicine pipeline commencing from diagnosis of disease until treatment. AI registered its pivotal role in clinical section by processing (diagnosis, image processing, drug discovery, digital pathology, oncology, mutation identifications) such huge data using algorithm. One of the major subset of AI is Machine Learning (ML), which competes with the humans cognitive skills using higher order algorithms comprising of Artificial Neural Network (ANN). The complicated nature behind the diseases like cancer, diabetes, cardiology, neurological and psychological disorders can also be unveiled with the assist of AI. The processing of healthcare related database executed by AI provides data with high accuracy and clarity. Overall, human intelligence assess their vast health database requirements using the Artificial Intelligence.

Index Terms— Artificial Intelligence; Diagnostics; Database; Machine learning; Healthcare; Treatment.

I. INTRODUCTION

1.1. Artificial Intelligence

The technology behind constructing smart machines is called Artificial Intelligence (AI). A potential of a system to explain the data collected from outside accurately and understand it through self-learning to apply the learning to accomplish specific targets [27]. It is a combination of computer science and human intelligence to achieve the goals in the world [11]. Artificial Intelligence is incorporated with humans' intelligence to perform tasks as we do. Artificial Intelligence is built by utilizing complex algorithms. AI has much needed parallel processing, saving more time and money in any computer related works [41]. The goal was to conceive ways to replicate human intelligence in machines by uncovering the processes that drive it so that they could be automated [20].

AI is one of the latest and global fields of science that uses the technology to imitate intelligence and critical thinking behaviour in comparison to human beings [36]. AI organizes and automates intellectual tasks and constructs intelligent machines that independently function on altering conditions aiming to set up intelligent systems. It is likely to use computers to master the human intelligence [52]. It is simply the intelligence exhibited by artificial entities to solve complex problems [11]. AI is integrated with various other fields that provide valuable outcomes for the researchers. The factors like high data processing speed, reduced errors and increased cloud storage make AI more compatible in the healthcare sector [14].

1.2. The History Of Artificial Intelligence

Warren McCulloch and Walter Pitts carried out the initial works on Artificial Intelligence which began in 1943. The "Father of computer science" Alan Turing, proposed the birth of the substitute intelligence conversation from human intelligence (1950). John MC Carthy, who coined the term "Artificial Intelligence" (1956), attended a conference on Artificial Intelligence organized by Dartmouth College for the first time. Allen Newell, Shaw & Herbert Simon wrote the first computer program, "Logic Theorist". It is known as Artificial Intelligence Program for its logical reasoning. The Mark 1 Perceptron was the first computer program with a perceptron algorithm in which knowledge was acquired by trial and error methods. The book Perceptron, written by Marvin Minsky and Seymour Papert, become the landmark work on neural networks (1967).

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Backpropagation-based neural networks have become increasingly popular in AI applications (1980) [52]. Garry Kasparov, the world chess champion was defeated by 3.5 to 2.5 using a computer program developed by International Business Machines (IBM). The program is called as "Deep Blue" [25].

1.3. Types Of Artificial Intelligence

John Searle classified AI into weak AI and strong AI based on the capability and functionality [52].

1.3.1. Weak AI: AI applied to a specific, narrowly focused problem is called weak AI. The principle behind weak AI is that machines can be made to behave intelligently, which means that computers can be easily programmed to think like humans [11]. It presents AI as a tool for problem solving [24]. For example, Alexa operates within a narrow set of functions with no self-awareness or genuine intelligence. Other examples include iPhone face verification, the autopilot feature at tesla, the social humanoid -sophia and G maps.

1.3.2. Strong AI: Strong AI is based on the idea that machines could represent the future state of human minds' thinking, in other words represent human minds [11]. It has the ability to perform any intellectual task like a human, including language processing, image processing and high-level computational functions [7]. Strong AI is also called Artificial General Intelligence (AGI). It is a generation of actual minds [24].

II. NETWORKS BEHIND AI

In the fastest world, every sector wants an intelligent system to solve their problems in a quick and easy way. An Artificial Neural Network (ANN) serves this purpose. It is the ability to learn complex nonlinear input- output relationships by adapting to the data provided and using sequential training procedures [9]. ANN comprises of numerous elements that are connected to each other. It consists of an internal layer known as nodes or units with one or more hidden layers, and an outer neuron layer. Usually, it has only one output with many inputs [41]. It is known as a neural network as its central theme is derived from the biological neural network [61]. It has four essential characteristics: non-convex, non-qualitative, non-limitative, and non-linear [63].

2.1. Machine Learning

Machine Learning (ML), a subset of AI which focuses on developing new algorithms that use prior experience and feedback to enhance their performance of that task. These algorithms are created to mimic the human creativity and intelligence available in the environment [23]. Machine learning is a rapidly growing field. It determines the probability distributions from the given input data to predict the output. Machine learning covers engineering science, including data structures, algorithms, probability, statistics and social science such as psychology and philosophy. Machine Learning algorithm is classified into three types of learning.

2.1.1. Supervised learning: Two models used in supervised learning are classification and regression. To address a classifying challenge, data in the form of experiences is labelled according to a goal category. The labelling procedure is normally carried out by enlisting each data item and reviewing by humans. The true positive and false positive ratios are calculated for supervised learning classification issues. A classifier is a software that predicts a new set of data on its own. In machine learning, a perfect classifier is the one that classifies the data with the utmost true positive rate and nil false positive rate. The classifier's performance will increase over time as it works on some training data. A second label data set is called as the test data set, which is used to test the classifier. In practice, large sets of data set are often divided into training and testing sets. Once a classifier is created, it may swiftly categorize the incoming data, but the testing and training procedures take a long time [7].

2.1.2. Unsupervised learning: In unsupervised learning, the system develops its own representation of the input. It is also known as self-organization, as the output is trained to respond to the patterns inside the input [21]. The data is unknown in this learning process, and the task is to generate a mathematical model that explains the structure of the input data from the beginning (de nova) [59]. Unsupervised learning can help to separate a wide range of alternative conditional representations and then acquire the knowledge of the normal probabilities of occurrence of these possible conditional stimuli [6]. With the help of Deep Learning (DL), unsupervised learning can be done in which the data is unstructured [54].

2.1.3. Reinforcement learning: This type of machine learning labels the data in comparison to some objective in the form of feedback as a reinforcement function. Consider a robot that is striving to relocate on its own. If the robot's sensors provide feedback showing the distance from the desired point, the reinforcement function is essentially a reversal of the sensor readings. The robot can reach any part of the world as it travels through the planet. Every state of the world differs in their rewarding system. It is preferable to be close to the desired area rather than staying away from an impediment. This learning creates a policy that shows the relationship between the robot's actions and the rewards. As a result, the policy instructs the system to operate for the sake of obtaining the reward [7].

III. DISEASE DIAGNOSIS

AI technology in healthcare and medical research has been increasing progressively in recent years. The areas where AI based healthcare delivery has more impact are administration, clinical decision support, patient observation and healthcare action. ML algorithms are being linked to Electronic Health Records (EHR) to aid them in retrieving relevant as well as accurate patient information. It makes the work of clinicians simple and easy. An ANN is a developed form of ML that has been tested for medical diagnosis and proved to be capable of understanding patients' medical issues superior than the clinicians. When compared to commonly used clinical decision support systems, ANN is projected to be more capable of predicting medical illnesses such as cancer, diabetes and cardiovascular disease. Beyond healthcare, AI is also applied in other areas like drug development. It also predicts the outbreak of diseases and the results of critically ill patients. Computer generated virtual health assistants or robots integrated with AI serve this purpose. These advances in AI make it extensively useful in the healthcare sector, providing high quality service and cost-efficient [50]. The significant advantages of using AI are enhanced productivity, reduced workload, utmost precision in output and multitasking [62].

3.1. Heart Disease Diagnosis

In recent times, heart diseases are the most common ones which causes more deaths across the globe. Coronary artery disease is the most prevalent heart disorder, forms atherosclerotic plaques in coronary arteries leading to Myocardial Infarction (MI), a heart attack. It is important to diagnose at the early stages. Coronary angiography is the standard method to diagnose coronary artery disease, but it involves highly trained operators and is also not suited for screening purposes.

Clinical Decision Support Systems (CDSS), a machine learning based technique, used for diagnosing heart ailments. Coronary artery disease, Acute Myocardial Infarction (AMI) and heart valve disease are detected and diagnosed by a neural network that combines both supervised and unsupervised learning algorithms. Decision trees are used to solve mitral valve prolapse along with fuzzy modelling. Genetic algorithms, independent component analysis, fuzzy clustering, random forest and Bayes theorem are used for the correct identification of ischemic patients, arrhythmia screening and Myocardial Perfusion Scintigraphy to avoid expensive and hazardous techniques. Along with improving diagnosis, these methods helps to segregate patients depending on their medical condition so that they are admitted either to the Coronary Care Unit (CCU) or general ward [53].

3.2. Cancer Diagnosis

Cancer is a deadly disease with lower rates of survival. The diagnosis and treatment process is prolonged and costly, with higher death rates. Early diagnosis and prognosis are crucial to increase the patient’s survival rate. Scientists have started applying computational methods to analyze the severity of the disease. In conventional methods, errors in the prediction remained as a barrier for clinicians to study the patient’s condition. The use of AI in oncology is known to improve diagnosis and prognosis, as it achieves a level of accuracy that is higher than general statistical methods. Models using AI algorithms have been established to facilitate this intend. Machine Learning and deep learning finds its application in cancer research in recent times. It constructs models to study the logical patterns of the large data, which helps in the prediction of a patient's life span. These aspects of ML motivated the researchers to develop more efficient ML tools to categorise patients into various groups based on severity.

Researchers employ multimodal Deep Neural Networks (DNN) by integrating multiple dimensional data so as to compare the Receiver Operating Characteristic (ROC) curves and Area Under the ROC Curve (AUC) values. The result is that combining these different data types and ensemble DNN methods improves human breast cancer prognosis predictions. Cox-nnet is the neural network modification of the Cox regression model that was developed to determine patient conditions from high throughput gene expression data as it analyses the pathway and gene level information [17]. The results showed that ANNs successfully predicted the probability of recurrences and patients are classified based on their survival period. Many other scientists also provided various AI based techniques to serve the purpose. Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are the frequently used medical imaging fields, along with AI that provide accurate images used for diagnoses. A novel deep learning structure has been designed based on Convolutional Neural Networks (CNN). It helps in the grouping of lesions in prostate cancer using 3D multiparametric MRI data. It is expected that AI based oncology studies bring a lot of improvements that reduces death rates and also improve the patients’ conditions [30].

3.3. Parkinson’s Disease Diagnosis

Parkinson’s Disease (PD) is a neurodegenerative disorder in which the voluntary activities such as walking, balance and coordination are impaired with age. In order to solve this problem, an evolutionary based Genetic Programming (GP) known as Grammatical Evolution (GE) technique was adopted. It is an automated tool for the diagnosis of PD which involves the analysis of handwriting. In this technique, handwriting samples of healthy and PD affected subjects’ are taken and comparatively analysed. Earlier psychometric tests, neuro-imaging, and cerebrospinal fluid examination methods were used. But these diagnostic methods were time-consuming, expensive and invasive.

Handwriting is a complex motor task whose performance depends on the activity of the basal ganglia. This function is compromised in the diseased individuals. The handwriting samples are studied using ML techniques, a grammar based programming used to study genotype to phenotype mapping of the subjects. PonyGE2, a Python programming was used to execute GE. The evaluation was done using HandPD dataset, which is a public dataset containing images of the handwriting samples of the healthy and diseased subjects [12]. They were given the printed templates of spirals and curves in which they were supposed to trace over them. It is found that GE approach performed better than other ML techniques in PD detection and diagnosis

3.4. Liver Disease Diagnosis

Liver disease is the more prevalent and one among the fatal diseases in the recent times. It is classified as chronic hepatitis, alcohol hepatitis, B hepatitis and liver cirrhosis. This cannot be identified easily as it tends to function normal after getting affected. Earlier statistical methods of modelling were used which was less capable of analysing large data. The scientists wanted an alternative approach to analyse complicated data. Data Mining (DM) techniques (Genetic algorithms, ANN, fuzzy sets, rough sets and inductive logic programming) provided a solution to this concern. Data were collected from the healthy and diseased individuals which includes sex, age, blood group, liver function and tumour investigation. It is classified as training and testing data. Scientists found that a neural network could differentiate between mild and chronic hepatitis [43]. Models such as decision trees, neural networks were designed to analyse the risk factors [34]. Diagnosis using these models are categorized into two stages:

- ✓ Stage one is to find whether the subject is affected by liver diseases with the Classification And Regression Tree (CART).
- ✓ Stage two of diagnosis is to find the kind of liver disease in the subject, done using Case-Based Reasoning (CBR).

In first phase of diagnosis, training data are employed to build the CART models and the testing data are employed to analyze the performance of the data. It codes the results as 'Class 1' and 'Class 2' for patients confirmed with liver diseases and healthy volunteers respectively. In second phase, the kind of liver disease among the four is identified by CBR. These techniques are found to be user-friendly and assists in accurate diagnosis and treatment of liver diseases [39]. With the improvement of such AI techniques, dreadful diseases like these can be prevented at the early stages itself.

3.5. Retinal Disease Diagnosis

Retinal diseases are widespread these days which causes vision loss. Age-related Macular Degeneration (AMD) and Diabetic Retinopathy (DR) is considered to be worldwide epidemic [48]. CNN is a deep learning method applied to visualise the images for diagnosis of the retina. On this evaluation, high precision and specificity was attained. The retinal thickness was measured from an Optical Coherence Tomography (OCT) image through ML techniques which requires set of biomarkers for the data measurement. This method successfully screened the patients and identified the type of retinal disease [32]. Automating ophthalmological screenings based on retinal demographs has been successfully achieved by artificial intelligence [3, 2]. AI in retinal diagnosis provided potential prediction and prognostic conclusions that helped in personalised healthcare and management enabling the ophthalmologists to offer high quality therapy for the patients [59].

3.6. Covid-19 Diagnosis

COVID-19 is the currently spreading disease worldwide (pandemic), which is actually an infectious (viral) disease caused by Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2). It's evident that is being fatal and the death rates increasing day by day irrespective of the age. The world is in the search of a method/techniques to diagnose the disease at earlier stages and decrease the death rates. As it is fast spreading, there is a shortage of the available diagnostic tools. It is found that it directly affects the lungs so initial screening was done using X-rays which images the lungs of the patients showing the severity of the disease. But it required highly trained experts (radiologist) to do this task and also time consuming. Hence developing a computer based system for the diagnosis is essential in order to save time and money. AI comes into the play to solve this problem. Convolution Neural Networks, an algorithm for deep learning used for diagnosis. A model based on this CNN was designed to identify whether the X-Ray images of patients showed positive for COVID-19 or negative. Data of healthy and affected persons were taken from the GitHub and Kaggle repositories respectively. These data were examined using the model. It measured in terms of precision, sensitivity, specificity, positive and negative predictive values. On complete examination, the CNN model detected COVID-19 samples with 100% precision [54].

IV. DRUG DEVELOPMENT

Drug development begins with target identification, the molecular level mutations result in causing a particular disease. Second in the pipeline is the validation of the target, based on which the entire drug discovery process relies. The third is lead compound (promising molecule) identification, lead optimization and pre-clinical trials. All the above mentioned steps come under in-vivo0020and in-vitro testing stages in drug manufacturing. Then comes the clinical trials after crossing the Investigational New Drug filing. A clinical study involving healthy and patient volunteers via three phases of trials. Upon successfully passing these stages, the drug is eligible for New Drug Application (NDA) / Food & Drug Administration (FDA) filing. On clearing FDA, the new drug can move into post-market drug safety monitoring [28, 56]. It takes an average of 12-15 years and more than a million dollars to develop a single drug.

A few commonly used AI tools in drug development are organic, deepchem, alphafold, chemputer, hit dexter, deeptox, delta vina and potentialnet. Various AI domains in the new drug discovery and development process are grouped [47]. The subfields of ML employed in drug discovery are (i) Decision tree algorithms: Random forest, Classification and regression tree; (ii) Instance based algorithms: Support vector, k-near neighbor; (iii) ANN: CNN, Botzmann network, Feed/forward network.

Watson, a supercomputer designed by IBM that combines Artificial Intelligence and powerful analytical tools to aid physicians in making better recommendations on cancer therapy and diabetes control [60]. Besides, Deep mind by Google is used in medical imaging diagnostics and as an assistant in mobile medicals [10].

The use of AI in different stages of drug design is as follows,

4.1. In Chemical Synthesis Of Drug

The yield and mechanism involved in drug chemical synthesis are easily predicted with the support of AI. Deep Learning outscored ML models in terms of predictability in the drug synthesis process [47]. AI assisted drug development speeds up the process and eliminates duplication of effort in the drug discovery streamline [16, 55].

4.2. In Drug Design And Screening

AI is found to be used in predicting drug-protein interactions and the 3D structure of target proteins [47]. Some examples of molecular docking tools used in molecular interactions study are deep CNN, AutoDock, DOCK, FlexX and Glide [10]. The toxicity, bioactivity and physicochemical properties of targeted drugs are easily analysed by Artificial Intelligence. Drug designing algorithms employ a few molecular descriptors like Simplified Molecular Input Line Entry system (SMILE) strings, potential energy analyser, molecule's electron density and 3D atom coordinates to anticipate the drug properties. A quantitative structure-property relationship workflow was developed to assess the physicochemical properties (vapour pressure, water solubility, boiling and melting point) of chemicals [66].

4.3. In Drug Repurposing

AI is used in tracing the effective drug for new diseases from the existing therapeutics in the drug discovery process. Deep learning has even found applied in new drug designing. The repurposed drug directly enters the pre-clinical and clinical trials without undergoing any research studies. AI and ML algorithms specifically determine the drugs effective against COVID-19 [42].

Few applications of ML in new drug finding processes

- ✓ Machine learning aids in the prediction of disease causing target sites in the human body.
- ✓ In drug development, the bioactive properties of lead compounds are identified easily using ML techniques.
- ✓ ML plays a significant role in studying the biological (A-Absorption, D-Distribution, M-Metabolism, E-Excretion and T-Toxicity: ADMET) and physiochemical properties of the drug [10].

V. MEDICAL VISUALIZATION

Image interpretation is made easy using advanced algorithms and software in AI [5]. Communication between humans and computers is made possible by the NLP (Natural Language Processing) software. NLP reads data from Electronic Medical Reports (EMR), categorises data & documents and gets structured data from unstructured raw data [10]. ML and DL are the major subdivision of AI in analysing medical imaging data [19]. Cognitive vision plays a prominent role in image recognition by machine learning models. It mimics the human brain function to train it for visual data analyses [46].

5.1. In Cancer Diagnosis

Mayo [40] assessed the number of false positive markings and mark free cases in the given set of 250 mammograms. He analysed the efficiency of Computer Aided Detection (CAD) software based on AI versus conventional computer aided detection. Findings revealed substantial reductions in AI based CAD software in false positive markings with no compromise in sensitivity. Almost a 69% reduction in false positive markings could reduce 17% of radiologist reading time in assessing digital mammograms per cancer patient. In dermatology, contemporary convolutional neural networks attained accuracy equivalent to trained dermatologists studying skin malignancy. In parallel, deep learning based algorithms surpassed dermatologists' efficiency in analysing dermoscopic images [65].

5.2. In Cardiologic Diseases

With deep convolutional neural networks, AI can detect breast and prostate cancer from lymph nodes and biopsy samples, respectively [65]. CheXpert, AI driven deep neural network with 83% accuracy in summarising chest X-ray data collected from a large set of patients [64]. AI monitors the blood flow pattern in the heart and alerts for abnormal flow; thereby, cardiac mortality can be lowered [1]. Deep neural based algorithm summarises breast cancer with high accuracy [30].

5.3. Automated Detection Of Radiographs

A deep learning based automatic algorithm was created by Hwang [31] to improve diagnostic precision and validation in thoracic diseases from chest radiographs. This modified deep learning algorithm can assort different thoracic diseases like pneumonia, pneumothorax, tuberculosis, pulmonary malignant neoplasm. It outperformed all experienced physicians (thoracic radiologists) in image and lesion-wise classification among the provided chest radiographs. Radiological applications of AI includes the diagnosis of pulmonary nodules, tuberculosis and various lung disorders, have benefited from the advanced machine learning algorithms [65]. Du-Harpur [22] dealt with the clinical and dermoscopic images of skin cancer. This study proved that CNN achieved 86.5% specificity, whereas experienced dermatologists attained only 60%.

5.4. In Diabetes

Diabetic retinopathy affects around 28.5% and 18% of diabetic patients in the United States and India, respectively [26]. Macula-centered fundus pictures of the retina were acquired from EyePACS in the United States, India and France for the development of a specific algorithm among diabetic retinopathy patients. Gulshan [26] designed one such deep learning based neural network algorithm for detecting diabetic macular edema/ diabetic retinopathy from the provided retinal fundus demographs with high specificity and sensitivity. Support Vector Machine (SVM), a binary linear based classifier that operates effectively on limited datasets. The subcutaneous glucose concentration in type 1 diabetes patients were estimated using SVM with improvised classification precision upon the addition of two biomarkers (oxidative stress marker and interleukin-6) [46].

5.5. In Neurology And Related Fields

The genetic conditions and structural modifications in the brain results in epilepsy disorder [46]. Smart wearable employed with a ketogenic program for epilepsy is used to improve the glycemic control, which shows reduced seizures in epilepsy patients. The ketogenic program works by understanding the behavioural changes and patients' psychology [51].

Some commonly used convolutional networks deployed in medical imaging are ResNet, VGGNet, DeenseNet and Inspection V3. Transfer learning and deep learning techniques of AI found used in tracing pediatric pneumonia, diabetic macular edema and choroidal neovascularisation [57].

VI. 6. APPLICATIONS OF AI IN HEALTHCARE

6.1. Toxicity Assessment

DeepTox, an algorithm model, works based on the deep learning method. It is used for detecting the toxicity of drugs by comparing it with the available data sets. MoleculeNet, a 2D structural translator applied in drug toxicity analysis. Beyond 7 Lakhs compounds toxicity is tested using this MoleculeNet platform [10, 47].

6.2. Pharmaceutical Sector

One could see the involvement of artificial intelligence in the pharmaceutical industry, starting from lead compound identification to medical billing. The deviations in quality during the drug manufacturing process can be minimized by AI. Whereas passive AI aids in choosing the appropriate excipient in a drug manufacturing line [18]. Some of the AI tools used in the pharmaceutical sector are provided in table 1.

TABLE 1. Different ai tools used in pharmaceutical sector

AI Tools	Nature	Applications	References
IBM Watson	Assistive robot	Used in oncology for assessing patients medical stage and recommending therapeutic approaches	[47]
Erica robot	Care robot	Helps in medical fields with its high understanding ability and facial expressions	[60]
MEDi robot	Medicine and Engineering Designing Intelligence, care robot	Pain management in children during surgery and physical rehabilitation	[60]
TUG robot	Mobile robot	Supply of medications, foods and samples from one place to another	[37]
Berg	Boston-based	Validation of disease causing biomarkers and providing therapies	[60]
Relay	Mobile robot	Delivery services of patients needs in hospital	[37]

6.3. Healthcare Gadgets

AI-powered technologies can monitor the condition of sick patients remotely with high accuracy [38]. Smartphone apps like Alexa, AI speaker Aria, Robot Maria and others assist in the amalgamation of people's robustness. The AI based wearable healthcare gadgets in practice are smart watches, activity tracking band, biosensor tattoos, implants and smart clothing [33]. A case study conducted by Tran [58] on usage of smart devices revealed that approximately 20% of people registered the positive and 3% accounted for the negative impacts.

6.4. Radiology Applications

Image acquisition, management and population imaging are all functions of AI in radiology, in addition to the usage for automated image interpretation [4]. CNNs are employed in tracing the molecular level fingerprints from the provided molecular graphical data. Some of the general applicability of AI in the healthcare sector are shown in figure 1.

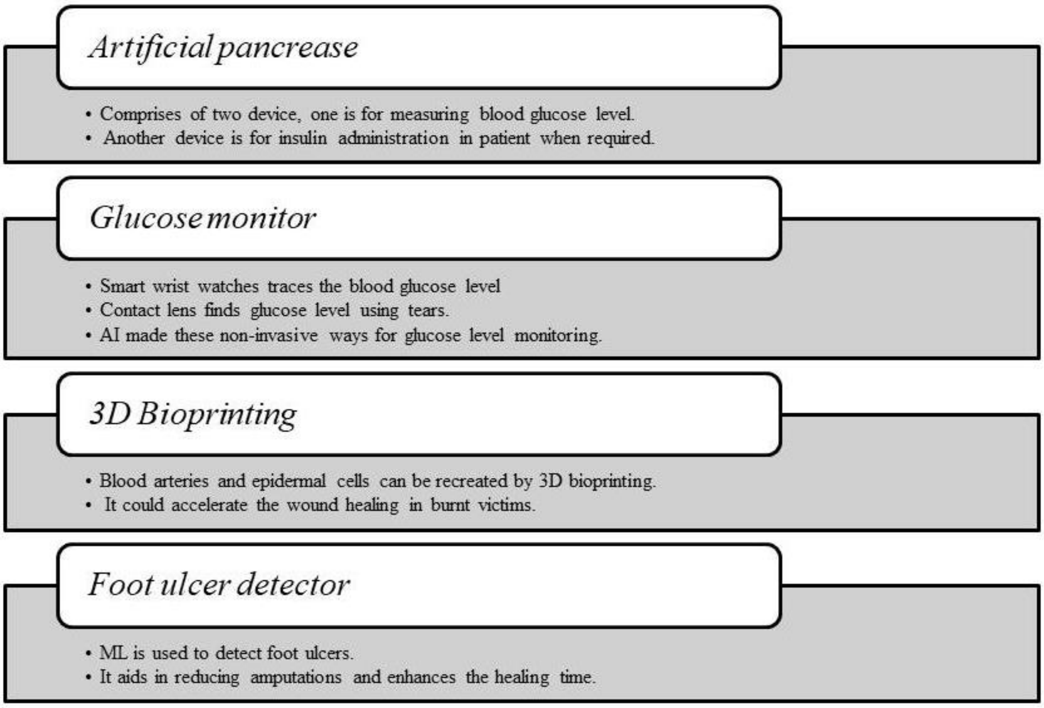

Figure 1. Applications of AI in healthcare

VII. Recent Trends in AI

AI explains various healthcare issues such as cardiovascular ailment, cancer and neurological disorders. Machine learning and advanced search engines are being used to get more ideas and precise results [36].

7.1. Trends In Dentistry

AI has an immense capacity for the improvement of dentistry. The CNN is one of the foremost used subclasses of ANN in dentistry. It processes images, audio and videos using mathematical operations and connection architecture. The clinical application of CNN is to detect and identify teeth with a precision rate of 95.8 - 99.45% compared to the clinical experts, who showed 99.98% precision. CNN has the tendency to detect and diagnose dental caries. It detects lesions in the teeth with a sensitivity of 74.5 - 97.1% but when diagnosed by the clinicians using radiographs the sensitivity varied from 19% to 94%. This is definitely an improvement compared to the work done by the clinical experts. New algorithms are being formulated for various dental disciplines to produce feasible preliminary results, showing that it is an excellent aid to oral health professionals [44].

7.2. Telemedicine

The transfer of medical details through digital communication to execute medical procedures and examinations is known to be telemedicine. The main objective is to bridge the communication gap and access within the medical line, thereby reducing delays and cost logistics. The first and foremost part of telemedicine is patient monitoring. It is like a face-to-face consultation of doctor and a patient through video conferencing to assess and the documentation of patient's current state and clinical history from a distance. The objective is to provide easy access, simple, efficiency, and cost deduction compared to the physical monitoring of the patients. The use of big data analytics and neural networks manages and retrieves electronic health care records properly. EHR is a system that manages the records of the patient by replacing the manual process of checking the patients with a chat associated with some questionnaires. It allows doctors to send prescriptions and other information directly and quickly to the patients. It also uses cloud computing to collect and store the patient's information using remote servers [45].

7.3. Drug Discovery

Drug discovery and development are essential for the well-being of people. It is a long and complicated process in which the target selection for clinical trials takes more time and involves more investment. After all the clinical trials and safety checks on patients, the drug is reviewed and approved for commercial purposes. It is found that it needed 2.6 billion USD for a drug to be discovered and commercialised and it takes 12 years for the process to be completed. AI with new technologies helped to produce cheaper, quicker and more efficient pharmaceutical drugs. Apart from drug discovery, it also helps in predicting the structure and properties, screening and toxicity of the drugs [35].

Understanding the 3D structure of the proteins is essential for the drug discovery process, which is performed by homology modelling and de novo protein design [13]. However, with the advancements in AI techniques, 3D structure determination has been very accurate. AI tool AlphaFold relies on CNN, well predicts the protein structures and is scored to know the accuracy of the model. Pharmaceutical companies have started to invest on AI based R&D solutions for their growth [15].

VIII. Challenges in AI

Artificial Intelligence has the ability to transcend time and spatial barriers [38]. Despite many potential advantages, AI in healthcare faces some notable legal and ethical issues in clinical practice. Some of the common challenges encountered in adopting AI are a lack of trained personnel, huge implementation cost and extensive data maintenance. The usage of AI in the medical field confront ethical issues, classified as data safety & privacy, transparency of algorithm and practice ethics [49].

To improvise the AI algorithms the below mentioned points are applied to overcome the legal and ethical issues [8, 29].

- Maintaining accurate audit trails in order to keep the data handling safe and secure.
- Framing a proper global data governance model for implementation of AI in healthcare field.
- Frequent refinement of an algorithm is required to produce reliable results.
- Retaining transparency in data processing to create confidence among patients.
- Improving the algorithm fairness and biases in data handling.
- Executing cyber security and intellectual property law for the privacy of patients.

IX. Conclusion

The inclusion of Artificial Intelligence in the healthcare is rendering various positive impacts to humans, beginning from disease target tracing to appropriate treatment. AI certainly brought new advances to treat human ailments in numerous aspects. It has made many changes in healthcare, which even humans cannot do. It has taken the field to the next level which makes the capitalists and innovators rely more on this technology for further developments. Thus, the introduction of AI has attained a notable breakthrough in the healthcare sector.

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Applications of Artificial Intelligence and Machine Learning in Healthcare

DESCRIPTION

A huge amount of potential is vested in Artificial Intelligence and Machine Learning techniques to transform next-generation Healthcare applications. This book aims to cover a wide range of applications of Artificial Intelligence and Machine Learning techniques in disease diagnosis, remote patient monitoring, and assisting healthcare providers. Early detection of diseases such as cancer and tumours will highly reduce the mortality rate of the disease. Predictive modelling could help in determining the effect of the drug, on a patient building a strong clinical decision support system. The Covid-19 pandemic has led to the huge adoption of telehealth applications, which is also covered under the scope of this book.

WHO THIS BOOK IS FOR

Scientists and scholars who are engaged on projects related to computer science, artificial intelligence, machine learning, deep learning, big data analytics, and other similar subjects. By exploring its principles, learners will acquire a profound proficiency in Artificial Intelligence and Machine Learning Applications.

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