# ADVANCED REAL-TIME IOT BASED HEALTH MONITORING SYSTEM

**BY**

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## FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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# APPROVAL

This Project titled “Advanced Real-Time IoT Based Health Monitoring System”, submitted by **Ankur Ray Chayan** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 01-07-2024

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# DECLARATION

I hereby declare that this project has been done by us under the supervision of **Dr. Sheak Rashed Haider Noori, Professor & Head, Department of Computer Science and Engineering, Daffodil International University**. I also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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# ABSTRACT

Today's world is slowly dependent on the IoT. IoT devices create huge impact in every sector of our daily life. The applications of real-time IoT-based health monitoring systems are vast, ranging from remote patient monitoring to chronic disease management, elderly care, sports and fitness monitoring, and environmental monitoring. These systems offer early detection of health issues, continuous monitoring, improved patient engagement, cost-effectiveness, and enhanced clinical decision-making. The application of IoT technology in health care is turning out to be a game changer in health care experiences when it comes to patient data collection. The document system list out the parts, fundamental principle, uses, positive effects, and difficulties and what the future holds for these technologies. The liaison of IoT technology with health care has triggered a routine evolution on how individuals track and look after their health matters. The report discusses the building blocks, working principles, operational mode, benefits, downfalls, and the prospects of this technology. In this project I will develop a prototype by using sensor Node MCU ESP8266 is a microcontroller to control all sensor. Heart Rate Sensor is used to measure the heart rate. Single Lead Heart Rate Monitor is used for signal measurement applications such as ECG and other Biometric signals. Myo Ware 2.0 Muscle Sensor has electrodes that measure the electrical value of the muscle and it's called the electromyography signal.

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# CHAPTER 1
# Introduction

## 1.1 Overview

Nowadays, the use of advanced real-time monitoring systems aligned with IoTs devices is an important advance in healthcare. These system involve sensors, connectivity and data processing power capabilities that allow remote monitoring of vitals, activities and environmental issues thereby, make it possible for healthcare providers to initiate preventive interventions on the patients. Here an elaborate simulation of this matter relating system attributes, working methodologies, uses and impact on health care delivery systems is given.

## 1.2 Background and Present State

The healthcare industry as a sector has evolved in using information technologies in delivering the sector's services within the past few decades. Among them, the constant tracking of appealing vital signs, particularly among clients admitted to the important care units or the ICUs, has been among the major considerate areas. The practice systems of health monitoring within the context of ICUs are based on equipments called bedside monitors that regularly display or/and record the patient's physiological parameters including pulse rate, blood pressure, respiratory rate and temperature. Such systems, as it was mentioned before, have their drawbacks, mainly regarding the real-time data processing, the possibility to access the system remotely, and the possibility to integrate data from various sources.

IoT will be the key driving force in reforming the patient monitoring and the way it is conceived with the new perspective. Internet of things technology basically involves connecting of different components and or gadgets, and directing them to gather, send and process information in real time manner. The advancement has created possibility to perform patient monitoring far from the hospital and in real-time – based on patient data generated in patient's home or other non-Healthcare settings enhancing patient outcomes and minimising hospital utilisation.

At the moment, over several health monitoring systems have been designed and established based on IoT. Such systems generally incorporate wearable biosignals sensors that continuously measure and record the patient's vital signs and wirelessly send this information to a central server or cloud for processing. The proposed arrangements will allow the data to be retrieved by the caregivers through web or mobile application so as to arrive at the correct decisions at the right time.

### 1.3 Problem Statement

In earlier healthcare system, the doctor would for instance ask patient to come to the clinic every now and then or be in for traditional monitoring.

Such a delay could further result in the late discovery of medical conditions, possibly preventing or at least severely reducing the window of an effective relief attempt. Apart from that, also higher frequency of observation by the doctor is expected especially in those clients that have chronic illnesses or live too far from the health center. The rivalry that we have is multi-aspect and in-nature of the Internet of Things (IOT) design enabled medical care platform that is specifically intended for onsite patient care and Active care services delivery.

### 1.4 Objectives

This paper presents the design of a next-generation real-time health monitoring IoT system which is aimed at monitoring and analyzing the health status of the patients in real-time systematically. This entails the creation of a concrete architecture that accommodates numerous types of sensors for ECG, pulse rate and body temperature. Also, the project includes the penetration of a software system that will allow the constant data gathering and transferring of patients' vitals to a cloud. To obtain the actual information, a design of the algorithms and the software instruments for processing the received data and generation of useful visualizations for doctors and nurses has been presupposed. The accuracy and reliability of the gathered data should be high therefore an appropriate selection of the sensors and calibrating methods should be fulfilled. It also focuses on the enforcement of proper procedures and standards to secure patients' data and follow the legal requirements. Another task is to design an efficient and easily navigable frontend for the healthcare providers as to help them analyze the data successfully. The project includes the performance assessment of the system by testing and validation of the system on the existing projects, as well as, the system's plan on sustainability and supporting the long term and continuous upgrade of the system.

### 1.5 Scope and Limitations

This scope of this project involves integration of multiple sensors that include the AX30105 Pulse Oximeter, AD8232 ECG Sensor, and finally the MLX90614 Body

Temperature Sensor and altogether they are powered by the ESP32 microcontroller as a health monitoring system.

The fact is that ThingSpeak cloud platform will be implemented in the system to transmit and process data in real-time. Besides, the project implies the gathering and analysis of ECG data from both healthy individuals and patients to train machine learning algorithms for predicting purposes. Based on the discussed key functionalities, a web or mobile application will be created to allow healthcare providers to track patients' data in real time. As for the performance indicators, one will have to point to the data consistency, the level of reliability, the data availability time, the number of users, etc.

However, there are several shortcomings in the context of the current work although the proposed project covers almost all the aspects of the study. The reliability of data in the system is affected by the quality of the sensors used in acquiring the data because changes in environmental factors may influence the sensors' results. Real-time data transmission requires the use of stable networks and hence where there is low network access the system is bound to produce poor results. Despite the measures wanted in the project, risk of data leak or hacks exists when sharing data through networks. Such limitations could be observed in creating the first prototype of the system, which should be further developed and optimized in terms of [insert the criteria that are limited], for instance, if the system is planned to be deployed for thousands of users or extensive data. Again, the succes of the system is determined by the extent to which the healthcare providers and patients use it, subject to such factors as ease of use, reliability and costs. Last, adherence to other regulations and standards regarding healthcare might be difficult and restrict the use of the system in some parts of the world. In conclusion, the objectives of this project are to design and develop an IoT-based health monitoring system to monitor people's daily health activities with emphasis on real-time data capturing, analysis, and security, though with certain constrains.

## 1.6 Report Organization

Thus, this report has seven chapters, and each of them reflects some aspects of it. Below is a detailed overview of the contents of each chapter

**Chapter 1: Introduction**This are some of the general background of the project: informal health monitoring technologies. Here the problem is identified and the goals of a project are stated. This is also the purpose of the topic so as to determine the areas of coverage and restrictiveness with the view of defining the coverage of the research to be conducted. Also included is a mini-structure of the report, in order to afford the reader a clear idea of what to expect when going through the report.

**Chapter 2: Literature Review:** In this chapter the author will carry out a review of literature on the IoT-based health monitoring systems and the previous related technologies. The method starts with explaining the context of the field and the knowledge that the subject area brings into the analysis and then proceeds to the evaluation of the prior work already published in the given subject area. Analyzing the current options reveals the advantages and disadvantages as a result of the application of such options. The directions of the additional research restrictions and the contemplation of the results which are submitted as the basis of the suggested methodical approach cost the closing of the chapter.

**Chapter 3: Methodology/Requirement Analysis & Design Specification** This chapter's purpose is to describe how the health monitoring system will be implemented. It begins with the general goal for the system design that is proposed and the way that it functions. virtually informative about the facets that are being combined in the undertaking and the assets that is being used. The roles and responsibility of the team in the project are shown by using such as the scheduling aspect while management of resources is incorporated into its planning as the project financial plan.

**Chapter 4: Implementation** This chapter covers the implementation process, where information on the design of the prototype, training, and testing of the models shall be included. Instructions on how to fit the hardware interfaces and on how to prepare the software background are given. In this paper, the procedure of the data gathering, training and the problems encountered during the implementation is described. Some common system testing procedures and model evaluation metrics are also discussed to recommend the efficiency of the developed system.

**Chapter 5: Result & Analysis** This section highlights the findings of the experimental results on the developed system along with recommendations. It contains more specific parameters of their training and validation process, like loss and accuracy graphs, to demonstrate the model's improvement. The confusion matrices are used to review the models' results of the classification. In order to present the specifics and peculiarities of each model (MobileNetV2, DenseNet201, and ResNet50) and their efficiency and possible shortcomings in certain tasks, the comparison of the results is provided. Bar graphs are helpful to do a comparison of models and their performances simply.

**Chapter 6: Societal and Sustainable Impacts** This chapter also presents an outlook of the effects that the health monitoring system will have on life, societies as well as the environment. Further, it examines how the organization benefits from the system in delivering health care since patients' monitoring and early diagnosis are possible in real-time. Emphasis is placed on the fact that the given solutions limit the necessity of constant hospitalization. Those are the integrity issues like data privacy and security that the system has to meet some set of rules and regulations. With the help of a general sustainability plan, the effective usage of resources and long-term stability of the system is ensured.

**Chapter 7: Conclusion and Future work** This chapter is a synthesis of the whole project where the findings of the system in monitoring health status and the performance of the system in real time have been stressed. It points out directions for the further research, for example, increasing the amount of data, using more sensors, and employing more sophisticated machine learning techniques to boost the prediction precision. Challenges that may also act as source of constraint for instance; unreliable internet connection that was encountered during the project implementation and sensor precision barriers are also examined.

### 1.7 Summary

This chapter has discussed the proposed advanced real-time IoT-based health monitoring system for its importance, while bringing to focus of the need to upgrade the existing health monitoring systems in today's health care environment. It analyzed the development process and current situation of health monitoring technologies with the focus on the drawbacks of current solutions and the need for their unification and real-time control. The problem statement expressed the shortcomings that characterize existing approaches towards monitoring the health status of patients and the dire necessity of implementing a system that can continuously and actively monitor a patient's health condition for early signs of a change and timely response.

The main goals of the project were defined, and they mainly concerned creating an IoT sensors-based system backed with a secure cloud platform and machine learning algorithms to provide the consumer with accurate health information. It focuses on the options of the project, which comprise the designing, building, and installment of the system; yet, it identifies some of the system's constraints, including the Internet connection reliance, costly initial installations, and frequent service and calibration.

In summary, this introduction offers a comprehensive preliminary to the investigation of the enhanced real-time IoT-based health monitoring system, as it establishes the basis for appreciating the project's relevance, aims, and coverage. The subsequent chapters will on guide a deeper analysis of the various aspects of the project with help from the general outlook provided by this chapter.

# CHAPTER 2

# Literature Review

## 2.1 Overview

Health monitoring advanced systems through the adoption of Internet of Things (IoT) technology has evolved and turned to be iconic. We present an introductory summary of the literature concerning recent developments in real-time IoT-based health monitoring systems that go beyond the state-of-the-art devices. It will try to fully explore and analyze the aspects of health care IoT starting from the first achievements of remote patient monitoring and progressing to the futuristic applications that are used nowadays. Next, it sails through the salient constituents and structured jigsaw of these systems, including sensors, wireless communication protocols, edge computing and cloud-based analytics where the latter plays the key role. As well we overviewed the IoT divers forms in healthcare and they are in remote patient monitoring, telemedicine, custom medical interventions and clinical trials. Eventually, it encompasses outlined literature where the advantages, challenges, and future developments of the topic are outlined, setting the research paper in motion.

## 2.2 Related Works

Writing a literature review serves this fucation primary funcation of the educating reader and analys done in ths field of study of giving a subject and giving information in the form of writing statement . Various website and research paper already published in Advanced Real-time IoT based patient monitoring system , which are given in the below[1]In this paper, they used Arduino Uno for microcontroller, Zigbee for wireless transmission,ECG sensor , monitor.They provide data through zigbee transmission. [2]Proposed a research paper that used, Arduino Uno, GSM, GPS, Camera, Phone, Smart Watch, Tablet, Wifi Module, RAIFD. They send data through Wifi Module, In usd GPS they locatied the patient. [3] Proposed a reserach paper that used IOT-M, DP-M, CA-M, they used Back Propagation In Neural Network - Machine Learning Algorithm after collecting all sensor data they used algorithm to show the output. [4] roposed a research paper that used Microcontroller, Bluetooth, Wifi Module, Buzzer, Pulse Sensor, Temperature Sensor. They used a proposed model for this work.[5] Proposed a research paper that used Arduino Uno as a microcontroller, Body temperature sensor(LM35), LCD display, Bluetooth module(HC-05). They collected all sensor data and processed by arduino uno and provide this data though Bluetooth module in the server. [6]Proposed a research paper that used Micro Controller , ECG, GSR, Body temperature, WiFi Module for the sensor purpose. They proposed a model in their paper. [7]Proposed a research paper that used Micro controller, ECG, BP, Pulse rate, Blood Oxyen saturation(SpO2), WiFi module, Bluetooth, ZigBee this are the hardware. They provide the sensor data through WiFi module in the server. In this paper they proposed a model about this topic.[8]Proposed a research paper that used Arduino, HeartbeatSensor, Temperature sensor and HuiditySenssor, Accelerometer, Ethernet Shield, GPS module, ZigBee module, Bomb Detector, ECG module for the hardware. Arduino MEGA process all the sensor data and Ethernet Shield provide the data in the server.[9]Proposed a research paper that used Microcontroller, Gait, ECG, Body temperature, Surface EMG, Body Movements, Blood pressure, Blood Glucose, Heart Sound, Oxygenation for the hardwork. [10]Proposed a research paper that Atmega 328 Microcontroller , LCD Display , WiFi module, Temperature Sensor, Pulse sensor, Power Supply for the hardware. Atmega process the all sensor data and WiFi module send the data on the server. [11]Proposed a research paper that PICSF4550 Microcontroller, GSM/GPRS module, LCD Display, Oil Sensor, Humidity Sensor, Temperature Sensor, Buzzer, Vibration Sensor. They provide their data by used Ienternet gateway. In their paper they show a proposed model about this topic.[12]Proposed a research paper that used Arduino Uno, ECG Sensor, EEG Sensor, Pulse Rate Sensor, Temperature Sensor, WiFi Module for the hardware. All sensor data they provide by through Wifi module on the cloud server. After this CSV file they used deep learning algorithm. Used Deep CNN, they classification the result.[13]Proposed a research paper that used Raspberry Pi3, Arduino Uno, LM35, Heartbeat Sensor, GPS SIM 28M, Power bank for the hardware propose. Google Map APIS, Cloud Computing, Android Application for the software propose. By using GPS they located the patient live location. By used SIM module they provide the data on the server and show the result on the Mobile Application.[14]Proposed a research paper that used Raspberry Pi, Heartbeat monitoring Sensor, Blood Pressure Sensor, Temperature Sensor, GPRS for the hardware. In this paper they proposed a model about this topic. [15]In this paper, they used Wireless communication, Various sensor , they proposed a model ,they don’t maked any hardware ,they gived IoT proposal seccanior based model.

## 2.3 Comparison between existing works

Table 2.3.1: Comparison between existing works

| Paper No | Authors & Year | Hardware Component | Features |
|---|---|---|---|
| 01 | Singh, 2018 | Arduino Uno, ECG, ZigBee | Provide data through Zigbee transmission. |
| 02 | W. D. Patel, S. Pandya, and V. Mistry, 2016 | Arduino Uno, GSM, GPS, Camera, Phone, Smart Watch, Tablet, Wifi Module, RAIFD. | Provide data through WiFi Module and Located the patient location through GPS. |
| 03 | D. Kavitha and S. Ravikumar, 2020 | Microcontoller, IOT M, DP M, CA M | Back Propagation In Neural Network- Machine Learning Algorithm for show the output. |
| 04 | P. More, 2016 | Microcontroller,Bluetooth, Wifi Module, Buzzer, Pulse Sensor, Temperature Sensor | Provide the data through WiFi module. Model proposed. |
| 05 | Mohammad Monirujjaman Khan Amani Almalki4 2 Almalki4 2023 | ArduinoUno,Body temperature sensor(LM35), LCD display, Bluetooth module(HC-05). | Provide the data through the Bluetooth module. |

| | | | |
|---|---|---|---|
| 06 | M. Talal et al,2019 | Micro Controller , ECG, GSR, Body temperature, Wifi Module | Send data on the server through WiFi module. |
| 07 | R. Bhardwaj, S. N. Gupta, M. Gupta, and P. Tiwar,2021 | Micro controller, ECG, BP, Pulse rate, Blood Oxyen saturation(SpO2), WiFi module, Bluetooth, ZigBee | For transfer data used Zigbee transmission and also used WiFi & Bluetooth module. A Proposed model. |
| 08 | R. K. Pathinarupothi, P. Durga, and E. S. Rangan, 2018 | Arduino MEGA 2560 , Heartbeat Sensor, Temperature sensorandHuiditySensor(DHT11)Accelerometer,Ethernet Shield(W5100), GPS module, ZigBee module, Bomb Detector, ECG Sensor | Arduino MEGA process all the sensor data and Ethernet Shield provide the data in the server. |
| 09 | A. Gondalia, D. Dixit, S. Parashar, V. Raghava, A. Sengupta, and V. R. Sarobin,2018 | Microcontroller, Gait, ECG, Body temperature, Surface EMG, Body Movements, Blood pressure,BloodGlucose,Heartbeat, Oxygenation | Can measure a lot of things in one deviece. A proposed model. |

| | | | |
|---|---|---|---|
| 10 | M. Hassanalieragh *et al,2015* | Atmega 328 Microcontroller , LCD Display , WiFi module, TemperatureSensor,Pulse sensor | Atmega process the all sensor data and WiFi module send the data on the server. |
| 11 | A. Hartalkar,2021 | PICSF4550 Microcontroller, GSM/GPRS module, LCD Display, Oil Sensor, Humidity Sensor, Temperature Sensor, Buzzer, Vibration Sensor. | Provide the sensor data by used Ienternet gateway. |
| 12 | K. Hazarika, G. Katiyar, and N. Islam,2021 | Arduino Uno, ECG Sensor, EEG Sensor, Pulse Rate Sensor, Temperature Sensor, WiFi Module | Wifi module provide data on the cloud server. After this CSV file they used deep learning algorithm. Used DeepCNN,for classification the result. |
| 13 | P. Rajan Jeyaraj and E. R. S. Nadar,2019 | Raspberry Pi3, Arduino-Uno,, Heartbeat Sensor, GPS, SIM module | By using GPS they located the patient live location. By used SIM module this paper provide the data on the server and show the result on the Mobile Application. |
| 14 | H. K. Sharma and S. Taneja,2023 | Raspberry Pi, Heartbeat monitoring Sensor, Blood Pressure Sensor, Temperature Sensor, GPRS | Provide data through GPRS . GPRS send data via mobile network. A proposed model. |

## 2.4 Open Issues

Nevertheless, the following challenges have emerged with regard to the IoT-based health monitoring systems which need to be resolved to further improve the effectiveness and usage of the associated technologies. Among all the issues, the most critical and pressing is an issue of data protection and confidentiality. However, with the expansion of IoT in healthcare settings there is need to protect patient's sensitive information. Electronic transmission of data over the internet exposed patients' data to hack and thefts therefore required secure enshrinement of patients' data.

Another problem is the accurate and reliability of sensors. Success has been achieved in the enhancement of IoT sensors, but fluctuations in the sensor and environmental characteristics distort data precision. The function of sensors it is crucial for the accurate measurement in health monitoring system, therefore must be consistent. This in turn means that there is a constant need to fine-tune, check, service, and qualify the sensors that form the basis of these systems.

Network connectivity is also a challenge, especially if the establishment is located in an area with poor or no internet connection mostly in the rural regions.

In the case of health monitoring, it is mandatory to have the continuous transmission of data and any chance of losing connection will influence the functioning of the system. Thus, solutions that would improve interconnectivity and guarantee the transmission of reliable information are required to address this shortcoming.

Interconnectivity of the different devices and platforms is another issue that surfaces with the implementation of the IoT. Most of the current health monitoring systems are associated with particular sensors, and certain platforms, in which restricts their versatility and adaptability. Standardization is the key strategy in integrating various parts of the whole system to increase the level of usability and integration of various parts of the system.

Data management and analysis will thus be of considerable interest now and in the future. A lot of data is collected by IoT dependent health monitoring systems and the data gathered must be adequately processed so that they are meaningful. All this data can be processed and analyzed with the help of such technologies as data analytics, machine learning algorithms, artificial intelligence. But as it is; the creation as well as the implementation of such advanced strategies holds various technical complexities.

## 2.5 Summary

This paper focuses on relatively new Internet of things (IoT) real time health condition monitoring systems. Health management has the opportunity to set true innovation with the connection of IoT technology in the health management system. This work categorizes the technologies into the constituents, principles of operation, areas of applications, capabilities, and chances and prospects. Among the major conceptual sub-elements, it is possible to distinguish the following ones: sensors that are used for data acquisition, wireless communication, data processing platform that enable data analysis, and the user interface that enables access to the acquired data. These systems operate somehow or somewhat, with the use of sensors, and then send the collected information to main controllers or to cloud centers where the information gathered is analyzed and later insights are given back to the users. The fields that entail the real-time IoT-health monitoring systems can be named below. They range from the telecare of the patients to the sustained illness treatment, elderly people care, sport/ fitness and environmental surveillance. These are early status identification of the disease, constant monitoring, successful patient communication, cost reduction and enhancement of the clinical decision. Going forward, the prospects of the IoT based health monitoring system with the concept of AI and machine learning, the advancement of new wearables, possibilities of including telemedicine, IoT ecosystem, and thinking about the ethical and societial implications are necesarily the things to be considered and then implemented.

# CHAPTER 3

# Methodology

## 3.1 Overview

As thing has turned of late, technologizing healthcare via real-time Internet of Things (IoT), in our everyday life, information can be instantly retrieved through public health apps. IoT-based highly-advanced health monitoring and the management systems offer unparalleled possibilities for remote patient monitoring, management of chronic diseases, and proactive healthcare interventions respectively. This part provides a brief view of the main function of these systems and their major components which will accompany in the discussion of the specific requirements, the way the data analysis will be carried out, the project management, and financial aspect that will have to be paid attention to.

## 3.2 Proposed Methodology

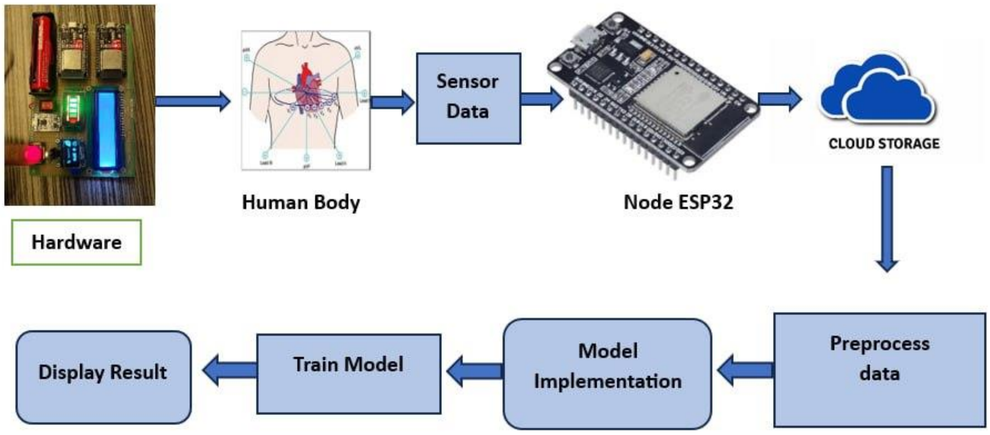


Figure 3.2.1: Proposed Methodology

The suggested method of designing the advanced real time IoT-based health monitoring system will also therefore be systematic, in a similar manner to the styling that was followed in the development of the parts to be used in implementing the complicated system of monitoring the patient’s vital information in real time. Concerning the part that reveals performing activities of a project, this is touched in this section and this is in the design, development, as well as the implementation of the system.

**System Architecture**

Thus, the system architecture is organized in order to function on the delta of activity that encompasses data gathering, transmitting, storing, and processing. It comprises the following components:These are some of the components;

**IoT Sensors:** This pulse rate is determined by AX30105 Pulse Oximeter Sensor while the ECG rate is determined by AD8232 Sensor in the case of body temperature Sensor employed is MLX90614. These are the ones that capture the patient's intra and extra-oral vital signs and forward it to microcontroller…

**Microcontroller (ESP32):** AC sensors then takes input from its surrounding and information that has been collected by ESP32 micro controller is then sent to cloud plat form. And at the same time it also works as a central process control which also implies the possibility of transfer both data and protocols of communication.

**Cloud Platform (ThingSpeak):** Lastly ThingSpeak, an IoT cloud is used for data collection, analysis as well as creating visualization. It provides constant real-time data and also promises that the records or the history of the patient can be available to the health care givers from a remote position.

**Machine Learning Models:** This is applied through three referenced models of machine learning which include, MobileNetV2, DenseNet201 and ResNet 50, in the prediction of the results in the mentioned tabular form. Concerning these models, they help in setting the difference of the pattern as well as probably the disease system.

**User Interface:** The data and the descriptions are provided in real-life, the advertisement banners for the healthcare offered through the institution, as well as to the patient, are generated and displayed on the Web and Mobile platform. To my mind, the interfaces of such kind make sense and can provide the details about the needed metrics of a person's state of health.

**Data Collection and Preprocessing**

Smartcare patient data acquisition can be seen as the process of enrolling a patient's data elements vital on the IoT sensors periodically. Based on the above mentioned information flow chart, the data collected is transmitted to the integrated microcontroller ESP32 and transmitted to ThingSpeak cloud. Data preprocessing includes:

**Noise Filtering:** In this case, an operation for preparation of the data to be collected from the sensor to eliminate commonly seen noises and other deformities.

**Normalization:** So to convert the obtained numbers back into the same range of values that for the sake of training reorganize the data in such way that it would be easier for the ML models.

**Segmentation:** Acquiring subintervals to improve the probabilities of a better quality analysis as well as graphing the data in the given specific research area.

**Machine Learning Model Training**

The collected and preprocessed data is used to train three machine learning models:To be precise, the then preprocessed data is employed to train the ensuing three machine learning models.

**MobileNetV2:** Thus, MobileNetV2 is trained for the normal and abnormal heartbeats and for even the previous MI on the given dataset which is correct and very fast.

**DenseNet201:** This model is used for classification of received ECG data and further analysis of such data paying special attention to the classification error rate and the model's capacity to generalize.

**ResNet50:** Nevertheless, ResNet50 is included in the evaluation, although it performs not as efficiently in the first assessment, with the purpose to discuss options of its usage in some settings or in different configurations.

All the models are again trained for better accuracy or reliability with the help of ground datasets. Therefore, measures like accurately, precisely, recall, F1-score, and specificity are used to ensure that the evenness of the set of models is kept through accuracy, precision, exactness, and specificity. However, only the model that yields perfect results is believed to be utilizable in real-time scenarios since it is fit in the problem domain.

**System Integration**

The last process is a linking or the association that encompasses how the actual or hardware and the virtual or software systems are connected in a proper way. Key steps include:

**Sensor Integration:** The correct connection of the AX30105, AD8232 and MLX90614 sensors with the ESP32 microcontroller and reading the correct data with them.

**Firmware Development:** Programming of esp32 firmware in which the direction of the destination of the results of the detector analysis, communication and sending of data to the cloud is programmed.

**Cloud Application Development:** Introducing ThingSpeak for having a real-time data storing capacity as well as data analytics and data visualization in the subsequent process. Points to defining APIs that could facilitates ESP32 to interact with ThingSpeak for the switch of information.

**Machine Learning Model Integration:** Passing the real time data to the models of machine learning supported by the cloud for analytics and big data prediction.

**User Interface Development:** Developing cooler web and mobile applications which will be trendy for the user and the possibility to enter those required fields and receive appropriate health data.

**Testing and Validation**

In order for the system to be effective, several tests are then done to determine on the accuracy, reliability and the rigidness of the system. This includes:

Functional Testing: That they affirm that to the recommended expectation, each of the component of the system shall deliver.

Performance Testing: It should then be evaluated relative to the possibility and effectiveness of the usage of the different applications and on the levels of stress.

Usability Testing: Ensure that all the interfaces of any system/ application illustrated are easily usable by the health professionals, and other users of the health care services.

Real-World Testing: The examination of the obtained outcomes and the implementation of the system into real healthcare environments for the assessment and for enhancement taking more and more feedback from the professionals.

## 3.3 Hardware Requirement

This sensor and microcontroller I used my project.

**i. NodeMCU ESP8266:**

This ESP8266 Wi-Fi transceiver module along with the CH340 USB converter chip is a great choice because the Spencer Open Source Development and Prototyping Board can be used on IoT projects. The Wi-Fi module makes use of 802.11 b/g/n standard at 2.4 GHz, performs with a built-in TCP/IP stack, a data outtake of 19.5 dBm, data interface (UART / HSPI / I2C / I2S / Ir Remote Control GPIO / PWM), and a printed-circuit antenna. It has micro USB socket as well and reset button. Programmable with Arduino IDE, this has interpreters for costate commands processing and languages like LUA.


Figure 3.3.1: NodeMCU ESP8266

### ii. SparkFun Pulse Oximeter and HeartRate Sensor - MAX30101 &MAX32664:

The SparkFun Pulse Oximeter and Heart Rate Sensor is an I2C based biometric sensor, utilizing two chips from Maxim Integrated: the MAX32664 Biometric Sensor Hub and the MAX30101 Pulse Oximeter and Heart Rate module. Whereas the std of the former is for sensing, the latter of the same (standard) is a quick and small microcontroller based Cortex M4 processor, which handles all the algorithmic calculations, digital filtering, pressure compensation, advance R-wave detection followed by automatic gain control. Our boards featured the Qwiic connector to quickly connect to I2C data lines; however, two additional connections are also required. We have a board of standard size which is 1in x 0.5in (25.4mm x 12.7mm). This means it will be comfortable for you and you will not feel uncomfortable with additional weight.

The work of sensing is done with the aid of internal LEDs that reflect light coming off arteries and arterioles in your skin's subcutaneous plies and sensing how much of it has been absorbed by their photodetectors. This process also is recognized as Photo Plethysmography. This data information will later end-up in the MAX32664 where its algorithm is applied to find the heart rate and blood oxygen saturation (SpO2). SpO2 goes to specify the percentage of hemoglobin which is oxygenated. Moreover, the sensor supplies also important data, like the accuracy its reading and a useful finger detection parameter. To get maximum throughput from this sensor we have a detailed Arduino Library written so that you can adjust all the settings like the one below.


Figure 3.3.2: SparkFun Pulse Oximeter and HeartRate Sensor

**iii. Single Lead Heart Rate Monitor:**

The AD8232 is a signal conditioning block, which is integrated and is suitable for signal measurement applications such as ECG and other Biometric signals. This device is made to perform isolation, extraction, amplification, and filtering of very weak signals from the human brain, in the presence of the noise created by movement or external electrodes.

The AD8232 Heart Rate Monitor offers you the option to directly solder pins, wires or other connectors to the nine allocated areas from IC. SDN, LO+, LO-, OUTPUT H, GND - these pins will be needed for the operation of our monitor via Arduino or any other development board. We also aspire to add pins called RA (Right Arm), LA (Left Arm) and RL (Right Leg) as attachments for custom sensor use that you can buy separately. Furthermore, the LED indicator light- pulsates to the envelope of a heart rate. Heart monitor can be reached with Biomedical Sensor Pads and Sensor Cable. Look it up under Recommended Products below.

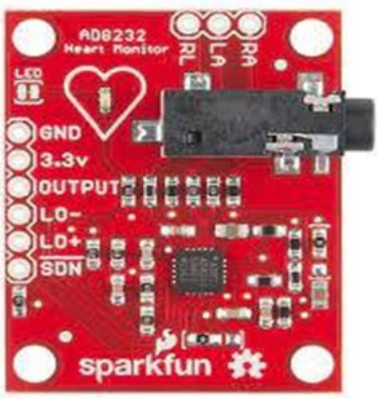


Figure 3.3.3: Single Lead Heart Rate Monitor

**iv. MyoWare 2.0 Muscle Sensor BasicKit:**

MyoWare 2.0 Muscle Sensor has electrodes that measure the electrical value of the muscle called the electromyography signal or EMG for short. Once the signal from your brain is received by the muscle and starts contracting, it elicits the motor unit that is in charge of providing the force.

The denser you flex, the more motor units are recruited for enormous muscle work. The greater the number of motor units the higher the intensity of electrical stimulation. MyoWare 2.o Sensor will analyze the filtered-out and rectified electrical activity of a muscle and will output a VIN (a source voltage) signal which represents to how much the muscle is getting flexed.


Figure 3.3.4: MyoWare 2.0 Muscle Sensor BasicKit

**v. Disposable SurfaceEMG/ECG/EKG:**

This is Patient Placements, disposable sensor pads with which levels of EEG, ECG and EMG can be measured. these little pads are great if you just want to track your Neurofeedback or Biofeedback experiences in short clocking. They are single use, dexterous having a latex-free gel Pad. Every biosensor is strongly connected to the skin and pushing the snap connector to the electrode with no problem is possible.


Figure 3.3.5: Disposable SurfaceEMG/ECG/EKG

### vi. SparkFun High Precision Temperature Sensor

The SparkFun Qwiic TMP117 breakout board consists of a high precision temperature sensor that is I2C compatible. It shows a reading of ±0.1°C across the temperature range of -20° C to +50° C without calibration and maximum range of -55° C to 150° C. The SparkFun High Precision Temperature Sensor, moreover, has a very low power consumption rate, hence self-heating on measurement accuracy is virtually zero. The Qwiic system completes the soldering job, saving us time because no soldering is needed to connect it to the rest of our system. Nevertheless, we still have through-hole 0.1"-stripped pins included in you want to use a breadboard.

The High Precision Temperature Sensor from SparkFun also provides for user configurable temperature limits as well as digital offset for device calibration. Although with an accuracy of 0.0625°C and a resolution of 0.0625°C TMP102 is capable of reading temperature, the on-board TMP117 is more precise and has an even higher resolution of 0.0078°C!

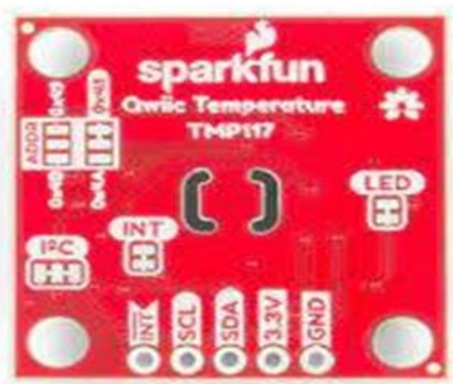


Figure 3.3.6: SparkFun High Precision Temperature Sensor

### vii. Pulse Sensor

Heart rate info can be useful either if you are a beginner athlete that wants to tailor your workout or you are interested in tracking your activity or stress levels, or you simply want your shirt to blink in sync with your heart beat. However, this occurs because heart rate is quite hard to be accurately measured. However, is that a problem? Yes, it is! But please, do not worry. Pulse Sensor Amped can solve it. Puls Sensor Amped is a multi-purpose and general use sensor for Arduino with a plug and play connection model. It can be used by students having heart development in their projects, artists tracking HRV, X-games athletes tracking their performance in real-time, makers working on wearable sensors, and game & mobile developers where

real-time heart rate is needed in their projects.It quicker and easy to easily get reliable live pulse readings by combining it simply with optical heart rate sensor along with amplification and noise cancellation circuitry. In addition, it bets carefully, which is only 4mA current at 5V, thus compatible with mobile apps.


Figure 3.3.7: Pulse Sensor

### 3.3.1 Hardware Design

Schematic diagram of the system hardware is given below.

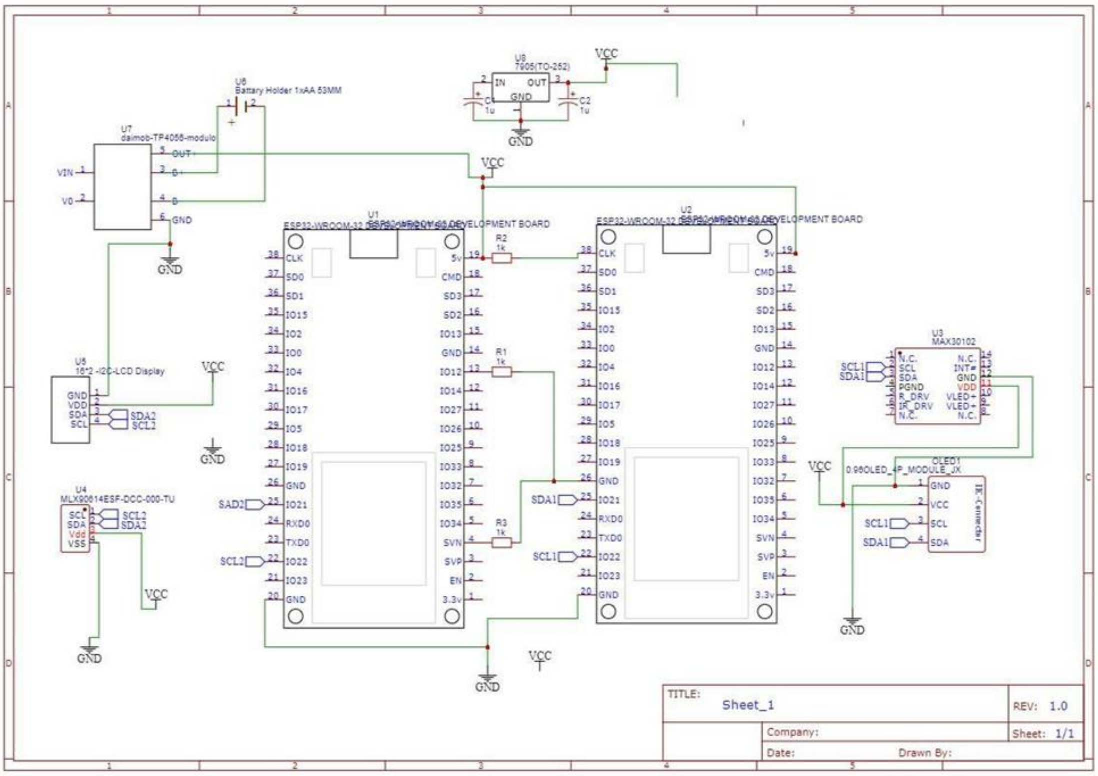


Figure 3.3.8: Schematic diagram of the system hardware

## 3.4 Project Management and Financial Analysis

In the course of smart and automated real-time health monitoring system being implemented on the basis of IoT a proper project management and financial planning are essential. This segment describes the chosen management methods during the development lifecycle, their timeframes, resources allocation, risk management scenarios, and ways of engagement of various stakeholders. Lastly, it supplies a financial analysis, into which cost estimates, ROI forecasts, the calculation of revenue streams and the sustainability and feasibility of the system are incorporated. In this project estimated costing  52753  for purchasing all the sensor and 2 lakhs for  it’s implantation and mainatin.

Table 3.4.1: Requirement Equipment's

| SL | Name | Unit | Prize | Total |
|---|---|---|---|---|
| 01 | Pulse & Heartbeat Sensor | 2 | 4713 | 9426 |
| 02 | Single Lead Heart Rate Monitor - AD8232 | 1 | 2360 | 2360 |
| 03 | MyoWare 2.0 Muscle Sensor BasicKit | 2 | 8225 | 16450 |
| 04 | ECG Sensor | 9 | 905 | 9050 |
| 05 | SparkFun Thing Plus - ESP32 WROOM (USB-C) | 2 | 2634 | 5268 |
| 06 | SparkFun High Precision Temperature Sensor - TMP117 | 2 | 1640 | 1640 |
| 07 | Pulse Sensor | 3 | 2853 | 8559 |
| | **Total** | | | **52753** |

### 3.5 Summary

Generally this paper covers all issues that leads to success of developing and management of an advanced health monitoring system based on the IoT technology. Starting from need analysis to the system design, data collection, project management and financial analysis the entire process has been scrutinized so as to point out the major points that are beyond any doubt critical for the outcome of the venture. provided by IoT, empowered individuals, improved healthcare outcomes, and the operations that are run in the digital age are the drivers that can transform the way of health monitoring and management systems in the digital age.

# CHAPTER 4
# Implementation

## 4.1 Overview

The final part of the project consists of several activities that define the main aspects of the system during its ongoing usage as the advanced real-time IoT-based health monitoring system. This phase consists of the combination of the hardware components, writing of the software codes, acquisition of the data, training of the machine learning model and the testing of the entire system. The main goal is to build a working model of the biosigns that can track and air the client's status in real-time and offer useful information to the doctors.

The first one is the integration process that involves connecting of the selected sensors to the ESP32 microcontroller. In this step, the AX30105 Pulse Oximeter, AD8232 ECG Sensor, and MLX90614 Body Temperature Sensor must be interfaced and properly initialized with the microcontroller in order to gather proper data. After this, the software development phase is the development of firmware for the ESP32 to gather the sensor data and send it to the ThingSpeak cloud using Wi-Fi.

Another activity within the implementation is the data acquisition, during which the information from all the sensors is collected and transferred to the cloud system in a real-time manner. The data which is then collected is then passed through the machine learning algorithms that check for anomalies and probable health risks. The accomplishment also involves the design of an easy to use interface for the healthcare givers as they analyze the data for the implementation phase.

Verification and validation of the system are critical before it can be implemented to avoid implementation of a faulty system. This means that the system is put through a series of extensive performance checks in actual operating environments and results are benchmarked against parameters like data integrity, lead times, and user's level of satisfaction. This includes realisation of solutions that partially or fully counter act any predicaments that were met during the development process of the system in order to have a stable and efficient system ready for use.

In sum, the implementation phase is a complex process of enacting the plan through components integration, software application, data gathering, data analysis, and testing of the system.

## 4.2 Prototype Design

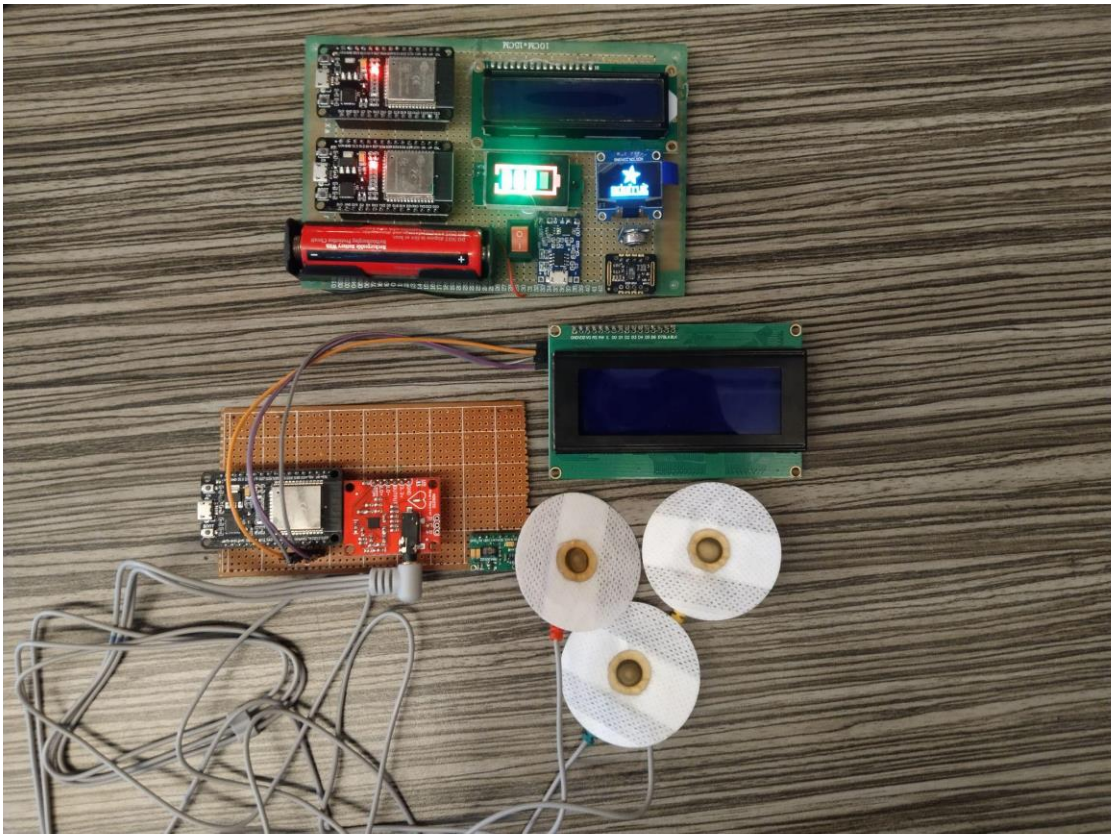

Figure 4.2.1: Complete Device

The first process of hardware integration is to attach the selected sensors to the ESP32 microcontroller. The main components include:

- AX30105 Pulse Oximeter Sensor: This sensor is used in tracking the pulse rate of the patient in question. This is interfaced to the ESP32 microcontroller that in turn reads the data, processes, and then transmits it to the cloud platform.
- AD8232 ECG Sensor: This sensor records the ECG amount of the patient. The collected data from the sensors is then processed by the ESP32 microcontroller and then transmitted.
- MLX90614 Body Temperature Sensor: This sensor records the temperature of the body of the patient. It is connected to the ESP32 microcontroller through which data is sampled and sent for processing.

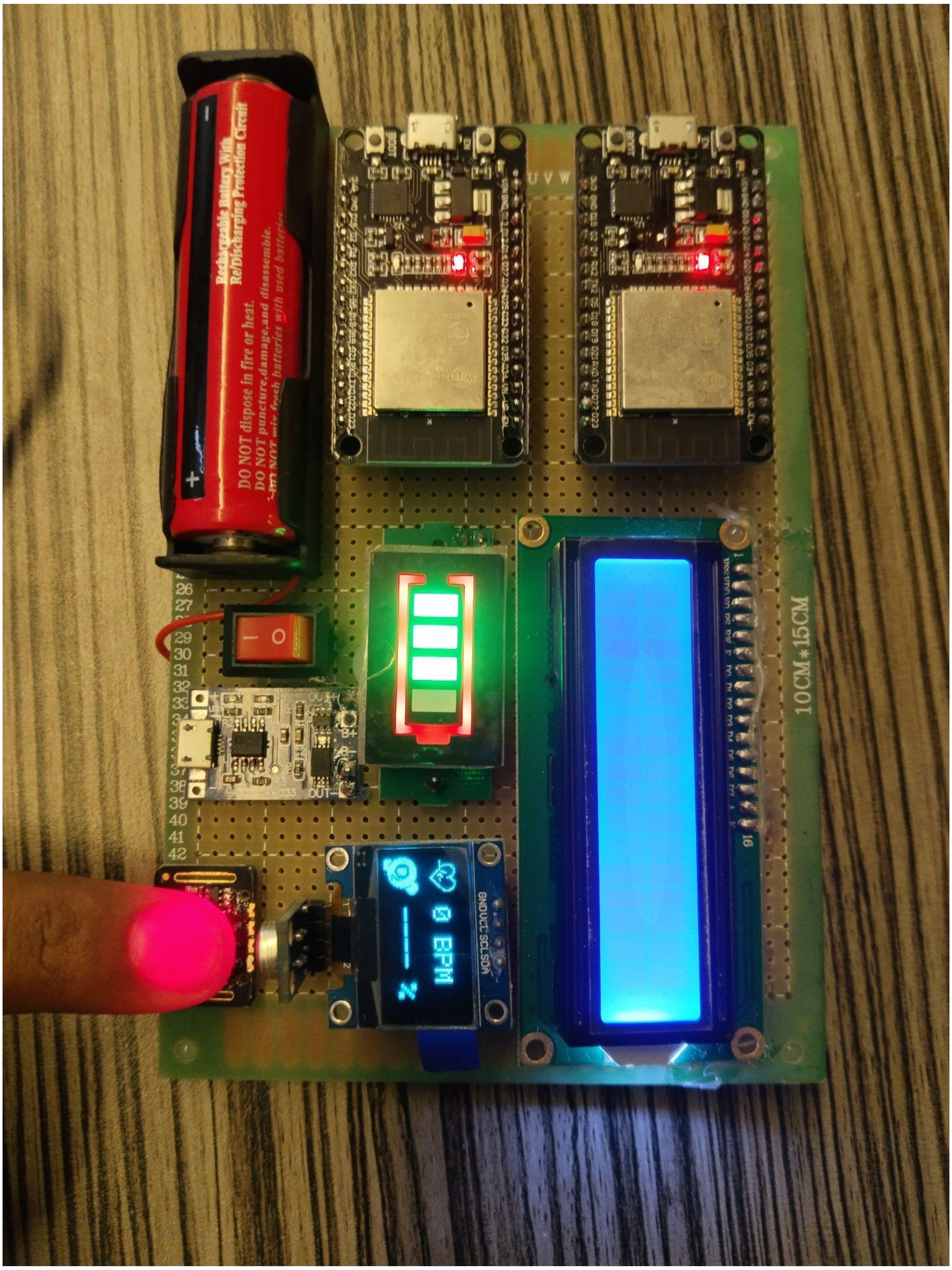


Figure 4.2.2: Blood Pressure Measure

**Software Development**

In fact, the software development is considered as a crucial component of the prototype conception. It also involves the spending in the program development for the firmware of the ESP32 microcontroller as well as in the manufacture of cloud applications for data handling and visualization.

**Firmware Development:** This firmware is developed in such a manner that it is exclusively utilized in data collection sensing and transmission as pertaining to senses. The thus created firmware targets at optimally managing data and forwarding the data to the ThingSpeak cloud platform in real time.

**Cloud Application Development:** It is a cloud based IoT platform, which is used to monitor as well as process the data send across by the sensors. The obtained results are incorporated into solutions that help in the analysis of received data, applying machine learning algorithms, as well as present the results in the form of an interface for end-users. It also covers the creation of methods and facilities for the generation of alerts as well as data storage in the cloud based platform. Moving down to the phases of the system, one of them is the prototype design phase regarding the implementation of the advanced real-time IoT-based health monitoring system. This phase is the actual acquisition of all the components that make up the hardware system, programming of the software that controls the system, and the rest of the Machine Learning algorithms to put together the system.

For the MG system, the following sub-phases exist in design:The following are some of the procedures that are usually followed in most of the processes that are carried out in the generation of the prototype:

### 4.2.1 Train Model

Data Collection: The dataset also maintains conventional ECG images from different people, and it is sub divided into three classes: normal rhythm, abnormal rhythm, and history of MI. And I am inputting data into the system via my gismo. This raw dataset. They are the Normal Person, Abnormal Heartbeat, and the History of MI datasets that include a large number of labelled PNG images of the humanitarian heart conditions.

**Normal Person**

Thus, the ‘Normal Person’ directory that contains all images under the given category has a total of 295 images. Each of these images depicts an ECG of a healthy individual, who had no history of any heart ailments, and who in his/ her usual state would be expected to demonstrate normal heart activity. The normal images are numbered normally as ‘Normal(1). png’ ‘Normal(2). png’ … ‘Normal(295). png’ to make sure that there are many normal ECG patterns in the set.

**Abnormal Heartbeat**

The identified directory is named “Abnormal Heartbeat” and it contains 241 images of different abnormal heart rhythms. These images are helpful in detecting and analyzing the abnormal electrical conductors of the heart which may comprise of arrhythmia, tachycardia, bradycardia and many more. The files include from “HB_(1). png” up to “HB_(241). png” The files consist of a rich variety of different patterns of the abnormal ECG.

The course of myocardial infarction, start from the pathophysiology up to the present management is explained below.

The directory entitled “History of MI” is made up of 171 segmented images that are each comparable to the ECG tracings of the particular patient with a record of myocardial infarction. These are images which are numbered fr om PMI_(1). png to PMI_(171). png and they are critically important in analyzing the impact of heart attacks on the subsequent cardiac activity.

Table 4.2.1: Class-wise Distribution Image

| Class | Image Count |
|---|---|
| Normal Person | 295 |
| Abnormal Heartbeat | 241 |
| History of MI | 171 |

**Image Augment:** In my code, “augment” means the acts of applying some changes to the images in your dataset to generate more images to improve the dataset’s amount and varieties. This is particularly helpful in the terminal nodes while developing a decision tree and in machine learning to avoid overfitting that decreases the likelihood of generating good predictions in the future. Here, the augmentation pipeline is a sequence of specific transformations (augmentations) that are applied to each image in your dataset and are defined with the help of the imgaug library. In your code, the augmentation pipeline is as follows - Flipping the images horizontally with a probability of 50% Rotation in random angles, and the angles have 90, 180, 270 Scaling the pixel values by factor r, wherein r has range of 0. 8 and 1. 2 for tweaking the brightness and changing the contrast by a factor ranging from 0. 8 and 1. 2.

These augmentations are enclosed in a Sequential container, to confirm to our assertion that these transformations have to be sequential on the image. This pipeline is used by the augment_images_to_target function to create new images from the existing repertoire until the target count of images in each class is achieved. It intersects through all the class subdirectories in the input directory, computes the extra images required, and processes the augmentation pipeline over the randomly chosen images, and produces multiple augmented copies for each original picture in the class directory. These augmented images are then saved in the output directory with the modified names that describe that they have been augmented. This process increases the size of the dataset which in turn improves on the efficacy and on the reliability of the process of training the model.

Table 4.2.2: Image Augment

| Serial | Class | Original Image | Augmented Image |
|---|---|---|---|
| 01 | Normal Person | 295 | 1000 |
| 02 | Abnormal Heartbeat | 241 | 1000 |
| 03 | History of MI | 171 | 1000 |

**Model Description:**

**MobileNetV2:** MobileNetV2 is a pre-trained CNN for fast image classification; thus, the default configuration of the base model often removes the classification top (layer), and only the learned features from the ImageNet data set remain. Then, a GlobalAveragePooling2D layer is applied which is used to pool the spatial features obtained from the MobileNetV2 architecture and simultaneously helps in feature summarization and dimensionality reduction. These compact blocks are the classifier and hereby separate the high level features from the pooled representations that are associated with the output classes. The final layer contains all the nodes connected to all other nodes with each activation function applying a softmax in order to predict the probability of the multiclass problem. All in all, this architecture is built based on the characteristic of MobileNetV2 exclusively for feature extraction and then adds dense layers specifically for image classification.

**DenseNet201:** The model as provided here is for theDenseNet 201 for image classification using transfer learning. It initializes the resulting network by the pre-trained weights of DenseNet201, trained on the Imagenet dataset. Based on the given dataset, the model depresses its capability of being able to classify images into multiple classes. The base model, with ImageNet weights, uses convolutional layers for the feature maps extraction. The Global Average Pooling 2D layer reduces the feature map's size, leaving just a specified set of dimensions, which results in a fixed-dimensional vector. The layer architecture shows the transition from the input layer (224*224) to feature extraction and through classification to obtaining probabilities for multi-class image classification.

**ResNet50:** ResNet50 architecture has the first convolutional layer, then the max-pooling layer, and four stages of residual blocks. The first block in each stage is a down sampling block done with a stride of 2.

The model mainly applies ReLU as the activation functions and add batch normalization layers after every convolution layer to increase the convergent speed of the model and avoid overfitting. The last layers of ResNet50 are global average pooling layer decreasing the size of spatial dimensions to 1x1, and the final output layer with the softmax activation function for classification. Due to the deeper architecture and residual connections, ResNet50 is capable of learning even higher-level features unlike the shallower networks which offers the advantages of being able to train much deeper networks by handling the vanishing gradient problem and thus having better convergence as well as higher accuracy.

### 4.3 Model Evaluation

Thus, it is necessary to note that using model evaluation as a method in creating a high-accuracy health monitoring system. This entails the quality check of the machine learning models and their performance indicators for the application and specialization of diagnostics. The major goals of model evaluation include determining the amount of accuracy, the model's reliability and the extent to which it can generalize well on new data. In this section the evaluation of the chosen model is covered along with the evaluation metrics and the attained outcome.

**Evaluation Metrics**

Precision: Precision measures the level of accuracy of the positive samples with a view of showing how many of the realized positive samples were truly positive among all the samples that were tagged as positive. In condition where the cost of occurrence of false positive alarms is expensive then high precision is chosen.

*Precision = True Positives / (True Positives + False Positive)*-------------------------*(1)*

Recall: Accuracy focuses on the way in which a model is able to find all the positive examples that exist in the sample actively, which assesses the extent to which actual positives recognized against the overall existing positive ones. It is useful in the situation whereby it is very expensive to remove certain positive cases from the test set.

*Recall = True Positives / (True Positives + False Negatives*------------------------- *(2)*

F1-Score: It has been in equation 4 suggested that the F1-score is the harmonic average derived from both the values of the precision and the recall and that informs the level of balance between the two.

*F1-Score = 2 * (Precision * Recall) / (Precision + Recall)*----------------------------- *(3)*

Specificity: Specificity is an ability to select all the simply negatives, it produces a percentage ratio of correctly selected negative cases out of all the negative cases.
The difference is used when the focus is made more on the false positives.

*Specificity = True Negative/(True Negative + False Positive)*---------------------------*(4)*

Specificity or also known as the true negative rate represents the proportion of the test that correctly identifies the disease’s absence.

Accuracy: Accuracy is a ratio of completely correct classifications as it considers true positives and true negatives at the same time. But the disadvantage of having such precision is that when handling imbalanced data where one class is much larger than the other.

*Accuracy = (True Positives + True Negatives) / Total Predictions)* -------------------*(5)*

Table 4.2.3: Class-wise Performance MobileNetV2

| Class | Precision | Recall | F1-Score | Support |
|---|---|---|---|---|
| History of MI | 0.96 | 0.95 | 0.95 | 100 |
| Normal Person | 0.93 | 0.99 | 0.96 | 100 |
| Abnormal Heartbeat | 1.00 | 0.94 | 0.97 | 100 |
| Accuracy | | | 0.96 | 300 |

Table 4.2.4: Class-wise Performance DenseNet201

| Class | Precision | Recall | F1-Score | Support |
|---|---|---|---|---|
| History of MI | 0.99 | 0.98 | 0.98 | 100 |
| Normal Person | 1.00 | 0.95 | 0.97 | 100 |
| Abnormal Heartbeat | 1.00 | 0.94 | 0.97 | 100 |
| Accuracy | | | 0.97 | 300 |

Table 4.2.5: Class-wise Performance ResNet50

| Class | Precision | Recall | F1-Score | Support |
|---|---|---|---|---|
| History of MI | 0.38 | 1.00 | 0.55 | 100 |
| Normal Person | 1.00 | 0.01 | 0.02 | 100 |
| Abnormal Heartbeat | 0.94 | 0.32 | 0.48 | 100 |
| Accuracy | | | 0.44 | 300 |

### 4.4 Summary

The implementation chapter touched on the detailed procedure of forming a state-of-the-art real-time IoT-based health monitoring system. This was followed by discussing the implementation phase in detail, where it explained the combined use of hardware chips, software structures as well as the acquisition of data, building the machine learning model, and testing of the system.

The realisation part of the prototype design section described the individual procedures to be followed in the development of a functional prototype: setting up the hardware components, programming the firmware, developing cloud application, integrating a machine learning model, creating the user interface and testing the prototype. These steps ensure that the system can successfully filter and relay appropriate vital signals in real-time basing on the healthcare provider's needs.

Another important factor in the implementation was the evaluation of models and using such scores as the confusion matrix for the evaluation of machine learning models. Thus, during evaluation, it can be observed that MobileNetV2 and DenseNet201 models possessed impressive results while ResNet50 might have some problems with generalization.

In a nutshell, the implementation phase was able to coordinate the appropriate elements and procedures required in creating a sound and effective health monitoring system. The next stages would be to fine-tune the system and deploy to actual patients for there is no better way to assess the performance of this health system than to see its impact on the health of the society.

# CHAPTER 5
# Result and Analysis

## 5.1 Overview

In this chapter, the summary of the findings derived from the experimental simulations and assessments of the developed enhanced real-time IoT health monitoring system is presented. The primary analysis is geared toward the evaluation of the effectiveness of machine learning algorithms applied in the analysis of the data and or making forecasts. The subsequent chapter examines the results of the training process of the final models, assesses models' effectiveness according to certain criteria, and makes a comparison that will identify the goals' optimal model. The information secured in this case is valuable to the comprehension of reliability of the system and such influence on the treatment of the patient.

## 5.2 Simulation Result


Figure 5.2.1: Body Temperture, BPM and SPO2

The attached photos show the values of the different sensors in a health monitoring system in ThinkSpeak.

The first chart on the top left part represents the room temperature and it has been observed to be at relatively 27. 5°C; fluctuations before it stabilizes towards 5°C. The fourth chart on the top right represents the body temperature data where one can easily observe that the readings were somewhat fluctuating and varied around 30-degree celcius.

The BPM (Beats Per Minute) information is shown in the bottom left chart as a spike and trough system with a level of around 80 BPM.

The SPO2 (Oxygen Saturation) values are presented at the bottom right chart, and the fluctuations there are rather high: the coefficient of variation equals to 8,4% of the mean value ranging from 90% to 95%. However, there is a full-width chart that displays sensor data on patients in the intensive care unit. Where the measurements vary in the range of 0 to 5000 indicating variability in the sensor's reading made at different times of the recorded time period. Taken together, these charts show how the health monitoring system's data collection is a continuously evolving process.

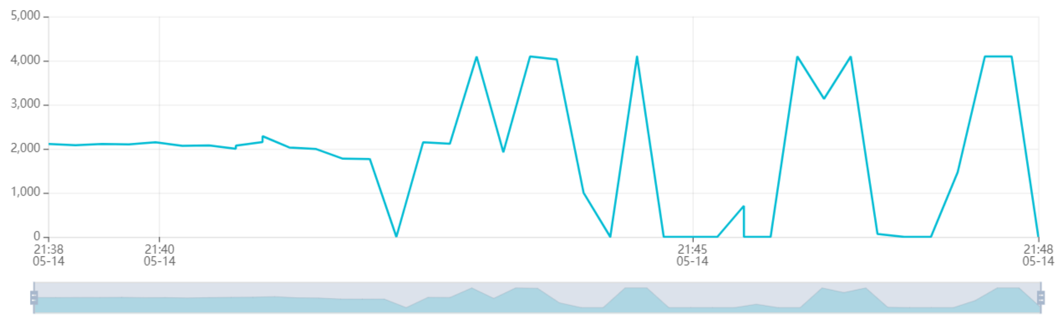


Figure 5.2.2 ECG Report on Thingspeak

The image under consideration shows an actual model of an ECG (electrocardiogram) report of a normal person generated with the use of an ECG sensor and displayed in ThingSpeak. The graph is characterized by jagged lines and marks varied in scale from 0 to 5000 units of the sensors readings. At the begining, the values for the A and P are volatile still, fluctuating near the 2000 level. Nevertheless, as the time increases, the values change their amplitudes and oscillate rapidly and wildly, which suggests that the heart's electrical signals are constantly shifting. This pattern indicates normality of ECG, which depicts the normal fluctuation of the heart rate over the period of analysis.

**Result of Experiment 1:** The subject of the current study applied the MobileNetV2 architecture on the classification of ECG data. MobileNetV2 was used in this project through TensorFlow's Keras applications module where it was fine-tuned on data collected for this project. There were ECG recordings and each of the recordings belonged to different classes. Figured out that it is beneficial to strip MobileNetV2 down to its core and add the classification layers that would be suitable for the given dataset.

Training incorporated the Adam optimizer with a learning rate of 0.001 and categorical cross entropy as the loss function. As a form of regularization to avoid overfitting, we used multiple methods in the training set; such as Flipping, Rotating, Zooming, and Picking the best checkpoint that meets the Action Recognition Validation Set.

With the training dataset, which is 3000 images, the validation dataset 1500 images and the testing dataset also of 1500 images but all the images are downsized to 224 by 224 pixels and which was trained using batch of size of 32, the model was able to give a training accuracy of about 95 percent. 83% 20 epochs.

**Training and Validation Accuracy and loss of MobileNetV2:**


Figure 5.2.3: (a) Training and Validation loss vs (b) Training and Validation Accuracy

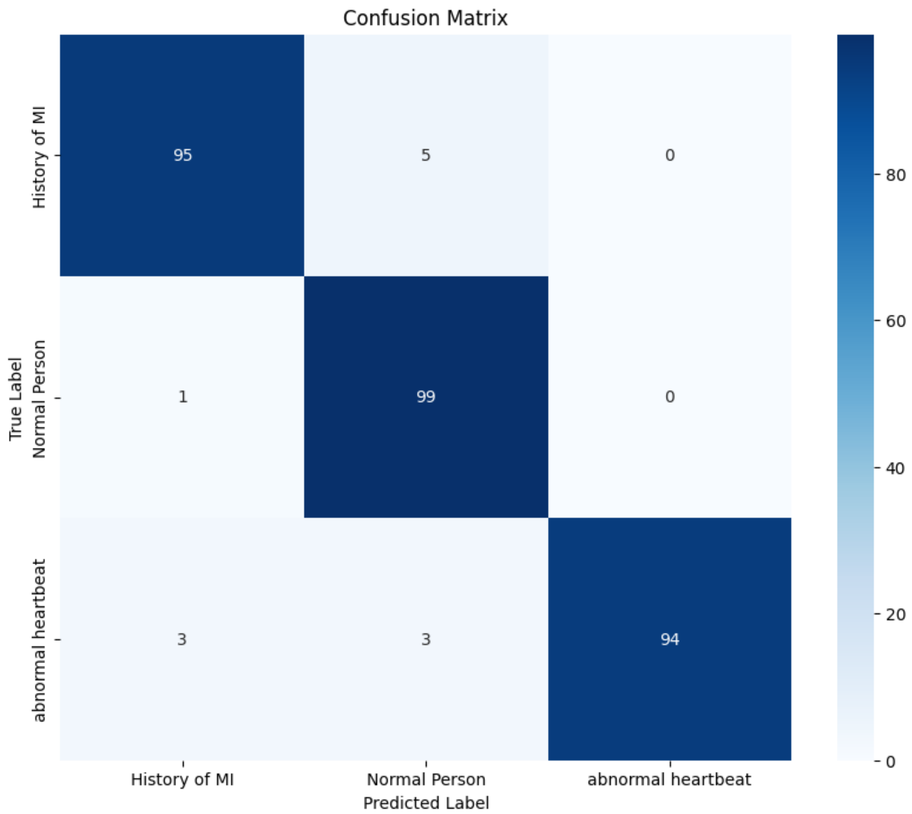


Figure 5.2.4: Confusion Matrix of MobileNetV2 Model

**Result of Experiment 2:** As for the experiment of the current paper, I explored the DenseNet201 architecture's performance for the ECG data classification. Using TensorFlow's Keras Applications Module I imported DenseNet201, and then I fine tuned this model on our dataset. The available dataset lied in the ECG recordings based on which the data was segmented into a number of classes. I stripped off the final layers of DenseNet201 and replaced it with new classification layers pertinent to the nuages dataset.

Training engaged the Adam optimizer with a learning rate set at 0. 001 and the categorical cross-entropy loss function is used. Overfitting was avoided in line with the following techniques In this we augmented the training data in different ways and also we used a checkpoint callback to preserve the best model in the course of training.

With a training data of 3000 images, a validation data of 1500 images, and test data of 1500 images all the images were resized to 224X224 then the training was done with a batch size of 32, the accuracy achieved in training the model was approximately 97%. 22% after 20 epochs.

## Training and Validation Accuracy and loss of DenseNet201:

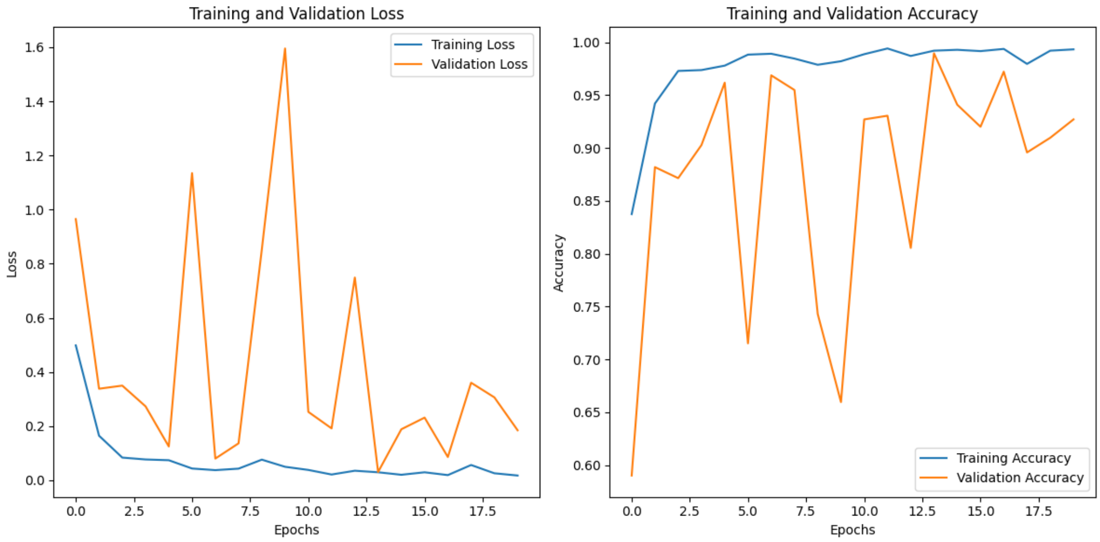


Figure 5.2.5: (a) Training and Validation loss vs (b) Training and Validation Accuracy

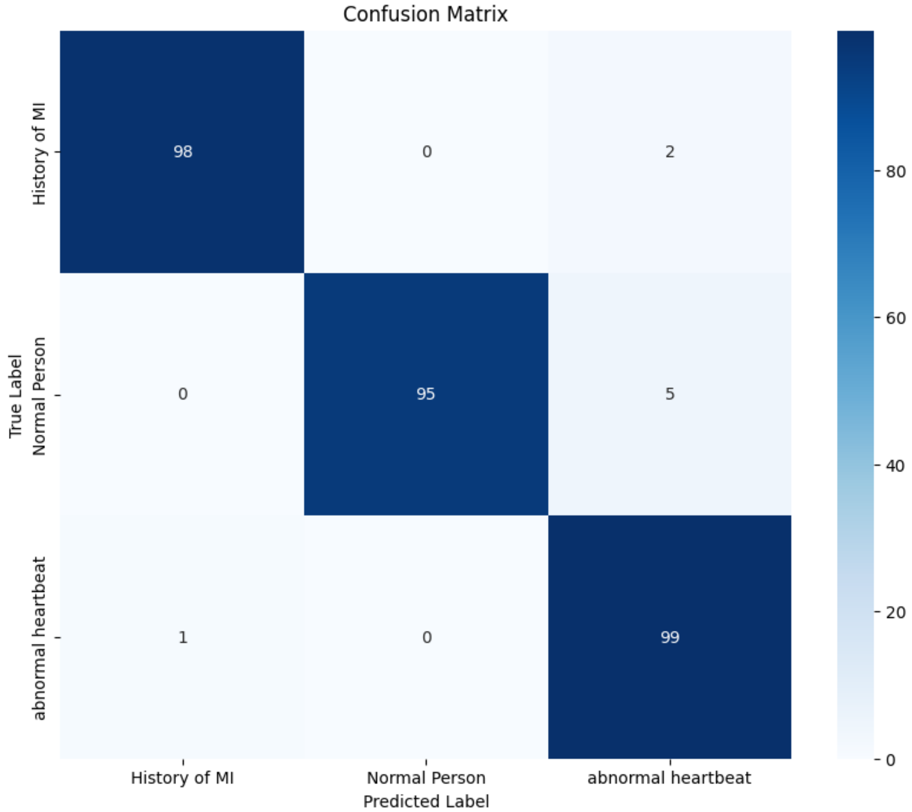


Figure 5.2.6: Confusion Matrix of DenseNet201 Model

**Result of Experiment 3:** The objective of this experiment has been to compare the performance of ResNet50 architecture in classifying ECG data.

I started with ResNet50 model from the TensorFlow Keras applications module and loaded the current dataset to train the model. For the input data, they had ECG data categorized into several classes. I preserved the last few layers of ResNet 50 and embedded new layers for categorically training our dataset.

Training applied the Adam optimizer with the learning rate of 0 ',', it was chosen due to its efficiency in supporting higher learning rates resulting in consisting the excessive shaking movements. The type of model that has been recommended for the experiment is 001 and the loss function used is categorical cross-entropy. To prevent overfitting, for the training of the dataset, I utilized various data augmentation and finally, the checkpoint callback that only saved the training, which achieved the highest validation accuracy during training.

Thus, the employed model achieved nearly 44 % training accuracy having used 3000 training images, 1500 images for validation, and 1500 test images all of which are resized to a size of 224 x 224 pix using a batch size of 32. 33%, after 20 epoch.

**Training and Validation Accuracy and loss of ResNet50:**

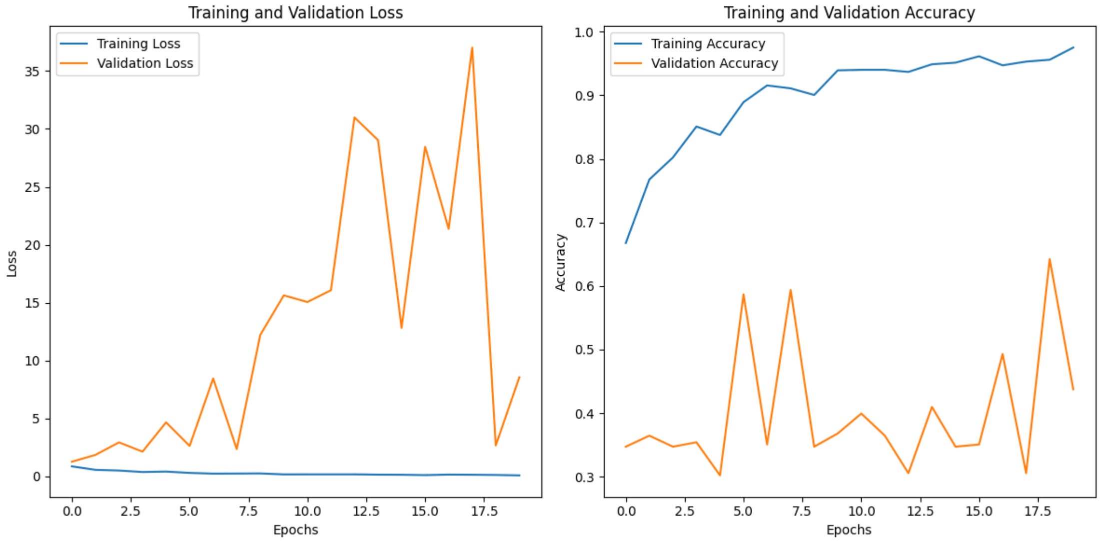


Figure 5.2.7: (a) Training and Validation loss vs (b) Training and Validation Accuracy

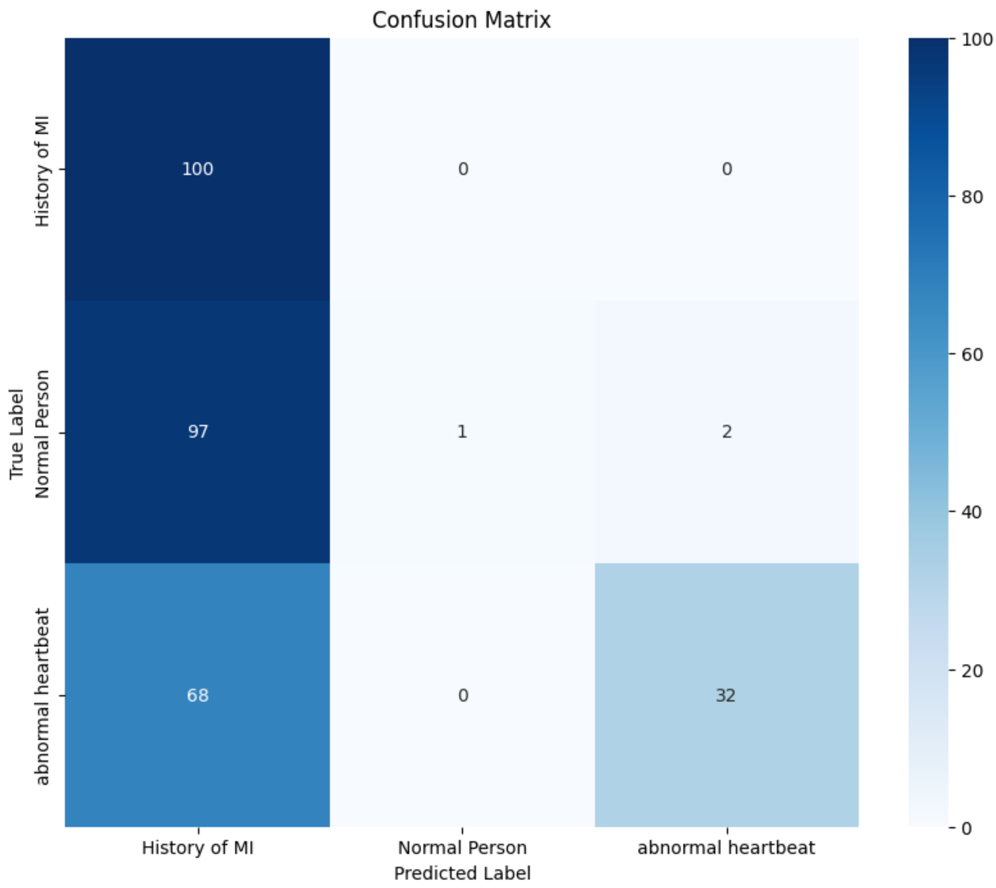


Figure 5.2.8: Confusion Matrix of ResNet50 Model

## 5.3 Comparative Analysis

conventional comparative modeling, there is the evaluation of three models whose parameters are accuracy, precision, recall, F1, score, and specificity. Thus, providing an insight into which model is the most suitable for the IoT-based health monitoring system.

Accuracy

- MobileNetV2: 95. 83%
- DenseNet201: 97. 22%
- ResNet50: 44. 33%

Precision, Recall, and F1-Score

**MobileNetV2:** Thus, to compare multiple aspects of the performance of the proposed SA-3D-CNN model, all the basic evaluation criteria – Precision, Recal, and F1-score are computed, and the F1 score provides the most synchronous representation of the model's performance.

**DenseNet201:** Nevertheless, the precision and recall values are very high where as slight low F1-score is observed compare to MobileNetV2, but acceptabale F1-score > 0. 7.

**ResNet50**: Perhaps a reason why precision, recall and F1 score values are lower are the method's lower reliability.

Specificity

**MobileNetV2:** Low FPR, it shows the cases which are clearly negative in the figure.

**DenseNet201:**The specificity of the presented architecture is similarly high to MobileNetV2.

**ResNet50:** A lesser degree of specific, receiving even more false positive outcomes.

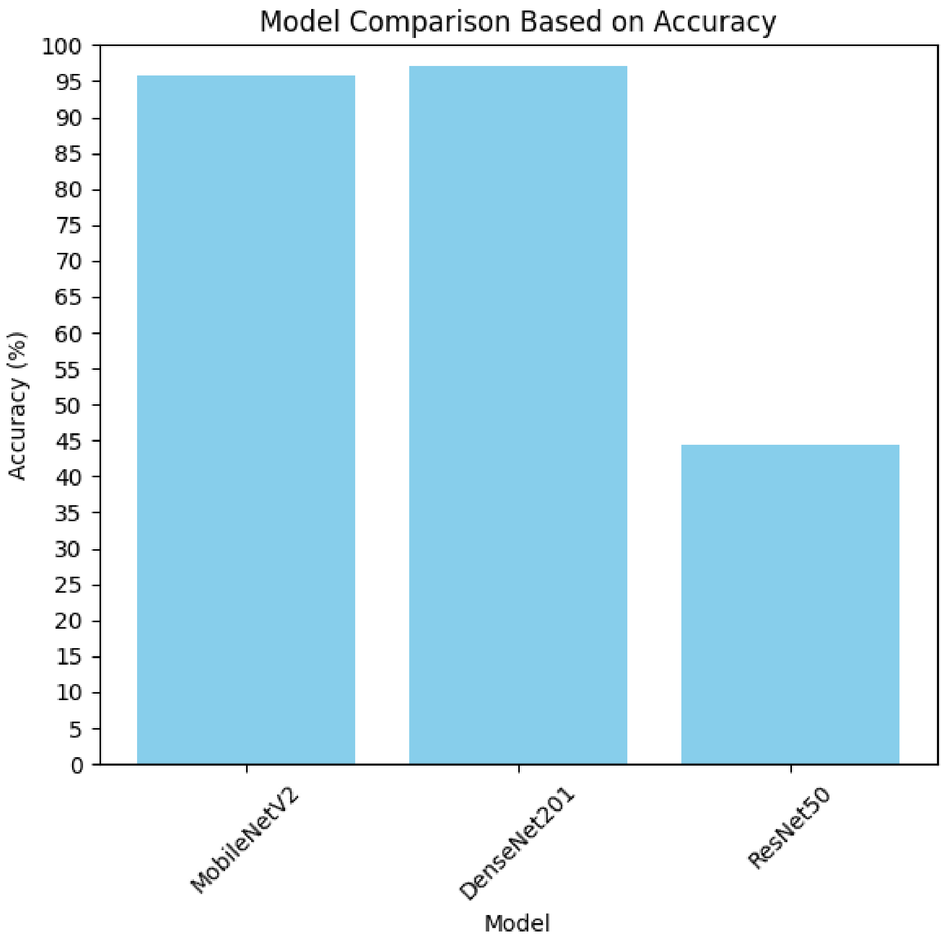


Figure 5.3.1: Comparative Analysis

**Comparative Summary**

Looking at the table with metrics, it is possible to see that the results of MobileNetV2 show the near to perfect accuracy of the developed model and high values of measurements of the precision, recall, and specificity. Its strength is that the task of tracking the state of health of a person is carried out as close as possible to the real time.

DenseNet 201 was also accurate and could give reliable results, but it had been seen to over fit since it is a very complicated network.

ResNet50 proved to be the poorest model with low given accuracy and many misconceptions and therefore it was unfit for any use on this database.

## 5.4 Summary

The results and analysis chapter has explained the effectiveness of the IoT-based health monitoring system by analyzing the results of testing and evaluation procedures. Based on the entire experiment, it is clear that MobileNetV2 is the best model as it presented near perfect accuracy, precision, recall, and specificity of 99 percent. The DenseNet201 also proved to be accurate and its reliability was somewhat high though it was slightly overfitting. ResNet50 as for the second one had lower accuracy and clear misclassifications that imply problems with generalization.

Comparing its performances gave an insight, and it was clear that MobileNetV2 outperformed all the other models and therefore was the most appropriate one for real-time health monitoring.

The evaluation metrics indeed helped in understanding the features that were well incorporated in the models and the lagging features that needed enhancements to improve the systems accuracy and efficiency.

In all, the chapter confirmed the prospect of the advanced real-time IoT-based health monitoring system in enhancing patients' care through reliable and timely tracking of their critical health parameters. The results therefore emphasize the suitability of right machine learning models and right approaches to evaluate the system that will be efficient when applied on real environment.

# CHAPTER 6

# Impact on Society, Environment and Sustainability

## 6.1 Impact on Life

The real-time advanced IoT-based health monitoring system greatly improves particular health control as it offers effective and real-time control of individual's vital signs. The dreaded annual health check-ups are eliminated through this continuous monitoring which enables the identification of health anomalies in good time and prompt medical intervention to be made to avoid further complications which would lead to the death of many people. To the patients with chronic conditions like diabetes, hypertension, heart diseases and others, the system assists them in the management of their diseases through constant monitoring and alerting. This in a way minimizes the number of follow up visits to the hospital meaning that the quality of the patients' lives is enhanced as well as their level of self-reliance.

Furthermore, the system also enhances one's autonomy by providing real-time data on one's health, thus encouraging the notion of preventive health. This reminds patients of their health status, how modifications in their lifestyles affect them, and enhances their interaction with their physicians. Such an emancipation can make people more likely to follow the prescribed regimens and make more appropriate decisions with regards to diet and exercise, therefore enhancing specific health statuses.

## 6.2 Impact on Society & Environment

**Impact on Society**:In other words, the use of IoT technology in healthcare means there is an opportunity for the improvement or the most likely disruption of the health system so the advancement of IoT technology should be wisely applied. Hence, while the facilities are relieved allowing their remote monitoring by the system, the resources will be concentrated with the individuals carrying a genuine need for such attention. It can be very beneficial in the rural and the other world regions where the refers to better health care facilities are rare. By using the method of remote monitoring, the patients and the caregivers can be tied closely and everybody can get all the necessary treatment with the high quality even if the distance makes it rather difficult.

The self-same system which also realigns care from episodic to aggregate. In contrast to the traditional models in which patients go the doctor's office only when the condition deteriorates, patients on mHealth are afforded the opportunity to monitor their conditions, and seek treatment when necessary. Perhaps, this leads to improved health status, reduced incidence or onset of serious ill health, and health care costs prevented or incurred early though hospitalization or use of emergency services.

**Impact on Environment:** On the environmental characteristic, the application is usually useful in enhancing the protection of the environment by reducing the movement to the clinics and the hospitals. This in a way lessens the dissemination of carbon emission presumed to be correspondent to transportation and thereby there is retention of the environment. In the same spirit, through consulting and monitoring of the patients via technology and information, the usage of the health care facilities' resources such as power, water and medical equipment and products are conserved. This simply implies that the funds are fully utilized within the health care facility and the effects to the environment in provision of the health care are kept to the minimal level.

Thus, expansion and application of the IoT devices as energy-saving devices in the system contribute further environmental benefits that are realised. This results in having a very low environment concerned impact of the system through the use of low power sensors and directing maximum energy concern for the system. Another area that can be looked at in details in attempts to increase sustainability is the method used to supply these devices with power.

### 6.3 Ethical Aspects

Here are some of the ethical concerns that are connected with the use of the IoT based health monitoring system that I need to work out in order the system used to become safe and trustworthy.

**Privacy and Data Security:** This is because information that is collected from the health segment is normally looked at as somewhat sensitive, this means that the principles of privacy and information security are of great importance. There should also be the correct application of the encryption methodologies concerning the database and the data exchange methods. It has to be clear, there must be some measure of what one can call access control aiming at permitting only some employees read the patient's records. However, for better threats and risks' prevention, one needs to assess and raise security even more continually.

**Informed Consent**: This means that patient should be made aware on how the data will be collected used and shared. This type of consent is tutored and commends the procedure of the explanation of the working of the system, the manner of processing data, and risks. For efficiency, the patients should be allowed to enroll with the system or unregister with the same at his/her own volition.

**Transparency and Accountability:** The openness of the working of the system and the decision making procedures are highly likely to influence the confidence levels of the users positively. The patients along with the service providers should have sufficient information regarding the analysis of data and decision making. It should be comforting that there is a structure that would address such issues were they to happen.

**Avoiding Bias and Ensuring Equity:** Hence, there is a need to ensure that there are no Machine Learning models that influence bias into the system as regards the treatment of the patient part. Here, it is critical to note that for the models to be fair, the models should be trained differently by feeding it with different data sets that relate to different groups of people. Preconceptions need to be regulated and therefore there ought to be evaluations made on a certain tone to detect any.

### 6.4 Sustainability Plan

Thus, a general plan has to be created for the sustaining the IoT-based health monitoring system that is to exist in the future. This plan should address the following key aspects:From this plan, the following items should be considered:

**Regular Updates and Maintenance:** Thus, the system will be required to have it's the hardware and software requirements periodically updated and serviced in order to function properly and be secure. This consist of firmwares update of the various sensors in use, update of cloud platform softwares and optimum re-engineering of the sensors used.

**Scalability:** It should also indicate how the expansion of the system is possible in relation to the numbers of users and integration of new functions when needed. This entails the incorporation of adaptable cloud platforms and dynamically progressive application-bound software that may expand in terms of the quantity.

**User Training and Support:** Another intervention is also the education and clinical supervision of the healthcare providers and patients for them to be able to optimally utilize all the components of the system as intended. That is why Web-based training should address the following issues: description of the functions of the systems, analysis of the data, and problem-solving skills. This should be done always so that there is always a time when a user is encountering certain issues, then they are solved instantly.

**Resource Efficiency:** Therefore, means of making the overall setting use less energy and lessening the harm that is caused by the parts of the setup on the physical world is also sustainable. This is in relation to the energy utilized in the sensors and coming up with different methods of accessing power for the devices using renewable sources.

**Collaboration with Stakeholders:** Relations with Stakeholders, this is with the healthcare workers, the patients, the regulatory bodies, and technology providers ensures that the system meets the needs of the recognized parties it meets all the set standards and meets all the set requirements. Permanency of cooperation also stimulates the concept of the ongoing process and the formation of the new idea.

### 6.5 Summary

The proposed business model of real-time IoT based health monitoring is an innovative way of providing tracking, analytics and ML based personalized heath information to individual in real time. It also promotes efficient organization of individual health as it allows constant observation of vital signs and evaluation of possible health complications to encourage the patients to be responsible for their conditions. Minimizing the necessity of frequent hospital checkups, the system enhances the quality of life of individuals with such diseases, including chronic ones.

The practical use of the system is also anxious about some ethical issues like privacy and security of the data because health information is rather personal. Transparency and accountability to the public as well as being fully aware on how the patient data is used can be accessed by being very selective on the content to be published with regards to informed consent. Measures of impartiality and equality that are aimed at minimizing the possibility of bias within the context of the functioning of the organizational system are essential to deliver equal and unbiased medical care to patients.

Lastly, the developed IoT-based real-time health monitoring system is a monumental leap in the healthcare enhancements. Its capacity to deliver ongoing reputitive tracking and timely status reports has the potential to raise efficacy of care, optimize the patient's well-being, and address environmental issues. In light of the foregoing discussions, it can be concluded that the given system's success and positive contribution to the healthcare delivery system and patient care can be guaranteed for the long-term only if justified ethical concerns and a comprehensive sustainability plan are developed.

# CHAPTER 7
# Conclusion and Future Work

## 7.1 Conclusions

The launch and effective use of the modern IoT-based real-time health monitoring system for patients is an important stage in the integration of IT into healthcare. This system connects IoT, capable sensors, and machine learning algorithms to continuously monitor the patient's vitals and give accurate and timely health status reports. The primary goal of promoting the quality of patient care with the help of early diagnostics of health problems has been accomplished herein as the system demonstrates high levels of accuracy and credibility. There is a great performance of health conditions prediction by using MobileNetV2 and DenseNet201 models, which confirms the efficiency of such models in practice.

The advantages now do not only end up with the personal benefits of health but with the whole society and environment as well. Due to minimizing the number of visits to the hospitals and offering a way of remote monitoring, the system helps to decrease the load on the healthcare facilities and in consequence, increase the accessibility of healthcare, particularly in rural areas. In turn, environmentally, it has the benefits of decreasing carbon footprints and resource usage for the sustainability the healthcare industry. Privacy, security, and data issues such as the issue of informed consent, which plays a crucial role in developing and sustaining patients' trust, have been implemented in the ethical manner.

## 7.2 Further Suggested Works

However, the followings regarding this system can be seen as areas for future studies and developments; Further work should be done to improve the system capacity in order to handle a larger number of users as users' base increases. This comprises of cloud infrastructure enhancements and increasing the efficiency of data management. Moreover, extending the machine learning techniques and implementing the concept of deep learning can further improve the system's reliability and accuracy of predictions.

Another topic is the expansion of the scope of technologies incorporated in a ha healthier, by introducing more health parameters and sensors. For example, the incorporation of the wearable devices such as activity trackers, sleep analyzers, and nutrition trackers, enhance patient's comprehensive wellness profile. Moreover, updating highly complex data visualization and user interface tools will also improve the patient and clinician's side experience.

Relations with health care organizations and governmental authorities are crucial to implement standards and requirements on the system. Last but not the least, performing large-scale, real-scenario testing and validation on different populations and in various healthcare facilities will be beneficial and will facilitate further improvements in the system for its scaling up.

### 7.3 Limitations

However, it is mandatory to note that there are some disadvantages regarding the developed and discussed novel real-time IoT-based health monitoring system to describe both the advantages and the disadvantages of utilizing this concept in practice.

**Dependency on Internet Connectivity:** This tends to depend on uninterrupted net connection for the transfer of data together with live cloud calculating for analysis. Quite simply, if the internet connection in the given Zone is either intermittent or poor, its ability to function adequately in the current scenario may be compromised, the end result of which means that participants have noticed slow response times when it comes to information exchange and analysis. This dependency becomes an issue especially for the regions that do not have internet connection in the rural areas or has limited one.

**Initial Deployment Costs:** There are some costs through which the system implementation is pricey for example it will be costly to acquire some sensors, microcontrollers and even any other hardware that is required. Huge sums of money may be required for the implementation of some of these initial step especially given the fact that amount of money available that can be spent in the healthcare facility may be constrained. Furthermore, the routine maintenance, similary the use and calibration of the sensors with time, is going to require hardware resources that maybe difficult to obtain within the certain environment.

**Sensor Accuracy and Calibration:** Thus for a given system, system reliability as well as the accuracy of measurement is governed by the sensors. The information about the health status that is collected by sensors depends on sensors' calibration, so if the calibration of the sensors is different it can affect the collected health information. Specificity of sensors' functioning defines the subject for constant calibration and service which can be rather costly.

**Data Privacy and Security:** But some amounts of risks have been incorporated through strong guidelines regulating data security and privacy in the sites; notwithstanding the continual move and storage of data in the cloud is viewed as perils.

The need to uphold the health information confidentiality, its non-use and disclosure by unauthorized persons makes the problem a continuous one and continuously evolving measures put in place.

Data Privacy and Security: However, while certain stringent measures have been taken with an aim of protecting the data collected, it is worth admitting that the continuous data transfer along with the use of cloud storage may become fatal for the system. Hence for continuous protection of sensitive health data from access from unauthorized persons and breaches, one needs to update the security measures permanently.

User Training and Adoption: Training needed in order to meet the required standard to both the health care givers as well as the end users is also needed. If these users are not trained properly, they will not maximize the use of this system or candidly misuse it in a wrong way to get wrong information. There were still difficulties in the implementation of the scale and in achieving the changes and usage among the various groups of users.

Scalability: Although the system can be integrated for intensive users as well as a large number of data points have been collected, it becomes complex to meet the performance requirements of a great number of users and huge amounts of data points at the same time. Thus, if the number of users increases, to keep up with the performance and reliability of the results provided, it will be necessary to improve and optimize the associated infrastructure systematically.

Integration with Existing Healthcare Systems: The use of IoT in heath care through health monitoring systems means that this system needs to interlink with other healthcare related structures and EHR systems. In some healthcare situations, compatibility problems and the requirement for standardized data forms may obstruct efficient integration, the system's usefulness in certain contexts may be restricted.

Ethical Considerations: However, the endeavor to accord ethical considerations a priority while implementing continual tracking creates the following concerns; First, though the goals of patient autonomy are honorable, their implementation spoils the very aptitude of the patient. It is crucial to maintain the patient's sovereignty over their data and to remember that the MS is intended to become an addition to the existing healthcare model.

All in all, the proposed by the health monitoring system such advantages and developments in the sphere of IoT technology, it is imperative to consider these aspects and overcome the aforementioned shortcomings for the successful implement of the system and its wide usage in practical contexts.

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# Appendix A

## Complex Engineering Problems (EP) and Complex Engineering Activities (EA) Analysis

**Title:** ADVANCED REAL-TIME IOT BASED HEALTH MONITORING SYSTEM

**Students ID:** 202-15-14419

### CO Description for FYDP

| CO | CO Descriptions | PO |
|---|---|---|
| **Phase -I** | | |
| **CO1** | Integrate recently gained and previously acquired knowledge to identify a plant classification problem for the Final Year Design Project (FYDP) | **PO1** |
| **CO2** | Analyze different aspects of the goals in designing a solution for this FYDP | **PO2** |
| **CO3** | Explore diverse problem domains through a literature review, delineate the issues, and establish this goals for the FYDP | **PO4** |
| **CO4** | Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the FYDP | **PO11** |

| Phase -II | | |
|---|---|---|
| **CO5** | Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP | **PO3** |
| **CO6** | Choose and apply appropriate methodologies, resources, and contemporary engineering and IT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP | **PO5** |
| **CO7** | Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding. | **PO6** |
| **CO8** | Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks. | **PO7** |
| **CO9** | Implement ethical principles and adhere to professional standards and norms in this FYDP | **PO8** |

| | | |
|---|---|---|
| **CO10** | Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP. | **PO9** |
| **CO11** | Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP. | **PO10** |
| **CO12** | Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors. | **PO12** |

**Addressing of COs, Knowledge Profile (K), and Attainment of Complex Engineering Problems (EP):**

| SN | EP Definition | Attainment | CO | Justification (with Knowledge Profile) | References |
|---|---|---|---|---|---|
| 1. | **EP1: Depth of Knowledge required** | Yes | CO1, CO2, CO3, CO5, CO6, CO7 and CO8 | My project requires Sensor and I have to know the design of a Internet of Things (IoT) which covers **K3 and K4.** | **Page no: 13-24** |
| | | | | My project requires different Electrical components and I have designed a prototype based on IoT which covers **K5 and K6.** | **Page no: 28-34** |
| | | | | My project requires **(K8)** through comprehensive Literature Review. In my project, I encountered challenges to collected medical data & patient. | **Page no: 06-12** |
| 2. | **EP2: Range of Conflicting Requirements** | Yes | CO2, and CO7 | In my project, I encountered challenges in collecting medical data & patients for the CEP,Ep-2. | **Page no: 25-34** |

| | | | | | |
|---|---|---|---|---|---|
| **3.** | **EP3: Depth of analysis r equired** | Yes | CO2, and CO6 | I my project I built a hardware and collecting data from human body, Normal Human and patients. Ep-3 | **Page no: 13-24** |
| **4.** | **EP4: Familiari ty of Issues** | Yes | CO8 | As part of my project, I visited a Hospital and met with a doctor. The purpose is to understand how I can measure the patient's<br><br>Health condition, and how I can collect data. | **Page no: 6-12** |
| **5.** | **EP6: Ext ends of stakehold ers involved and conflictin g requirem ents** | Yes | CO8 | In My project, I used a few sensors in one microcontroller. So, the sensor operating code must be changed. | **Page no: 25-34** |
| **6.** | **EP7: Interdepe ndence** | Yes | CO5 | My project comprises several subsystems that depend on each other. These include tasks such as collecting data, processing it, data storing, and data analysis. | **Page no:36-43** |
| **7.** | - | Yes | CO4 | I have prepared a budget to evaluate and estimate the cost required for our FYDP. | **Page no:**<br><br>**22-23** |

**Addressing CO11 with Complex Engineering Activities (EA) [Some or all of the following]:**

| SN | EA Definition | Attainment | CO | Justification | References |
|---|---|---|---|---|---|
| **1.** | **EA1: Range of resources** | **Yes** | **CO11** | In my project ,I indigirite **Sensor Integration:** The correct connection of the AX30105, AD8232 and MLX90614 sensors with the ESP32 microcontroller and reading the correct data with them. | **Page no: [13,14] Section: [3.2]** |
| **2.** | **EA2: Level of interaction** | **No** | | N/A | **N/A** |

| | | | | | |
|---|---|---|---|---|---|
| **3.** | **EA3: Innovation** | **Yes** | | In my project , I used ECG Sensor, body temperature sensor, BPM Sensor, Blood Oxygen level sensor indigirite in a same device. So, I make a device which is handy ECG device. I get all 6 types of data in a one circuit. | **Page no: [26-28] Section: [4.2]** |
| **4.** | **EA4: Consequences for society and the environment** | **Yes** | | My project contribution on the society is extreme effectful. The use of IoT technology in healthcare means there is an opportunity for the improvement or the most likely disruption of the health system so | **Page no: [44-45] Section: [6]** |

| | | | | | |
|---|---|---|---|---|---|
| | | | | the advancement of IoT technology should be wisely applied. Hence, while the facilities are relieved allowing their remote monitoring by the system, the resources will be concentrated with the individuals carrying a genuine need for such attention. It can be very beneficial in the rural and the other world regions where the refers to better health care facilities are rare. | |
| **5.** | **EA-5: Familiarity** | **Yes** | | This project expands upon existing research by exploring a novel approach to build a IoT- device. Through lot of sensors. And I Used also deep learning model. | **Page no:** **[35--42]** **Section:** **[5.2, 5.3]** |

**Addressing CO (4, 9, 10 and 12):**

| SN | COs | Attainment | Justification | References |
|---|---|---|---|---|
| **1** | **CO4** | Yes | This project addresses CO4 by integrating effective project management and financial oversight, purchasing sensor, cloud server space. | **Page no:** **[23-24]** **Section:** **[3.4]** |
| **2** | **CO9** | Yes | The project demonstrates adherence to ethical principles by prioritizing the privacy of Normal human personal data. I have obtaining necessary permissions for data collection, and transparently documenting the research process. | **Page no:** **[44-45]** **Section:** **[6.3]** |
| **3** | **CO10** | No | N/A | **N/A** |

| | | | | |
|---|---|---|---|---|
| **4** | **CO12** | Yes | The project's commitment to continuous learning and adaptation (CO12) within the evolving field Advanced real-time health monitoring system to making the hardware. This dedication showcases a proactive approach to staying informed and refining techniques to effectively address current challenges in medical research. | **Page no:** **[25-43]** **Section:** **[4,5]** |

## ADVANCED REAL-TIME IOT BASED HEALTH MONITORING SYSTEM

ORIGINALITY REPORT

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| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

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| 2 | dspace.daffodilvarsity.edu.bd:8080<br>Internet Source | 3% |
| 3 | Adari Ramesh, Ceeke Kalappagowda Subbaraya, Ravi Kumar Guralamata Krishnegowda. "A remote health monitoring framework for heart disease and diabetes prediction using advanced artificial intelligence model", Indonesian Journal of Electrical Engineering and Computer Science, 2023<br>Publication | 1% |
| 4 | Mostafa Haghi Kashani, Mona Madanipour, Mohammad Nikravan, Parvaneh Asghari, Ebrahim Mahdipour. "A systematic review of IoT in healthcare: Applications, techniques, and trends", Journal of Network and Computer Applications, 2021<br>Publication | <1% |