Health Monitoring IoT Device with Risk Prediction using Cloud Computing and Machine Learning

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A thesis submitted to the Department of Computer Science and Engineering
in partial fulfillment of the requirements for the degree of
B.Sc. in Computer Science and Engineering

Department of Computer Science and Engineering
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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

4. We have acknowledged all main sources of help.

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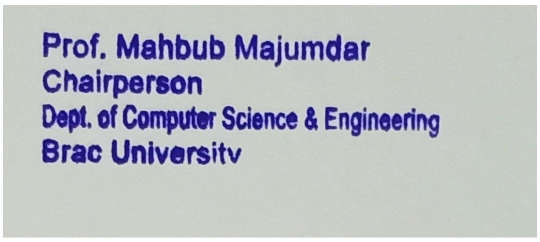

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Ethics Statement

The thesis is carried out in complete compliance with research ethics norms, and the codes and practices set by BRAC University. In our thesis, we use the data from primary sources. We collect data from different participants, and we use our own dataset for our thesis. We are ensuring we use references and in-text citations properly. We the four co-authors take full responsibility for the thesis code violations. For solving problems, we read different websites, YouTube tutorials, and Questionnaire Free tools. We also took help from our university faculty members. Finally, we declare that we give credit to every people from whom we took help. We did not make any fraud able means for completing the thesis. Our work is in compliance with the ethics standard set by BRAC University.

Abstract

Health issues often stay hidden due to not having regular health checkups. Sometimes these issues build-up to a significant health hazard which stays hidden until it's often too late. So we came up with a series of ideas that can deal with the above-stated problems and to some extent solve them. Our proposed device can actively check body vitals, send data through the cloud to designated doctors, and give patients notification of hazard from doctors. To carry out the above-stated solutions, we are designing an IoT device that interfaces multiple sensors to a microcomputer and sends the collected data to a cloud server for further manipulation which will be done by Machine Learning. After analysis, if the doctor feels there is any risk of health hazard to the patient, he/she can send in the notification of hazard through our proposed device.

Keywords: Health Issue; IoT; Cloud Server; Machine Learning

Dedication

We would like to dedicate this research work to our parents. Without their utmost support, we couldn't have achieved what we achieved. We also want to dedicate the research to our classmates and friends who helped us through thick and thin and motivated us to go forward. Our supervisor helped us co-ordinate works all throughout the year. And so lastly We want to dedicate this to him as well.

Acknowledgement

Firstly, all praise to the Great Almighty for whom our thesis have been completed without any major interruption.
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Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

AWS Amazon Web Services

$CRUD$ Create Read Update Delete

GUI Graphical User Interface

IoT Internet of Things

KNN K-Nearest Neighbour

ML Machine Learning

SVM Support Vector Machine

Chapter 1

Introduction

Health may be a full condition of physical, emotional and social health. There is a treatment to help us sustain the optimum level of wellness. The United States invested an additional 3.2 trillion dollars on health-care expenses in 2015. However, despite this spending, a U.S. survey published in 2013, the National Study Council observed that People in America die at an earlier age and have greater history with sickness and illness than other developing nation's people. Once we are talking about North America, the situation is way worse within Asia, Africa and other developing or underdeveloped countries. First, increasing rates of risk factors, particularly cholesterol levels and vital sign, tend to blame for a substantial portion of the time of life-related rise in chronic cardiovascular risk factors, in Asia alone.This thematic question illustrates the perspective of risk factor contributors to surplus coronary cardiovascular risk death rates in Asia-Pacific populations.

Indicators of risk of cardiovascular disease are usually taken through White Research. However, interactions in Asian and Western cultures with these conventional risk factors and the upset can vary. Also in Asian cultures the racial variations within the relationship between DM and ischemic cardiovascular disease are noted. In Asian nations, the incidence of overweight and obesity is growing as a consequence of economic growth, and, more specifically, the levels of diabetes are rising much higher. Particularly, a small rise in the index of body weight allows South Asians highly susceptible to insulin resistance and associated diseases. Therefore it has been proposed that smaller reference thresholds for body composition will be followed in Asian countries than in Western countries. Mean rates of total cholesterol in most Asian countries are smaller than those observed in Western nations, with smaller incidences of coronary cardiovascular disease. Throughout the Asia-Pacific region, it is projected that close to two thirds of heart conditions are attributed to cardiovascular disease, underlining the significance of raising blood pressure methodologies.

Latest reports suggest that there is strong proof throughout the Asia-Pacific area of the hazards of the upper vital sign at the slightest degree of cholesterol and of the hazards of upper cholesterol at the slightest degree of the vital sign as stated throughout the Western people. The heart attack may be a key reason for death and injury in most eastern Asian societies, and therefore the occurrence, especially of bleeding, is largely outside the Western community.The Eastern Heart attack and Coronary Artery Disorder Integrative Team of researchers investigated the impacts of vital sign as well as cholesterol concentration to the occurrence of stroke in East Asian populations and reported that vital sign is a core determinant of the probability of stroke, whereas cholesterol concentration is smaller and has an undue effect on the proportions of stroke sub types.

As illustrated by studies in the Asia-Pacific region, this thematic concern offers details on the relationship between health conditions and upset, and illustrates that modifiable factors that can affect heart disease.Secondly, only for Africa, WHO announces that Africa can never rise out of misery until its crippling health problems are resolved, the first African national health survey from the Globe Health Organization states[27]. It gives an insight into why Africa has such a significant burden of disease and premature death and suggests interventions that are known to figure within the regional context. Moreover, there are problems in diagnosing and treating cardiovascular disease in Africa, and they target only three entities: rheumatic cardiovascular disease, tuberculosis pericarditis, and cardiomyopathy. They ignore the hypertensive cardiovascular disease. Better health is vital to manage depression and to a stable and successful life. This is why we address this issue.

1.1 Motivation

With the emergence of advancement in science and technology, health care has been drastically developed. In spite of this massive advancement, we still unable to save lots of the lives of some people thanks to failing to predict emergencies, keeping diseases unchecked, irregular medical checkups. This work attempts to clarify the in-hospital diagnosis of patients hospitalized with possible severe heart failure, concentrating on predicting survival danger and significant emergency department complications. Throughout the emergency bed, 4690 were admitted from 7157 successive patients with discomfort or other signs suggesting acute myocardial infarction. For all, 246 (5 percent) died in surgery, with morbidity even amongst the 921 patients who formed 14 percent for myocardial infarction and three patients who had no infarction. Using multivariate logistic regression, individual predictors of mortality and mortality or other significant risk were calculated from the health background, diagnosis and electrocardiogram inside the emergency space. This included age, original degree of concern of infarction, electrocardiograph pattern, history of diabetes, history of congestive deficiency and admission arrhythmia, loss of coordination, abrupt congestive failure or unexplained indications. These analyzes can assess the likelihood of disease or death, or some big issue. Therefore, 18 percent of injured patients experienced a serious injury or died in hospital owing to presumed acute myocardial irregular heartbeat. Increasing certain patient's in-hospital prognosis may be estimated from a mathematical model.

A study reveals, neglected tropical diseases (NTDs) are an significant cause for Africa's death and injury. This research reports the amount of human loss of lives throughout the continent in 2015 due to NTDs. The total amount of 67 860 human lives wasted owing to NTDs in 2015 was 5,112,472,607 dollars. Class 1 bore 14.6 percentage points, Class 2 57.7 percentage points and Class 3 countries 27.7 percentage points. The average of potential life lost per NTD death for Group 1, Group 2 and Group 3 nations was 231,278 dollars, 109 771 dollars and 37,489 dollars, respectively.

The total amount of human lives lost by NTDs in 2015 was adored 0.1 per cent of the 53 continental African countries 'combined gross domestic product. Although NTDs are not a severe cause of mortality, they have a negative effect on the health of those impacted over the course of their lives. Thus, the rationale for investment in management of NTDs can also be informed by the importance of NTD morbidity, the provision of appropriate donated drugs, human rights concerns and the need to meet by 2030 the international organisation Sustainable Development Target 3 (on health)'s NTD-related objective 3.3.

1.2 Problem Statement

Health conditions also remain concealed because of the lack of daily health checkups. Sometimes these problems build up to a considerable health hazard that remains hidden until it is often too late. In addition, crises can't be accurately anticipated in due time. So we have come up with a set of ideas that can answer and to some degree solve the above-mentioned problems.

Firstly, to the majority of us, the prospect of a massive doctor's payment is overwhelming. When you decide to will healthcare expenses, it can be essential for you to plan a daily health test. These regular checks guarantee you allow long-term savings. That is because routine wellness check-ups reduce the possibility of possible wellness-related diseases that may be harmful. This will also serve to reduce the complications involved with undertaking surgery and certain significant medical costs in some situations.

Secondly, routine medical check-ups enable physicians to detect an illness until it spreads to a larger degree. These tests are conducted based on age, race, background, and lifestyle choices made by a patient. The doctors will advise the patient on various testing and medical measures to better diagnose the harm. Such tests that initially detect diseases, making it easier to treat them.

Third, a specialist might even be telling you to perform a blood check for a routine safety examination. They was undertaken to minimize the possibility of illnesses that may occur in the plasma. That involve obesity, asthma, cancer, hypertension, anaemia, and coronary artery diseases. Blood tests often enable doctors to help assess the operation of various body functions, such as liver, kidneys, heart and thyroid.

Moreover, we live in an incredibly fast-moving environment of lifestyles and hectic job schedules. This will set off a number of stress-bearing illnesses in the human body. Increases in anxiety and discomfort have been found to be directly related to a number of various physical and psychological conditions including elevated blood pressure, obesity, weight gain, mental illnesses, Alzheimer's, depression, asthma, and bowel issues. Daily medical check-ups mean that conditions are more quickly identified and recognized until they are too serious. Daily check-ups will guarantee you receive your doctor's guidance and encouragement to help keep away from the ills of a high-stress lifestyle[7].

Lastly, Our findings of the test should inform your doctor what they need to know about your well being. Depending on them, they will inform you and/or educate you about how to better protect your safety. One basic explanation is how frequently people neglect their dental hygiene. This can very quickly worsen and trigger complications at a later point. Simple improvements in lifestyle may be addressed if detected at an early stage issue. In the other side, if the disease is identified at an even advanced stage, treating it becomes incredibly difficult and may also be a huge financial strain on the patient. Regular check-ups are a great way to have an eye on what you can do to boost your health and that the risk of being sick

1.3 Objectives and Contributions

To resolve this above problem, we've got come up with a group of ideas that may answer and somehow solve the above-mentioned problems. Our proposed system will continuously monitor body vitals, send data to approved doctors via the net, and alert doctors and patients about the threat.

In order to implement the above-mentioned solutions, we are developing an IoT system that interfaces multiple sensors to a microcomputer and sends the information collected to a cloud server for further handling. The statistical data sets within the cloud may be sent for judgment and consultation to approved doctors at regular intervals. After review, if the doctor thinks the patient is at any risk of health danger, he/she will be able to submit danger warning via our proposed app. the information sets are compared to reference data sets within the cloud, and if any major anomalies are found, the appointed doctor is straight away informed and a replica of the irregularity is distributed.

With relevance to your patients, it should be mentioned that smart health monitoring systems reduce interval and period of time. This also offers aided and rapid treatment, while increasing raising the risk for hospitalization. With this device, a patient will know what actions to require when it involves a particular condition. After all, it ends up in better adherence to the medication schedule.

It is great for doctors, and also the very first thing that ought to be mentioned is that it allows for straightforward, continuous monitoring. It's crucial, especially for hospitals with plenty of patients, because a doctor will have data from all of them on the screen. It helps in balancing out the workload and time, resulting in a more organized workday.

Since this can be a device with exact stats readings, it also ends up in far better utilization of medical resources.

1.4 Thesis orientation

Chapter 1 - Introduction where motivation, problem statement, objectives and contribution are discussed.

Chapter 2 - Related works where background and literature review are discussed. In the literature review part, we reviewed the previous work on Health Monitoring.

Chapter 3 - Our Proposed Approach, here we discussed our methodology to create the device, run the machine learning algorithms, store data in the cloud, real-time implementation, and patient-doctor interface through GUI.

Chapter 4 – Includes the device description in details.

Chapter 5 - Includes the description where we discussed our dataset in details.

Chapter 6 - Algorithms where we discussed the algorithms used in our work.

Chapter 7 - Data preparation and deployment of the machine learning model on the Cloud platform.

Chapter 8 – Includes the Graphical User Interface in details.

Chapter 9 – Includes the Result Analysis in details.

Chapter 10 - Conclusion and Future works where the conclusion consists of our work till now and future works include the scope of improvement.

Chapter 2

Related Work

We divided related work into background and literature review.

2.1 Background

System safety surveillance may be a series of tasks performed to take care of a device in the operable condition which could be restricted to evaluating the current state of the network, with these findings triggering inspection which repair. For the Integrated System Safety Management (ISHM) program, several sensors are needed to provide real-time, on-board structural integrity assessments[16]. This chapter evaluates network health monitoring sensor technology, constructs a selection model for sensor optimization to pick the least detailed, cost-effective sensor subset, and creates an energy-efficient automated detection method that supports the selective sensor paradigm.

Rapid developments in hospital technology and low-cost cellular connectivity have helped tackle the problem of less patient services a great deal in the past decade. The combination of mobile interactions with smart devices has encouraged the transition of healthcare facilities from clinic-centered to patient-centered and is referred to in the documentation as "Telemedicine". Well into the wider sense, telemedicine is mainly of two categories: (1) direct communication form, where doctor and patient involvement is needed with specific requirements of good accessibility and reasonable processing power; and (2) documentation with forward sorting, which includes the recovery of clinical parameters such as symptoms, images, recordings and data transmission to the healthcare specialist in.

Telemedicine was introduced to allow treatment of patients with coronary failure, asthma, hypo tension, obesity, hyperthermia and hypothermia, according to current scientific studies. The most significant application is to diagnose chronic diseases such as cardiopulmonary disorder, asthma and respiratory collapse of patients of live time by means of remote surveillance systems away from primary care facilities. Heart disorders have been one of the major causes of human deaths worldwide; as an example, about 2,8 million people die annually as a consequence of becoming obese or overweight as overweight may contribute to adverse cardiovascular effects on vital sign and cholesterol that eventually increase the risk of coronary cardiovascular disease, ischemic stroke, diabetes and a number of specific cancers. Cardiovascular disease rates are projected to increase worldwide to 23.3 per cent by 2030, according to WHO[27]. To order to control hazard, management of these chronic diseases needs constant as well as long-run surveillance.

The universal internet networking is also used for online control and offsite diagnosis of telemedicine. It should be noted that smartphone phones represent more than 94 per cent of the world's people, i.e. 6.8 billion men, and just 2.7 billion Internet connections represent available. Telephone subscribers are increasingly growing and will hit 8.5 billion by the end of 2016 with 70 per cent of mobile consumers from developing nations. In addition, smartphone technology includes a number of services such as location tracking, short message service and WLAN / GPRS/3 G connection which provides omnipresent compatibility. Comprehensive research on the usage of cell phones in healthcare and medical procedures demonstrate the importance of built-in smartphone apps such as GPS and placement-enabled systems to have vulnerable adult patient autonomous survival. Current publications have often highlighted the uses of built-in devices in continuous monitoring and record keeping; as an illustration, in another article, the authors discussed the advantages of existing mobile health apps in terms of their efficiency for continuous data processing, flexibility, functionality and electricity consumption. Nonetheless, inconsistencies such as power source, configuration, and fake alarm production have threatened the strengths of mobile devices in real-time health tracking and diagnosis application.

Wearable devices are an alternative to built-in mobile devices that are used for constant video control, recording and transmitting patient data to healthcare professionals[8]. In fields such as physiological, biochemical, and motion detection, current wearable device applications include monitoring. Such devices are used for tracking patients 'health indicators and postures, as well as keeping track of sports and other events. Thanks to the very fact that these sensors are cheap, easily obtainable, easy to implement, computationally efficient, these wearable sensors are becoming promising. Several studies explore the clinical applications of wearable sensors in cardiac, psychological, asthma, and high blood pressure disorders; as an example, a device for tracking congestive heart failure in patients was created, containing a biosensor inside the form of a hoop measuring heart details. Similarly, instruments are designed to identify respiratory problems and collect auditory signals by inserting a microphone on the neck while breathing. The system consisted of a band-pass filter to cut back noise and other signal artifacts that helped to obtain roughly 90 percent precision of the measurements. Further that experimental analysis was extended with formulas to model apneas. Additionally, wearable devices is helpful in solving the tracking problems in motion objects by the use of several sensors mounted on one device. Another fair use is the combination of multiple sensors on the same device (tight fitting) to monitor respiratory diseases. These systems are found to be stronger than spirometers, but they require improvements to rising artifacts of motion.

The current research discusses the challenge of utilizing mobile devices to incorporate a wearable sensor by designing a remote monitoring device for cardiac patients. Like for the latest control systems, the device built has two implementations, one for patients and the other for physicians.

2.2 Literature Review

Before the network of Information existed, the contact between doctors and patients was just by appointments, emails, and telecommunications. There were no forms in which physicians might constantly be monitoring their patients and offering recommendations appropriately. The development of IoT in healthcare, however, has modified the situation considerably. Firstly, it's empowered doctors to deliver superlative care by remotely monitoring the patients using IoT enabled devices. Moreover, IoT has also increased the speed of satisfaction and engagement of patients, as interacting with doctors has become far more comfortable and efficient. Lastly, IoT has unarguably transformed the healthcare industry and is very beneficial for doctors, patients, families, hospitals, and even insurance companies. With the assistance of healthcare mobility solutions, next-gen healthcare facilities, and other similar technologies, IoT can easily automate the workflow of patient care.

It can enable the machine to machine communication, interoperability, data movement, and knowledge exchange that enables the healthcare industry to deliver efficiency[14].

Moreover, technology-driven solutions can even detach the additional costs by removing unnecessary visits, utilizing the higher quality of resources, and improving the look and allocation. Imagine if something could help doctors by telling them when a patient's vital sign goes haywire or if he isn't taking excellent care of his health and send that information to doctors while they're working? IoT can help during this by updating personal data of the patients on the cloud and eliminating the necessity of adding the data into the EMRs, IoT makes sure that each little detail is additionally being considered to form better decisions for the patients.

Furthermore, this may even be used as a medical adherence likewise as a home monitoring tool. During this manner, IoT Is Transforming Human Life[13]. Real-time tracking with the aid of mobile apps can save the lives of many patients in medical incidents such as cardiac attacks, asthma attacks and diabetes, etc[17]. Through real-time surveillance via a digital medical system attached to a smartphone application, IoT systems can gather all health-related data and move the machine through the information link[5]. Likewise, the IoT app can capture health data such as heat, glucose rates, oxygen, weight and even ECGs as the switch. These data will be stored within the clouds and may easily be transferred to the concerned person like physicians, your underwriter, or the other external consultants.[3] And this may allow them to understand the condition during a better and faster way.

The contribution of IoT devices within the health caring sector has been immensely noticeable. Active detection of the frame vitals and emergency response can motivate an epoch-making change within the health care sector.[9] Within the market, there are already many personal health monitoring systems (PMS) within the sort of glucometer, digital thermometers, digital pressure machines, wrist wearable, etc. Our objective is to pair up different PMS devices within the sort of sensors to an

IoT micro-controller and take readings simultaneously and process and manipulate the collected data during a cloud-based system[4].

Chapter 3

Our Proposed Approach

3.1 System Model

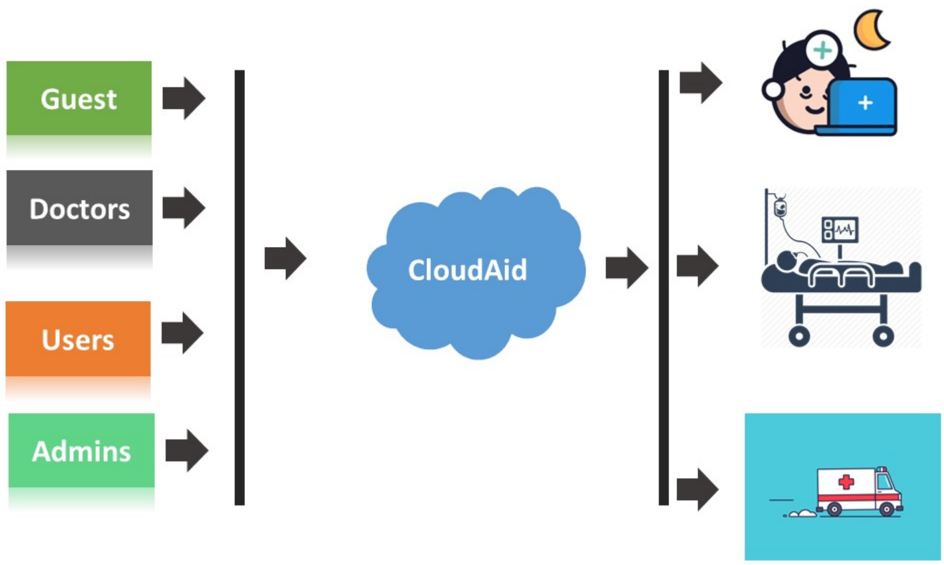

Figure 3.1: Workflow of the System

The system we have proposed in this paper is in all in one system that connects patients with doctors and keeps track of their body vitals. We have two sets of users, patients and doctors. At the patient's end, we have our device which takes inputs of body vitals such as temperatures, blood oxygen level, electrocardiogram, etc. from the patient's body and sends it to our cloud server. On the other hand, doctors can view the patient's records and give comments related to the reports at his end of the web-based interface.

The main processing of data is done on our cloud. As we have two different types of dataset, namely body vital dataset and electrocardiogram dataset, we are using two different models to train and develop a prediction model[1]. Firstly, we are using Support Vector Machines (SVM) for developing a prediction model of our body vital dataset. This processing is further discussed in chapter 6.2. This prediction based model detects trends in the dataset and generates a prediction based on inputs from the device and displays it on our web-based interfaces of both patients and doctors[15]. Secondly, to develop a prediction model for our electrocardiogram input, we selected Convolutional Neural Networks (CNN). Here we train our electrocardiogram dataset using this model and develop a prediction mechanism which is discussed in detail in chapter 6.3. This mechanism, when inserted into our cloud, generates a prediction in intervals when it receives ECG data from the device.

Our system provides a systematic approach integrating IoT, machine learning and cloud computing to solve the major issues of active health monitoring and reduces the gap between doctors and patients which in turn leads to better healthcare services for mass people[12].

3.2 Work Flow Diagram

The flow chart below shows the workflow of our proposed system and illustrates how we deal with the major problem of active health monitoring. The workflow of our proposed system is showed chronologically in the above diagram. It starts with a push of a button which starts our device and system. Our device is set with a specific interval at which it reads body vitals and electrocardiogram from the user and sends it to our cloud. The processing of these input readings is done in our cloud and is sent to both patient and doctors panel according to their specification. The doctors, after looking at the prediction, can provide medical suggestions to the patients through our web-based interfaces and on the other hand, patients can ask questions to their doctors through our website. To this, designated doctors can provide answers and feedback to the patient's panel, and the patients can view their past records and doctors suggestions in an arranged manner. In the end, there is an option of logging out to end all the processes[11] [10].

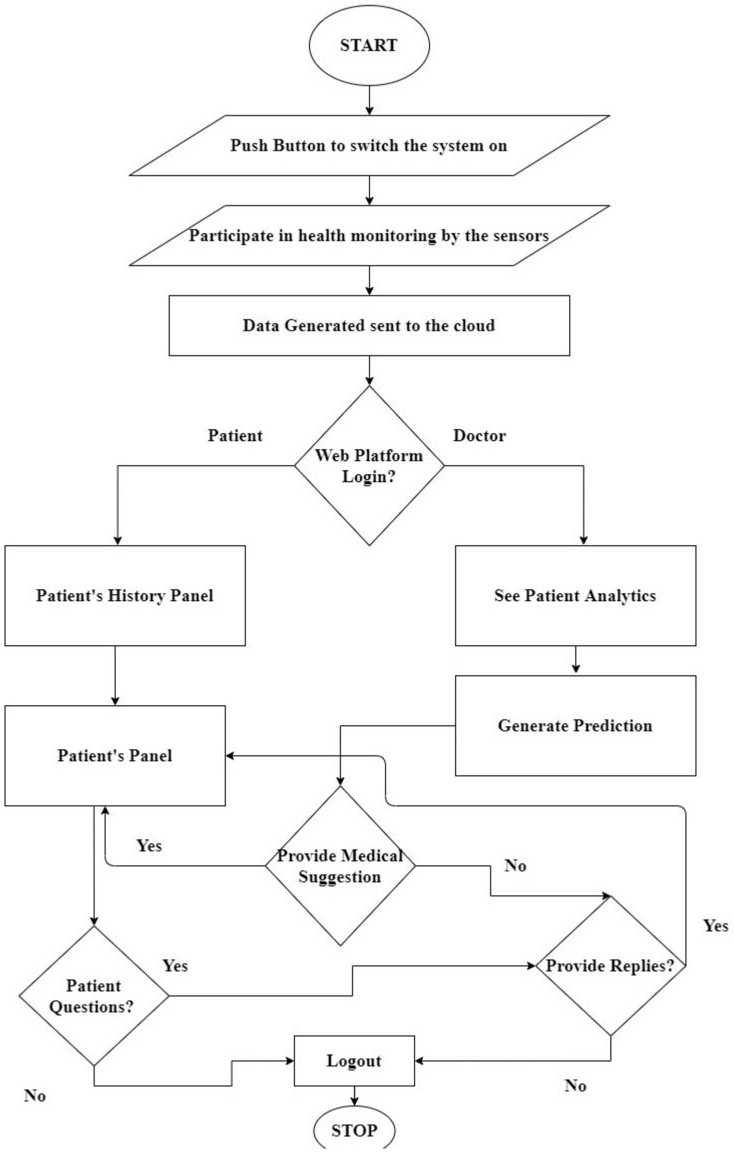

Figure 3.2: Flow chart of our proposed system.

Chapter 4

Device Description

4.1 Introduction

The health monitoring system we developed was based on the idea of making it portable and with multiple sensor reading and making the data generated to be sent to a remote location where it can be processed for the prediction. It was only possible by making the device an IoT device. The microprocessor we used has a built-in Wi-Fi module which deals with transferring data to the cloud. We soldered the device on to a board where all the sensors are available for use. Just by turning on the device and with very simple instructions, the device can be used with ease. The sole purpose of this developing this device so that it can save as many lives possible. So the whole system was developed with low-cost equipment and sensors but at the same time making sure it serves the purpose well.

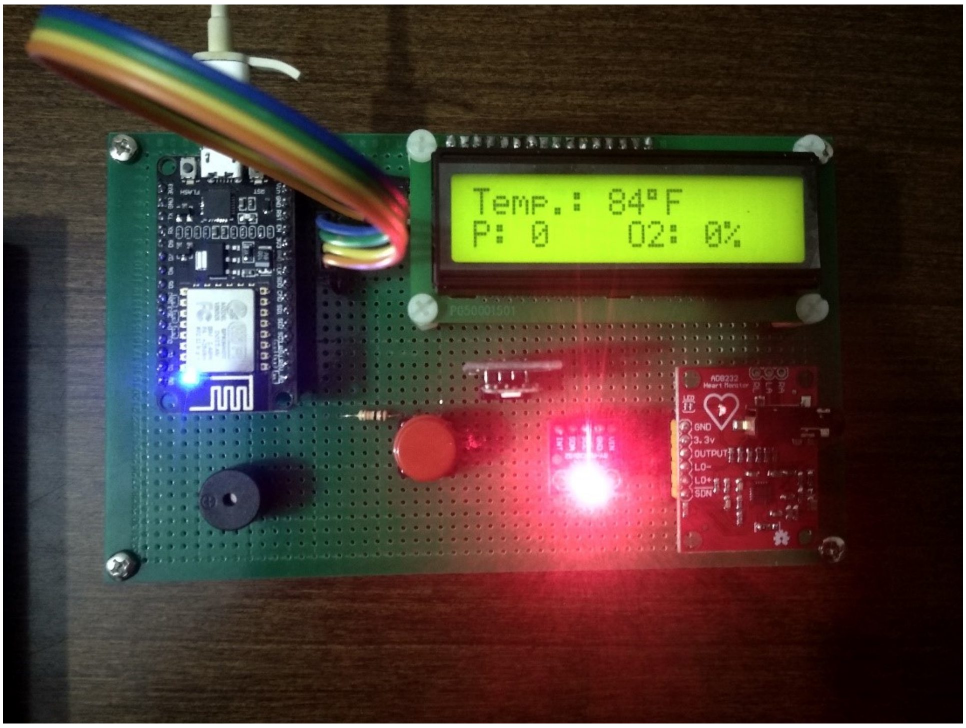

Figure 4.1: Health Monitoring IoT Device

4.2 Microprocessor

As for the microprocessor we've used the NodeMCU developed by the ESP8266 open source community. NodeMCU is an open-source firmware for which open-source prototyping board plans are accessible[18]. The name is basically the sum total of the nodes along with the micro-processing or controller unit which is the MCU. The expression of this micro-processing unit relates to the actual definations instead of the kits that come which are basically advanced level. All of these editions of board definations and the arrangement or the blueprint of the board are open for all for using.

The defined microcode utilizes a series of script languages also known as the lua. The microcodes are actually depending on a particular company, eLua. The users need to take into account that these definations and microcodes needs to decide on building their own system setup depending on and fulfilling their outcome requirements. There are codes that open and it is quite a wide range to choose form and customize according to the requirements for our partical health monitor system.

The unit has a port directly installing or sending codes that are Java based Arduino microcodes. There are non-analog setup pins for setting up the array of sensors and other equipments along with it. We have taken a similar approach and added multiple monitoring health sensors to get readings. The already included Wi-Fi component will allow an easy handshake between the device and the cloud platform for further computing.

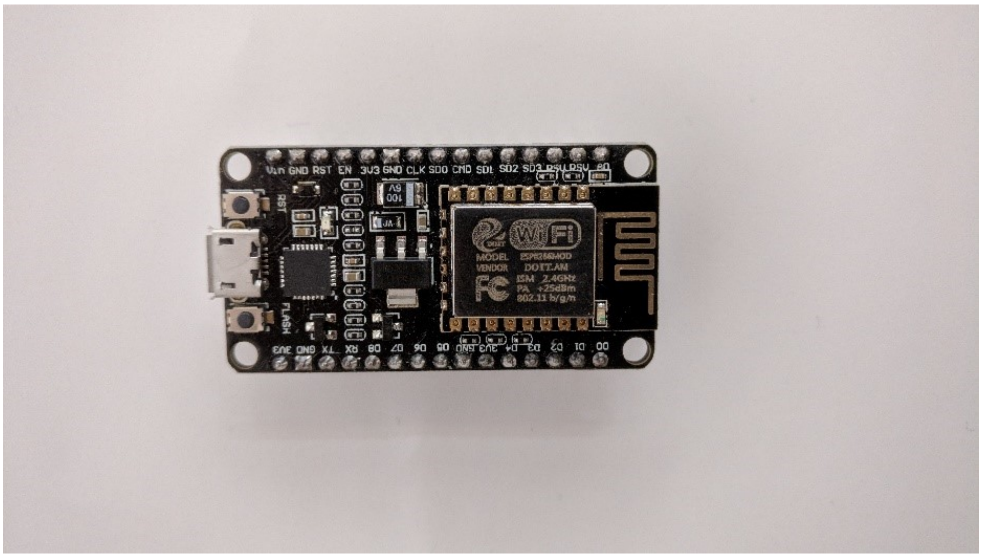

Figure 4.2: NodeMCU ESP8266

4.3 Sensors

We've integrated a total of 4 sensors to for detecting the health data we need from the patients. The list of the following sensors are given below:

- Pulse Measurement Sensor AD-8232
- Sensing Pads for Electrocardiography
- Very precise Oxygen level measure sensor MAX-30102
- DHT11 Basic Temperature with Humidity measure

4.3.1 AD8232 Heart Rate Monitor

To know the proper functioning of the heart the most easy way is to get to the know is to observe the pulses generated by the heart. This sensor is great tool to detect the electro changes of the intervals of the human heart. The measured data can be depicted in to the form of the electro cardiogram reports that we get generally from hospitals. It will the help of electro activity sensing pads installed on the body can see the rush of electric changes in the body because of the heart pulse. The fluctuations observed in volts is the resultant outcome of this detector.It is a very good tool to make the estimation we need for our analysis.The AD8232 could be a coordinated sign moulding obstruct for ECG and other bio potential estimation applications[20].

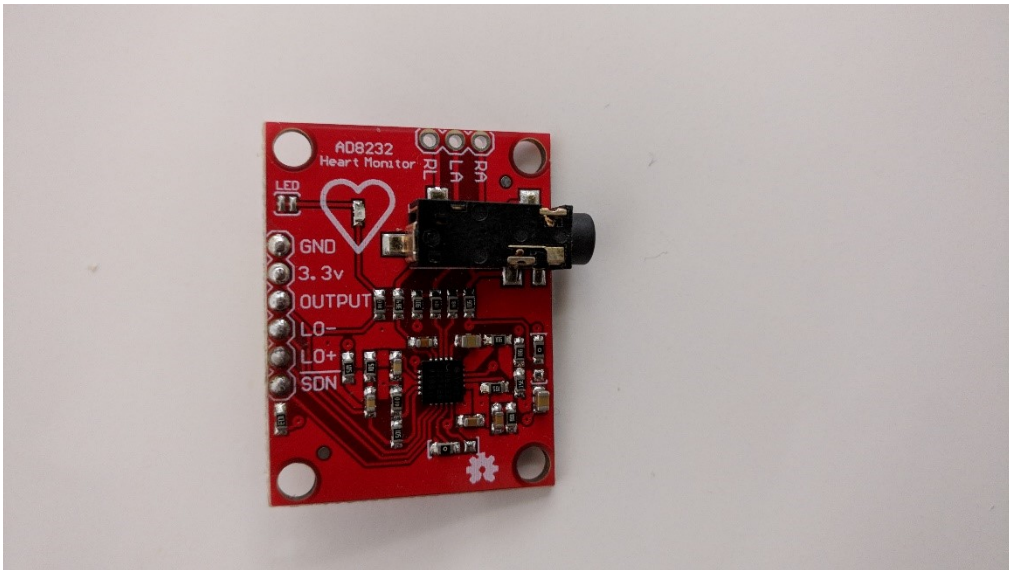

Figure 4.3: AD8232 Heart Rate Sensor

4.3.2 ECG Sensor Pads

These sensors connected with the AD8232 Sensors detect the electrical activity of the human heart. Generally, these 3 pads are connected to 3 different parts of the body. The parts of the body are wrists on both the right, left hands and finally the thigh on the right side of the leg.

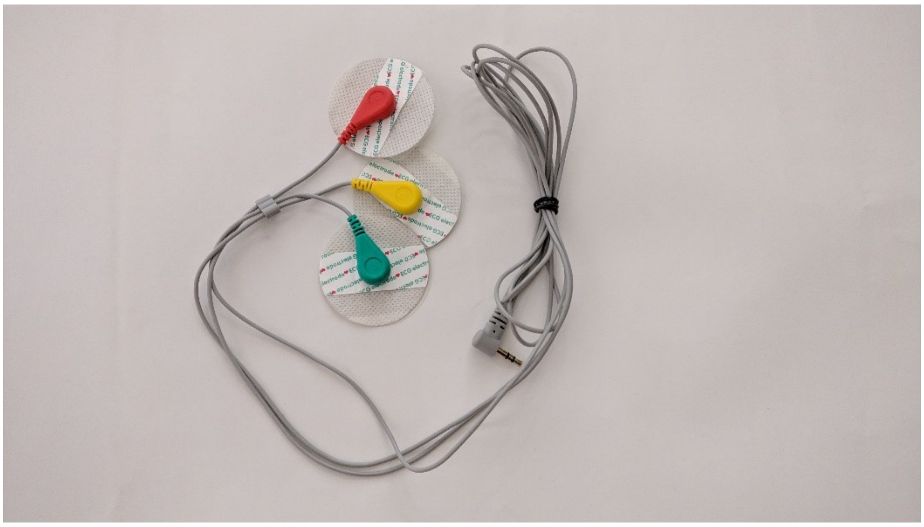

Figure 4.4: ECG Sensor Pads

4.3.3 MAX30102 High-Sensitivity Pulse Oximeter

The measure component provides the best of both worlds for measure of the oxygen meter of the running human blood alongside the actual rate the human heart is pumping out the blood. This thing has brought about a huge dimension in building our whole system as a result its portability and accurate precised results expedited our work. Since it being a very sensitive sensor it can be turned on and off by a push button to maintain the fact it does not give our wrong results when not in use. It contains generally a red led to send light and receive the data from the patient's fingers and these are powered by a 3.3v supply. The device itself can run on a mere 1.8 voltage power. It is made sure a correspondence of about a pefect I2C standard interface.[25]

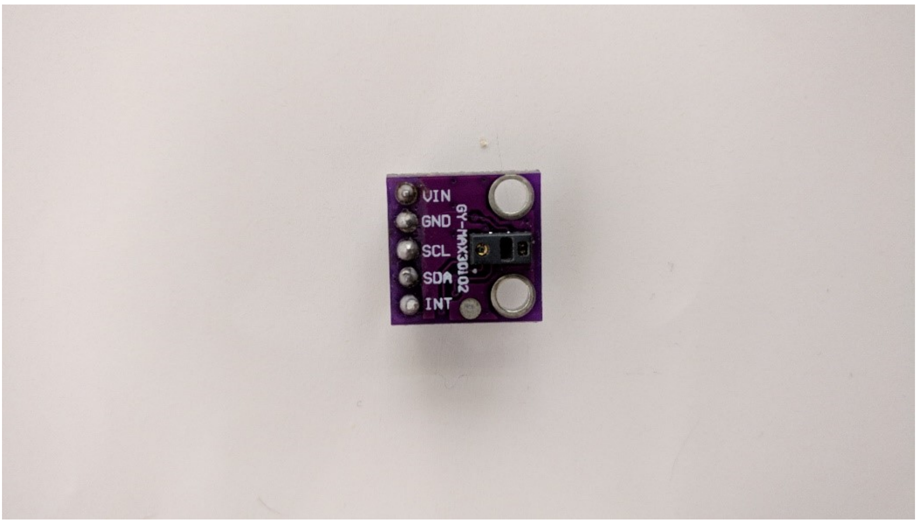

Figure 4.5: MAX30102

4.3.4 DHT11 Basic Temperature and Humidity Sensor

A very cost-effective temperature sensor has a power radius of 3v to 5v. It is a very good sensor in case of reading temperature values from 0-50 degrees Centigrade (C) which is a perfect range for detecting human body temperature changes.

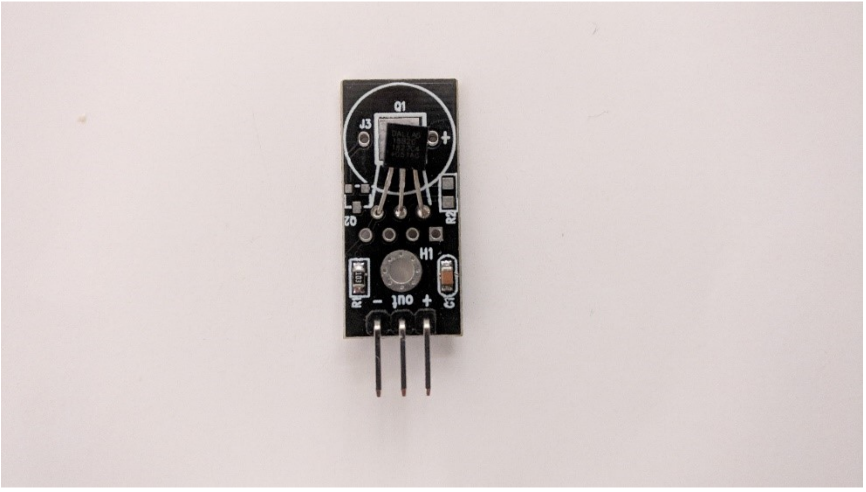

Figure 4.6: DHT11 Sensor

4.4 Circuit Layout

We've used a PCB board to mount the whole devices consisting of an array of sensors, the microprocessor, extended parts etc. Among the other equipment includes a 16x2 LCD Display a buzzer or alarm and a push-button for circuit activation and deactivation.

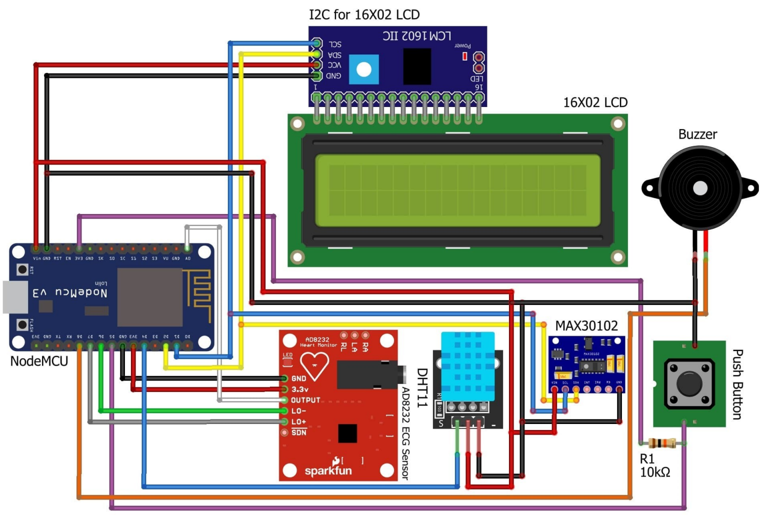

Figure 4.7: Circuit Diagram of Health Monitoring IoT Device

4.5 Data Generation

Data generated from the device is the most important factor for the whole risk prediction analysis. Multiple sensors take body vital readings with some very easy approaches. The LCD on top of the device shows the immediate readings from the patient. The monitor shows the readings of the body temperature, blood oxygen level and the pulse rate.

The pulse rate is received by placing the patient's finger on the red LED of the MAX30102 sensor. Now for the checking the ECG, the sensor pads are connected

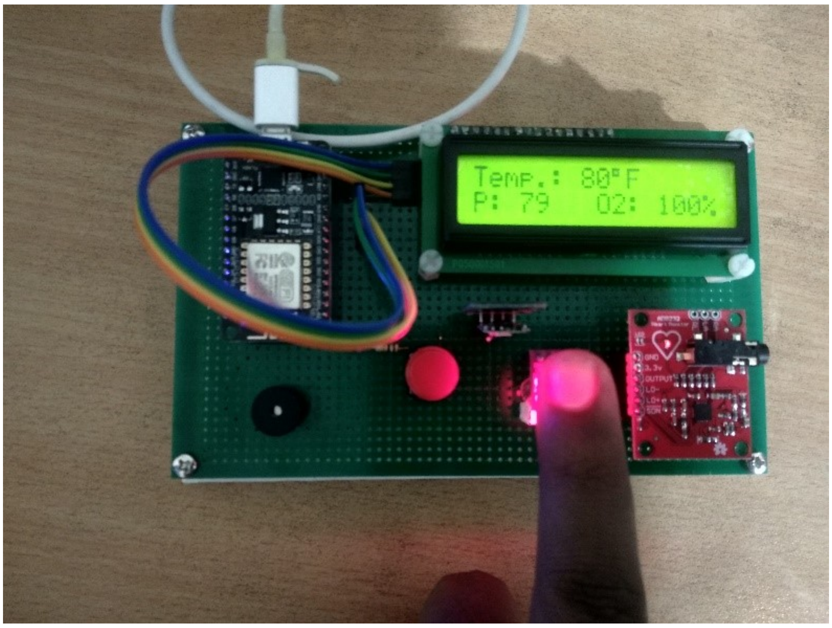

Figure 4.8: Pulse rate and blood oxygen checking

with the AD8232 sensor and the pads are connected to the body parts as shown in the image. The sensors generate an electrical signal, as shown in the serial monitor or Arduino. Finally, the temperature reading is taken from the DHT11 sensor, which is placed on an extension cord to be taken to a specific area of the body.

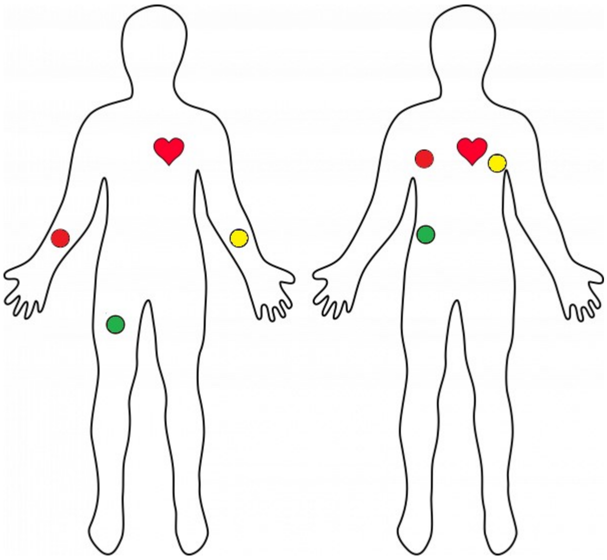

Figure 4.9: Sensor Pad Positioning

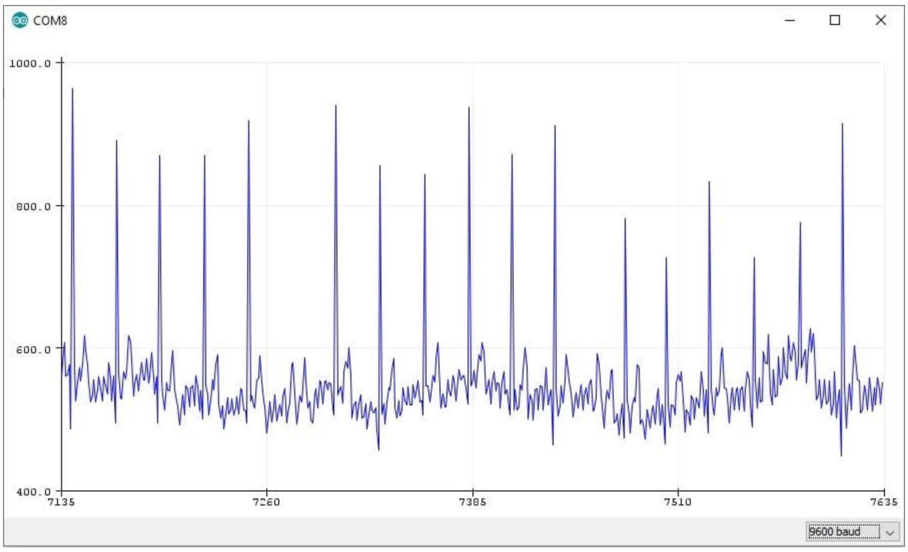

Figure 4.10: ECG Signal on Serial Monitor

Chapter 5

Dataset Description

5.1 Dataset Collection

We have collected our data set from surveying different well-known health diagnostic centres in Dhaka City. We initially enquired these centres whether we can provide data from them or not. They informed us in the affirmative and suggested us to provide them with a written document mentioning the requirements. We then discussed the issue with our thesis supervisor, and he provided us with a written application with his signature and our university's approval. We were able to get the required data after the submission and the diagnostic centre manager's approval.

The primary source of these data was the doctor's prescription of the patients, along with the patient's database information. Taking permission from the doctors as well as the patients, we took images of the prescriptions where we could find our required information. Since it was quite a cumbersome process of collecting data, we also took a different approach and opened up a Google doc and collected some experimental data. The whole data collection process took place by this formal agreement between us and the diagnostic centre authorities.

5.2 Dataset Compilation

Upon the completion of data collection, we converted the units of the data to a single standard unit of measure for keeping the integrity. The main data set was compiled into a .csv file by manual inputs of data received during the survey process. We had collected a total of 650 sets of numerical data, but we could properly compile and prepare a total of 500 sets of data for our analysis. A total of 500 rows and 8 columns of data was compiled. Along with that, we collected numerous sets E.C.G (Electrocardiogram) reports for low to high-risk patients, and we segregated them into classes of risk. We scanned the reports and extracted the images out of them. We used jpg formatting of the images.

5.3 Dataset Information

The numerical dataset contains a column of patient's health information as average pulse rate of the heart, the pure oxygen level of the blood, average body temperature for a period of time, their gender, age, height and weight. The last column of the dataset contains the decision factor giving the resultant health risk from a range of low to high. The E.C.G images are the depiction of the electrical activity of the

Sl	Column Name	Description
1	Heart Rate	BPM (Bits per minute)
2	Blood Oxygen	Level of oxygen present out of 100, i.e. (in percentage)
3	Body Temperature	Average body temperature in F (Fahrenheit)
4	Sex	Distinguished by (1) as Male (2) as Female
5	Age	Number as Years old
6	Weight	Calculated in Pounds (lbs)
7	Height	Broken down in Inches
8	Risk Factor	(High Risk 2 – Low Risk 1 – No Risk 0)

Table 5.1: Numerical Dataset Description

human heart. These are a piece of very important information for the detection of related heart diseases and anomalies as like: arrhythmia, pericarditis, myocarditis, coronary occlusion etc. The data is a graphical representation of changes of voltages. Along the x-axes, we have our voltages, and along the y-axes, we have our time period. The figure below is a basic example of our collected image data. There are waves and complexes that determine the characteristics of a single ECG signal. The waves of the electrocardiogram includes are the P, T, Q, S, R. On the other hand, the intervals and segments include PR , QT alongside the last Q.R.S and segments include ST alongside the last part of the report segment ie. PR.

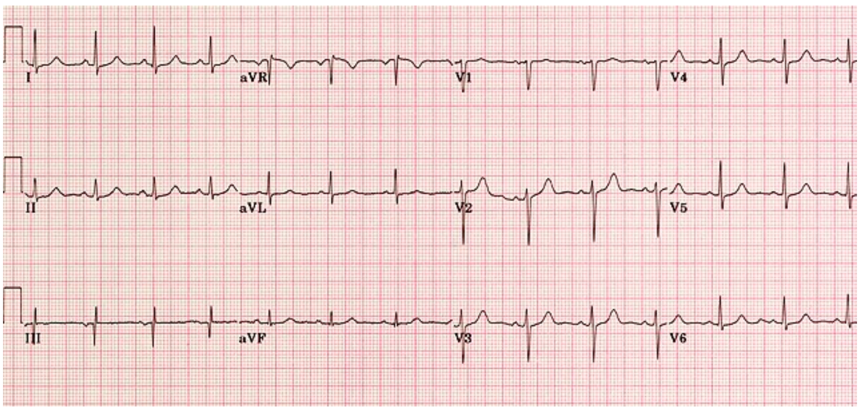

Figure 5.1: An E.C.G. report image.[23]

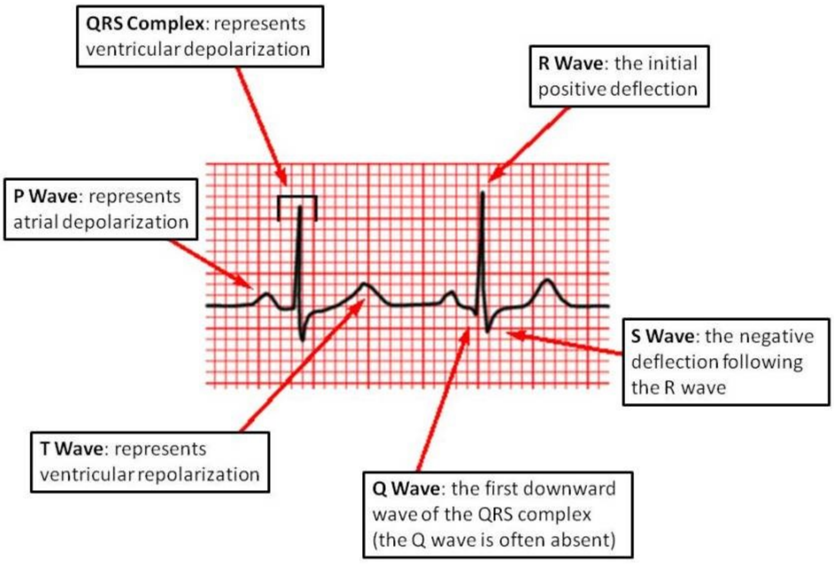

Figure 5.2: Waves and Complexes[22]

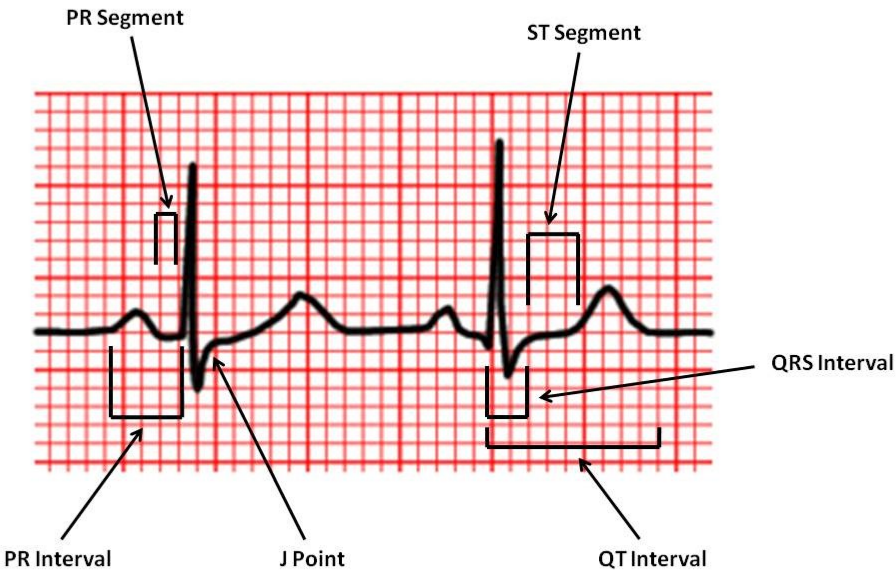

Figure 5.3: Intervals and Segments[30]

Column Name	Description
Human Overall Pulse Values	70-100 Bits per minute
Interval of PR	In between the range of 0.12 to 0.20 seconds
Interval of QRS	Less than or equals to 0.12 s
Intervals for QT	male and female less than 0.40 and 0.45s
Amplitude of P	Less than or equals to 3milli volts
Negative Deflection of P	Less than or equals to 1milli volts
Wave value for Q	Less than 0.04 seconds

Table 5.2: Normal values of ECG images [24]

Chapter 6

Algorithm

We have divided our algorithm into 2 segments. First of all, we selected our vital body dataset, and we have implemented the algorithm over it. Then we have analyzed the data using the SVM model and found the distribution of values. This enabled us to obtain a prediction mechanism to predict malicious body vital readings. Secondly, we have used the CNN model to build the prediction mechanism for our electrocardiogram dataset.

6.1 Data visualization

The following diagrams illustrate the various trends in the different classes in our datasets.

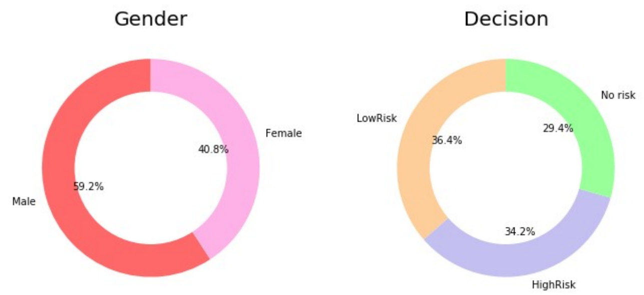

Figure 6.1: Pie chart showing distribution among genders and decision.

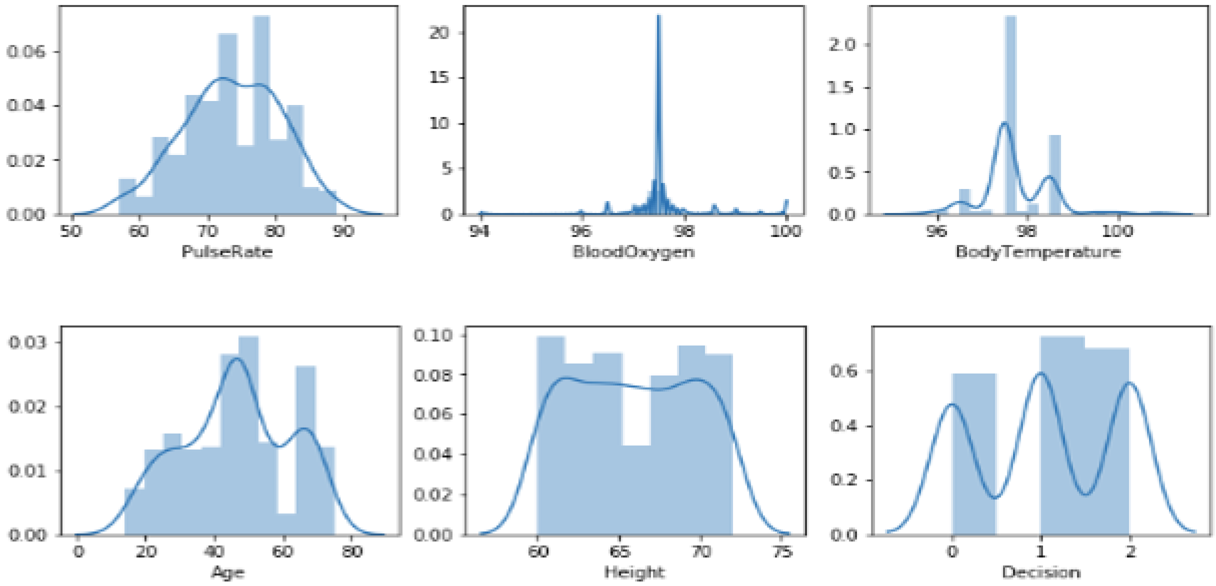

Figure 6.2: Histograms for the distribution of data in different groups

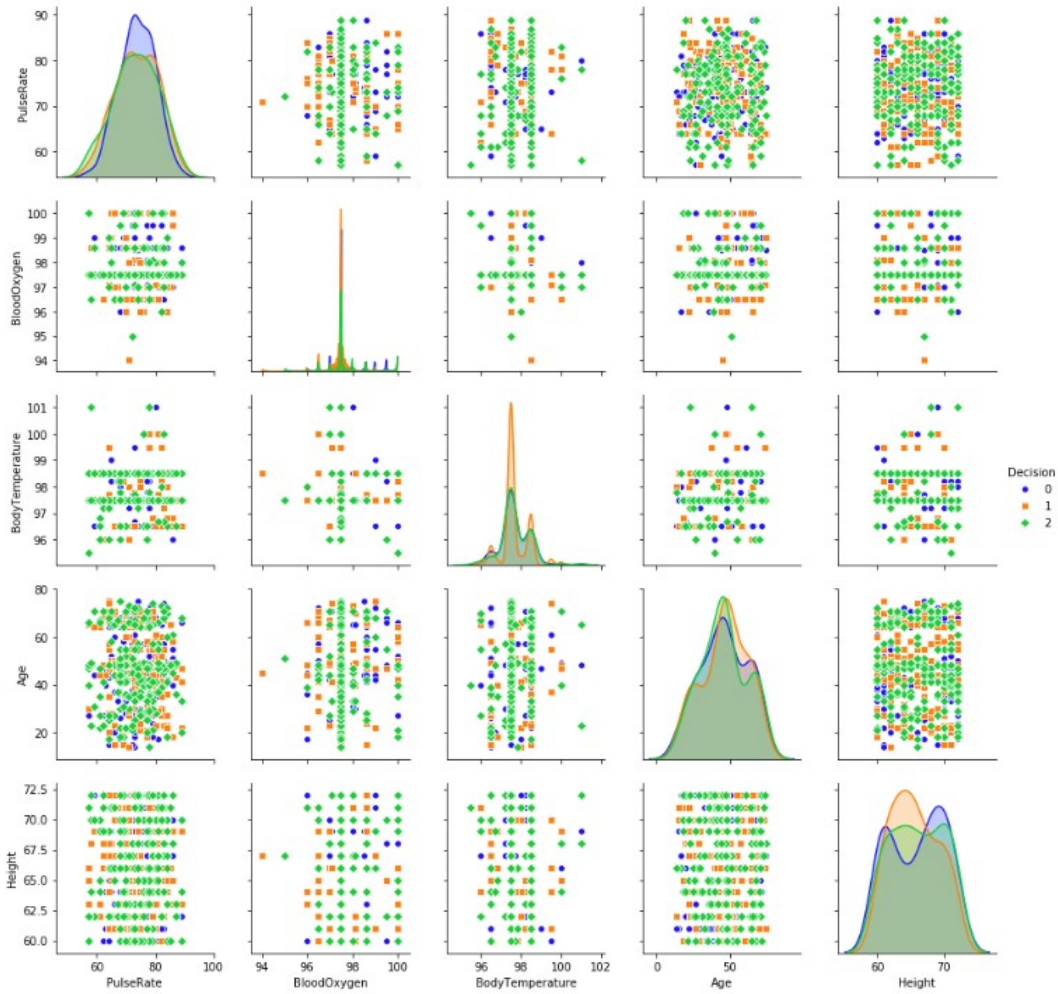

Figure 6.3: Illustration of a different dataset relative to the decisions

6.2 Algorithm for Support-vector machine model

Our project mainly deals with 2 datasets, vital body dataset and electrocardiogram dataset. The following passage explains the processing of the body vital dataset using machine learning. Machine learning basically the study of mathematical models and algorithms where computer systems use patterns in statistical datasets to perform specific tasks such as prediction. The main classifications of machine learning are:

- Supervised learning
- Unsupervised learning
- Reinforcement learning

For our dataset, we have selected Support-vector machine (SVM) model to carry out our processing. The machine learning algorithm by which data is used to interpret classification and regression is known as support-vector machines[19]. The motive is to isolate the given dataset in the most optimized manner. Here the margin is defined as the difference in distance between consecutive points. The goal is to maximum the possible margin between support vectors in a hyperplane. The SVM algorithm uses kernel for its implementation[2]. An input data space in converted into the desired form by using kernel. There are three types of kernels. They are Linear Kernel, Polynomial Kernel and Radial Basis Function Kernel.

Before starting our machine learning processes, we had to preprocess our dataset into appropriate comma-separated values (CSV) file. After obtaining a properly processed dataset, we then moved on to the machine learning part of our processing. We used Spyder ide to achieve this task which is a part of the anaconda library. The first phase of our machine learning code deals with reading the CSV dataset. We have used the library called Scikit-learn (sklearn) to import the data from our dataset. This library works with the NumPy and SciPy libraries to perform their functions. After some testing and validating that our dataset, along with our decision, is interpreted properly, we move on to our next phase, which is splitting test and train data from our dataset.

In this phase, we used the function train.test.split() to divide our dataset into train and test dataset. We 3 parameters passed to perform the following task are features, target, and test set size. In this phase, we have split our dataset into a ratio of 80:20 where our train dataset contained 400 entries, and our test dataset contained 100 entries. The training dataset is used in training and establishing our model, and the test dataset is used in the prediction phase to calculate our accuracy.

This is the most important phase in our machine learning processing as here we build the support vector machine model. First, we imported the SVM module and created the support vector classifier object by passing argument kernel as the linear kernel in SVC() function. Then, we fitted our model on the train set using the fit() function. This fits our data from dataset into x and y plane to generate a linear regression model.

After establishing our SVM model, we move forward to our next phase, which is the testing phase. By using predict() function, we performed the prediction using the test dataset that we obtained after splitting our main dataset. After completion of the training phase of our training dataset and fitting the test dataset in the model, we have obtained an accuracy of 0.8674999999999999, which is approximately 86.75 percent accuracy.

The final phase in our machine learning data processing is the evaluation phase, where we evaluate the accuracy of our established model. Here we estimated how accurately the classifier or model could predict the patients with concerning body vitals from our inputs. In the end, by using joblib, we saved the model using the name risk-prediction.sav.

6.2.1 Comparison with other models

Linear regression: We have selected SVM over linear regression bcoz our dataset consists of multiple input data and one decision data. The linear regression model can only handle one input and one decision; hence we have selected SVM.

K-nearest neighbors algorithm: KNN sorts data based on distance metrices while SVM needs a well defined training process. So of the optimal design of SVM, it is guaranteed that the different data will be isolated optimally. KNN is commonly used as multi-class classifiers while generic SVM separate binary data are belonging to either level. SVMs have two major cases in which classes might be linearly separable or non -linearly separable, whereas, in KNN, we have to specify the distance matrix. If we speak about each of the classifiers being accurate, SVMs typically have greater accuracy than KNN as shown[6].

SVM Confusion Matrix

[[8 9 9]

[11 18 7]

[11 19 8]]

KNN Confusion Matrix

[[8 9 9]

[12 17 7]

[12 18 8]]

After applying both the models to our dataset, we got two accuracies one for each model as showing in the table below. From the table, we can see that for linear datasets such as ours, SVM generates more accurate prediction mechanism than KNN. Hence we selected SVM for our prediction model.

Model	Accuracy
SVM	0.8674999999999999
KNN	0.8550000000000001

Table 6.1: Comparison of the two models

6.3 Algorithm for convolutional neural network model (CNN)

Building a convolutional neural network (CNN) is an ideal process to use machine learning to recognize images. Python's Keras library makes it relatively easy to create a CNN. The computers use pixels to display pictures. Pixels are usually related to pictures. For example, in an image, or any other pattern, a certain group of pixels may mean an edge. use This assists Convolutions in recognizing images. A convolution uses the product of a pixel matrix with a filter matrix or kernel and give and output product of the values.. Until all pixels of the image are filled the above process is repeated. When computing a CNN, the input is a tensor with dimension (picture number) x (picture width) x (picture height) x (picture depth). A neural network with a convolutional layer should consist of the following features:

- Convolutional kernels (hyper-parameters).
- The number of input channels and output channels (hyper-parameter).
- The depth of the Convolution filter (the input channels) must be equal to the number channels (depth) of the input feature map.

Convolutional layers convolve the input and transfer the outcome to the next stage. That is identical to a neuron's response to a particular stimulus in the visual cortex. Each convolutional neuron only processes data for its receptive field. While fully connected feed-forward neural networks can be used to learn features and classify data, application of this architecture to images is not practical.

In this thesis paper, we suggested a CNN for identification of various trends in ECG. All convolution layers are applying 1-D convolution through time. The first phase

of our processing deals with importing the various libraries needed for creating our CNN model. Libraries such as matplotlib.pyplot, pandas, itertools, NumPy, pickle are imported. In addition, tensorflow.keras and sklearn are also imported, which are needed for image processing and matrices, respectively.

The second phase deals with reading and verification of our dataset. Using the PD.read.csv() command we import our Electrocardiogram dataset along with our testing dataset. Following this, we check if our system was able to properly import our datasets. The next phase we completed was the process of data augmentation.

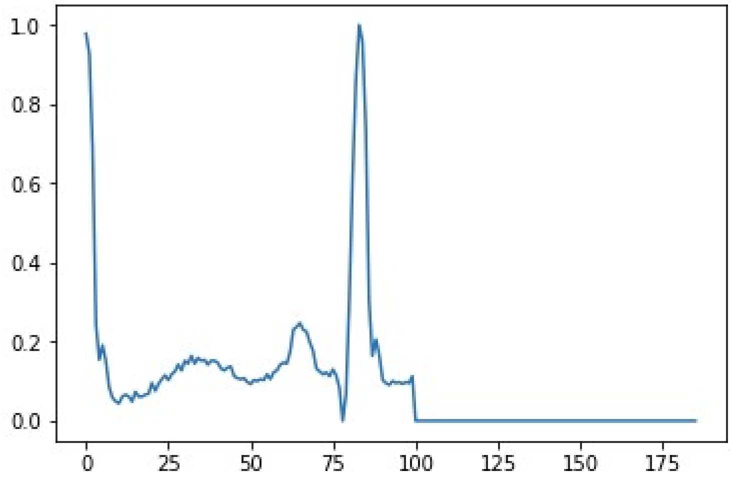

Figure 6.4: Distribution in our dataset.

To train the model properly, we should have to augment all data to the same level. Nevertheless, for a first try, we will just augment the smallest class to the same level as class 1. With that, we will be able to have a test set of around 5x800 observations. After augmentation, our dataset looked something like the following diagram.

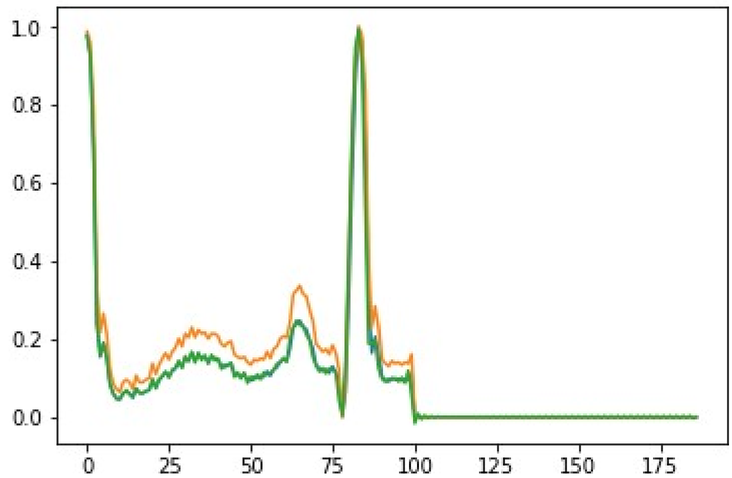

Figure 6.5: Distribution after augmentation.

While building the CNN model, we picked the sequential approach and used add() function to add our layers as we went forward with our implementation. Kernel size is the size of the filter matrix for our convolution. So a kernel size of 3 means we will have a 3x3 filter matrix. Our model takes kernel size as 5. The model we built has 10 convolutional layers. Our first layer also takes in an input shape and for our output layer we used 'Dense' layer type. Dense is a layer type that is applied in many cases for neural networks. The model will then make its prediction based on which option has the highest probability.

After the model is built, we compiled it and made it ready for the process of training that we performed using the test dataset that we obtained after splitting our main electrocardiogram dataset. To train, we used the 'fit()' function on our model with the following parameters: training data (train.X), target data (train.y), validation data, and the number of epochs. For our validation data, we used the test set provided to us in our dataset, which we have split into X.test and y.test. Here we used Epochs value as 50. The final phase we completed is the testing phase, where we verified our created model using our test dataset. Using the following command, we performed the prediction or testing, model.predict(X.test, batch.size=1000). This gave us a precision of 0.785.

```
Ranking-based average precision : 0.785
Ranking loss : 0.210
Coverage_error : 1.576
```

Figure 6.6: Accuracy table for our CNN model.

We saved the file under the name ecg-cnn.h5.

Chapter 7

Cloud Computing

7.1 Initial Assessment

In this project based paper, one of our concern was making our system mobile and accessible over the internet. As one of our major implementation is internet of things (IoT) and for this cloud implementation for our system is very important. As our device needs to work remotely over the internet, cloud is an important aspect of our thesis. Over the cloud we have very crucial tasks such as building the machine learning model, producing the prediction and connecting our device and GUI to develop and optimised system.

So what is the relation between machine learning and cloud? If correctly applied we can look at a very strong business aspect. Enterprises attempting to find applications for this technology may find that, in some cases, machine learning may possibly be a game-changer for the business.

Cloud-based machine-learning solutions are mostly carried by three main cloud service providers, namely Google, Amazon, and Microsoft. They vary quiet a bit from one another but share some commonality, advantages, and limitations[21].

For our thesis project we have selected Amazon's cloud providing service called AWS. The reason behind picking this platform is that they provide well sorted hubs to perform the tasks we need to perform over cloud. As our system is mainly a prediction based system we needed a cloud service that deals very efficiently with machine learning models. To solve these sort of problems AWS provides online jupyter IDE where we can apply our algorithm is Python and create our model (discussed in detailed in chapter 6). They provide CPU and GPU allocation for different tasks which helps in the image processing aspect in our CNN model (discussed in detailed in chapter 6.3). This is very helpful in developing the prediction based system over the cloud for our project. AWS is also able to interact with jeson API and hence this is very crucial for our system as we interact with our device and Gui using such API. For all the above stated reasons we have chosen AWS of amazon as our cloud service provider.

7.2 Approaches to Cloud Computing

We have relied on the Platform as a service (PaaS) portion of cloud computing. Our main agenda for choosing a cloud platform was to delocalize the main processing of our machine learning models and bring in a whole new dimension to our research work. We followed an array of steps to go about and utilize the service to its full potential. The steps include:

- Establish a connection handshake between our IoT system and Cloud
- Create our programming instances
- Prepare and visualize our data and datasets
- Train and deploy the machine learning model
- Evaluate the overall stability and performance of the model

7.3 In-depth procedures

The following procedures were followed, to sum up, the whole cloud computing aspect of ours.

1. Distinguish between the available built-in algorithms to decide whether or not they suit our specific dataset and use case.
   (a) If so, we select the built-in algorithm that most closely fits the requirements.
   (b) If no built-in algorithms are suitable, we use the jupyter platform provided by AWS to train our data.
2. Formatting computer file for training an algorithm. We must submit a CSV file with its header row removed, and therefore the target column must be set because of the first column. Meet any external design criteria relevant to the built-in algorithm that we are using where appropriate.
3. We create a Cloud Storage bucket where Machine Learning Platform Training can store training output
4. Selecting options to customize a training job. First, we utilize the Amazon Sagemaker the machine learning tools for the Amazon Web Services[29]. The training data on about (80 percent) will be utilized during the model preparing circle. We will utilize angle based enhancement to successively refine the model parameters. Inclination based advancement is an approach to discover model parameter esteems that limit the model mistake, utilizing the edge of the model work. The test data on about (20 percent) will be utilized to assess the presentation of the model and measure how well the prepared model sums up to inconspicuous information.

	A	B	C	D	E	F	G
1	PulseRate	BloodOxy	BodyTem	Gender	Age	Height	Weight
2	70	98.6	97.5	1	70	64	183.9279
3	71	98.6	97.5	1	27	61	167.9711
4	74	98.6	97.5	1	26	68	175.9294
5	80	98.6	97.5	1	28	66	156.3997
6	73	98.6	97.5	1	25	66	186.6049
7	75	98.1	97.5	1	30	61	213.7412
8	82	97.5	97.5	1	27	65	167.1275
9	64	97.5	97.5	2	27	66	189.4462
10	69	97.5	97.5	2	20	71	186.4342
11	70	97.5	97.5	2	33	71	172.1869
12	68	97.5	97.5	1	30	67	196.0285
13	72	97.5	97.5	2	38	60	172.8835
14	78	97.5	97.5	2	20	62	185.984
15	70	97.5	97.5	1	35	69	182.4266
16	75	97.5	97.5	1	29	72	174.1159
17	74	97.5	97.5	2	36	72	197.7314
18	69	97.5	97.5	2	67	64	149.1736

Figure 7.1: Data generated on a .csv file using google docs

(a) For the general training job, we select the built-in algorithm to use, the machine(s) to use, the region where the duty should run, and therefore the Cloud Storage bucket location where you would like Machine Learning Platform Training to store your training outputs.

(b) For the algorithm-specific selections, we will enable Machine Learning Platform Training to perform automatic preprocessing on the dataset. We will also specify arguments like the educational rate, training steps, and batch size.

(c) For hyperparameter tuning, we will select a goal metric, like maximizing model's predictive accuracy or minimizing the training loss. Additionally, we will tune specific hyperparameters and set ranges for his or her values.

5. Submitting the training job, we look at logs to observe its progress and standing.

6. When training job has completed successfully, we will deploy the trained model on AI Platform Training to line up a prediction server and obtain predictions on new data.

Chapter 8

User and Admin UI

8.1 Overview

Health is the root of all happiness, and it's a fact. But as the population of our country constantly rises, not everyone can have medical care on demand. Also, when we visit a doctor, we tend to forget our medical history or forget to carry them with us or even lose them. As a result, there is a hustle, and the doctors can't give proper treatment due to the lack of medical records. Hence, the proposed Cloud Medical Services comes to solve some of the issues where the system and the databases incorporated with it can be accessed and manipulated by the users where they can store their medical records on one place. Also, there is a doctor appointment system that will get rid of the hustle to wait in the line for the doctor treatment. The project contains lots of interesting features, including an emergency ambulance service that uses the Google Map API system and provides a lot of interesting features .Being an online web based app, it can be accessed from anywhere and any device as long as there is an internet connection available.

The mission is to produce and provide quality and innovative healthcare solutions. We are trying to solve the uncertain health hazards with the immediate course of suggestive actions alongside create a solution for doctors to know the patient's compiled medical history.

8.1.1 Users

There are 4 types of users for my system. They are Guest, Doctor, Registered User and Super Admin. Super Admin will have access to the full system and has the authority to manage them. The guest user will have only access to limited functionalities such as browse doctors or see the doctor credentials. The registered user will have access to make appointments and also enjoy all the features provided by the system. Doctors will have separate access and features where they can manage their appointments and see the contents of the patient's medical records.

8.1.2 Framework and Programming Language

The full project is based on Laravel, a web development framework. Laravel provides a structured MVC pattern that is popular to manage and develop an online-based system such as this. For the backend, currently, the project is using XAMPP, but I have the plan to make it live using amazon cloud. I have used Google Maps API to provide the extra features such as to locate nearby hospitals and to let the ambulance know the current location in case of emergency. As I am developing on Laravel, the programming language that I am using is PHP and JavaScript. Also, there are some JSON file extensions used though PHP is tough to manage but has some great features in order to make the project efficient.

Figure 8.1: Framework and Programming Language

8.1.3 Different API on System

Google provides JavaScript API for maps. The API data allows me to use the map data alongside make a few modifications of my own. The map API also has some built in layers that helps the user to navigate properly and clearly.In the project, we made the best use possible for the maps API and used ot according to our needs. To use the Maps JavaScript API, I must have an API key. The API key is a unique identifier that is used to authenticate requests associated with my project for usage and billing purposes.

8.2 User Interface

The features that will be included are-

- The user will interact with the UI by signing in the website if they already have an account or register a new account.

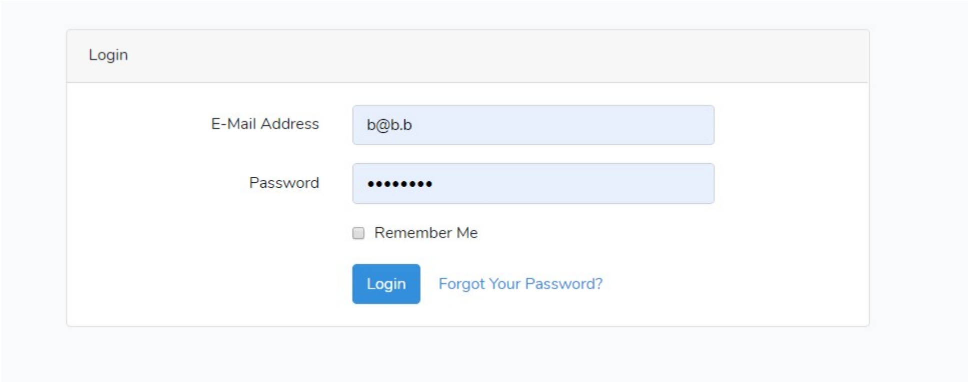

Figure 8.2: Login Form

- Category division: Doctors will be divided by their expertise category and will have a menu to select which category expert the user wants to visit. For example, heart, bone, brain, eye etc. category division will be there for ease of browsing.

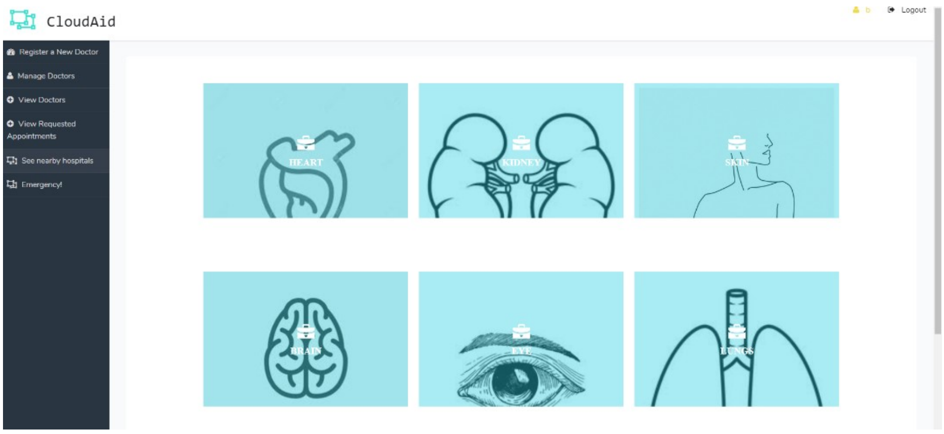

Figure 8.3: Category Division

- Browse doctor profile: Able to browse doctor's history such as his achievements, passing year, location of the chamber, availability timing, and current working place etc. It will be accessed by a clickable button on the picture.

- Request for an appointment: Patient can request for an appointment.

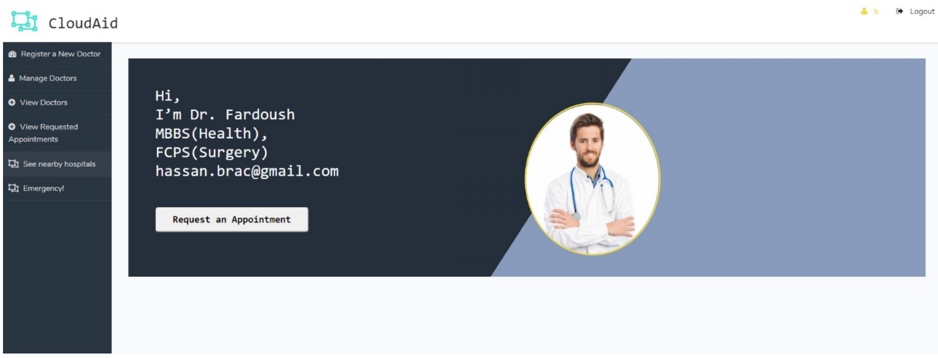

Figure 8.4: Appointment Request

- Set time for the appointment: patient can set a custom time for appointment based on the timing given by the doctor.

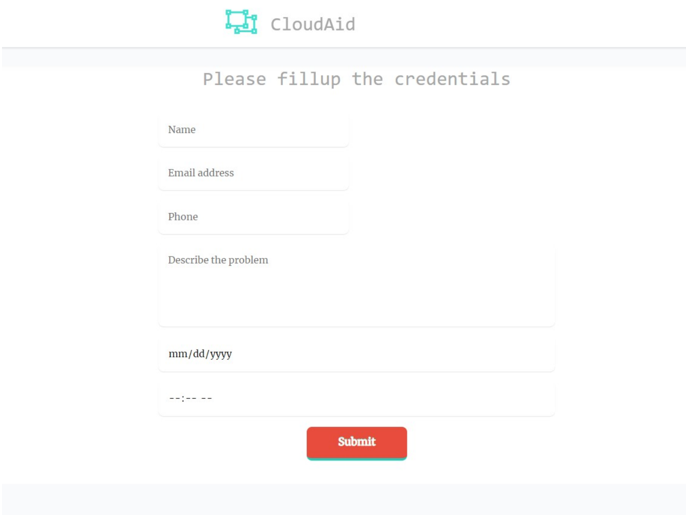

Figure 8.5: Fillable Credentials

- Delete appointment: Patient will be able to delete his appointment with the doctor.

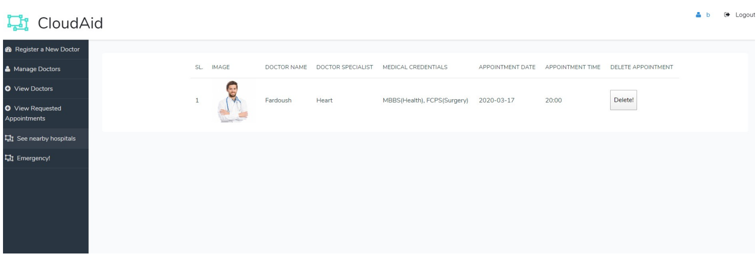

Figure 8.6: Deletion

- Update appointment details: Updating the appointment details such as changing the date or time for the appointment is also a feature. Also, Doctors can manage their appointment list. They can delete, edit or update the patient request.

- User Medical Records: A medical record storage will be provided to the user where he can store the medical records and show them to the doctor from the website without the hustle of losing them.

- User basic info edit/update: Users can update/edit or delete the extra info if they need.

- Emergency Ambulance Number: Website will contain emergency ambulance number feature and one-click call feature so that it's easily accessible.

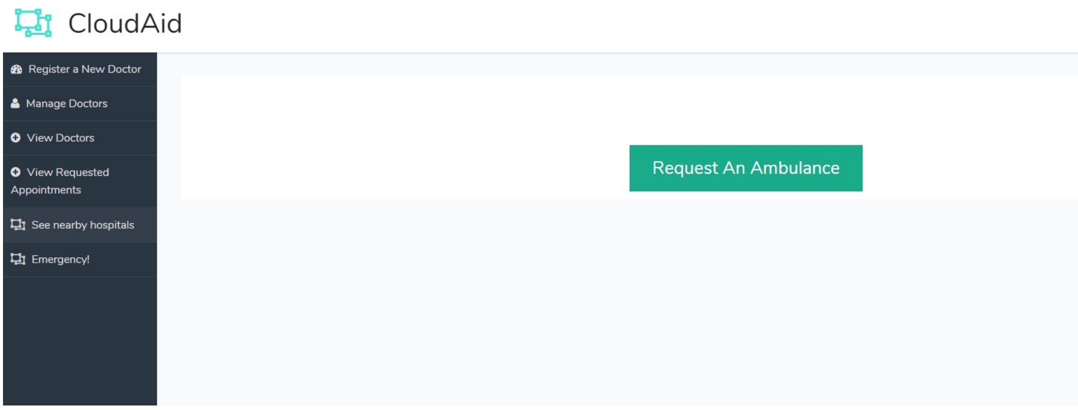

Figure 8.7: One-Click Requesting Ambulance

- Users will be able to see nearby hospital location from their current position.

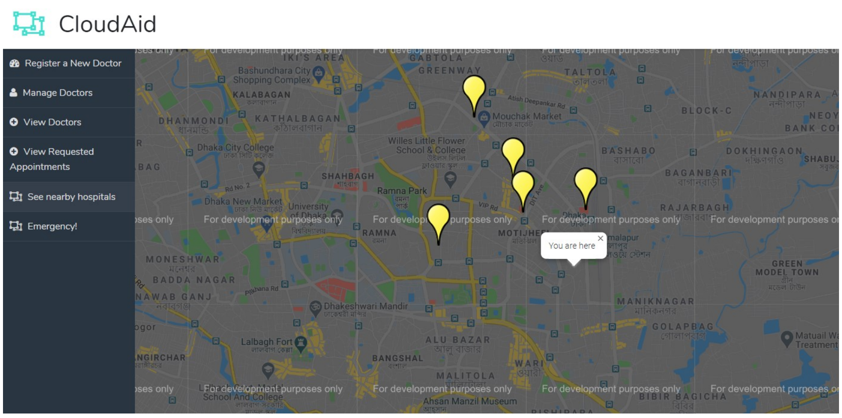

Figure 8.8: Suggest Nearby Hospitals

8.2.1 Super Admin Interface

- Super admins have the ability to register new doctors.

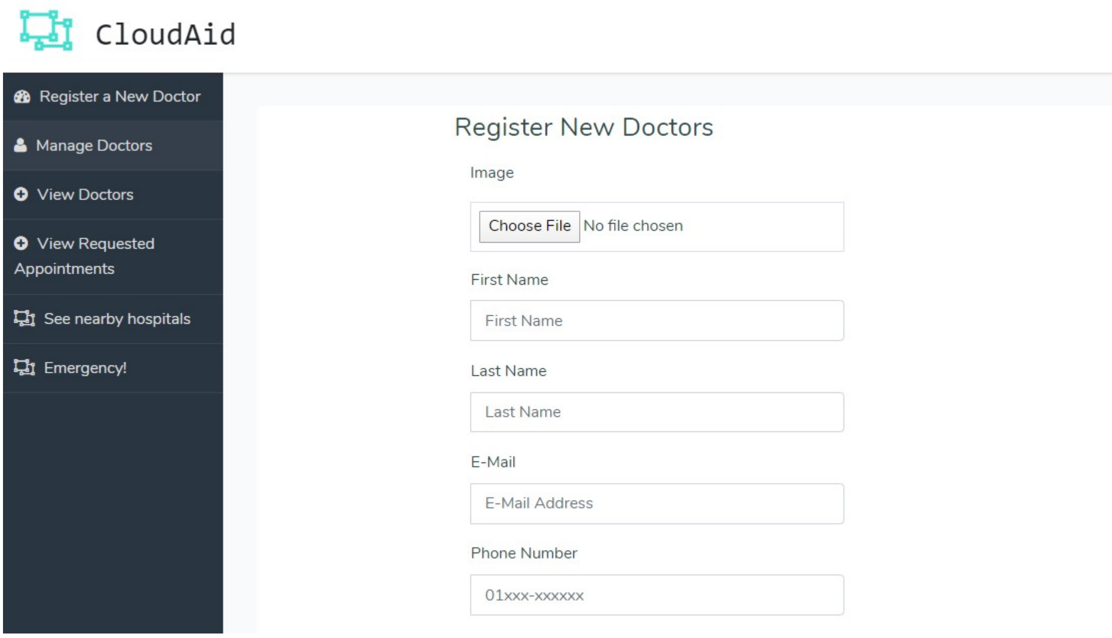

Figure 8.9: Admin Registering a Doctor

- They can manage every other credential and also delete or update a piece of doctor information.

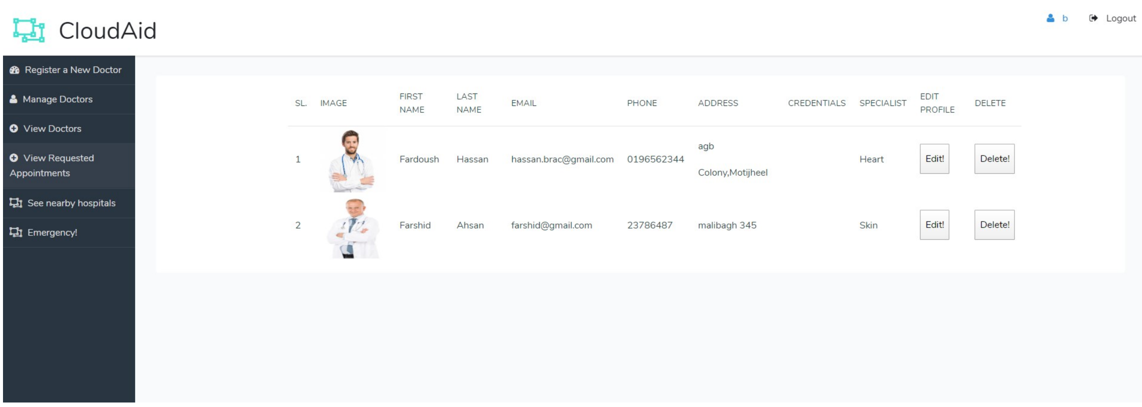

Figure 8.10: Doctor's Manage Table

8.3 Requirement Analysis

The requirements were analyzed in 4 steps. Every step was analyzed, keeping the users in mind. Every type of user had some specific new features theta unique to them only, and I had to think like every type of user to come up with proper requirements. Also, the requirements changed during the project development period as I found out some more necessary features that needed to be included in the project. So the analysis was continuously developing as I worked on the project.

The project also has a hardware implementation part that is low on cost and portable, and the device has an IoT connection enabled with the website. As a result, the data provided by the device gets stored in the cloud service and plays an important part in analyzing the current situation of the patient.

8.3.1 Functional Requirement

Functional requirement basically means what a system must do. A system may have a lot of functions and those functions can be of different types. A functional requirement answers a question with a short answer of yes or no. So if a requirement can be answered using yes or no then it is a functional requirement. For example, If a system has a dashboard it can be answered by saying yes or no easily. Functional requirements can be illustrated by using use case diagrams.So after making a list of functional requirements, a use case diagram model can be made that contains the basic functional structure.

Functional requirements are what systems are going to do such as different calculations, data change or alteration,technical detail and many other functionalities.

8.3.2 List of Requirements (Functional)

- Log in with necessary credentials
- Sign-up for new user
- Create an appointment with the doctor
- Able to update their profile info
- Browse doctor info
- Add/modify/delete medical records
- One-click ambulance call function
- Admin Control
- Separate UI for doctors
- Separate UI for patient

8.3.3 Non-Functional Requirement

Non functional requirements can be said the opposite of functional requirements . These are the requirements that can not be answered with a simple yes or no. For example, what type of database or what language will the system be based on. This question needs a bit explanation with detail. Thus it is a non functional requirement. The non functional requirements make sure the system is properly use able. If the functional requirements are met but non functional requirements are not met, the system becomes unusable. For example a website has a lot of features but it is slow because of server, then people will not use it.

8.3.4 List of Requirements (Non-Functional)

- Wrong Login Credentials will give an error
- On the register page, some credentials such as username, email, password are mandatory
- The same username will not get registered twice
- Using xampp and laravel as the back end of the website
- User must add specific profile info in order to validate himself
- Some external API might be used for better accessibility
- Admin will be able to control/monitor all the account activity
- The database will be encrypted on specific columns
- Doctors can cancel or re-schedule appointment dates if necessary
- Every delete/edit/update action will be notified by a popup alert

8.4 Use Case Diagram

Use case diagrams model the functionality of a system that uses actors on both sides and use cases on the middle connectiong with a line.. Use cases are a set of acts, programs and tasks to be handled by the program. A ”framework” is a few items being created or run during this period, including an internet web. The ”actors” are individuals or organizations which function within the framework under specified roles.

8.4.1 Use Case Diagrams for Our System

The use case diagram for my software has been divided into 5 distinct levels.

- Level 1: Authentication Level
- Level 2: Authorization Level using middleware
- Level 3: User Interference Level
- Level 4: Doctor Interference level
- Level 5: Admin Interference level

8.4.2 Level 1 – Authentication Level

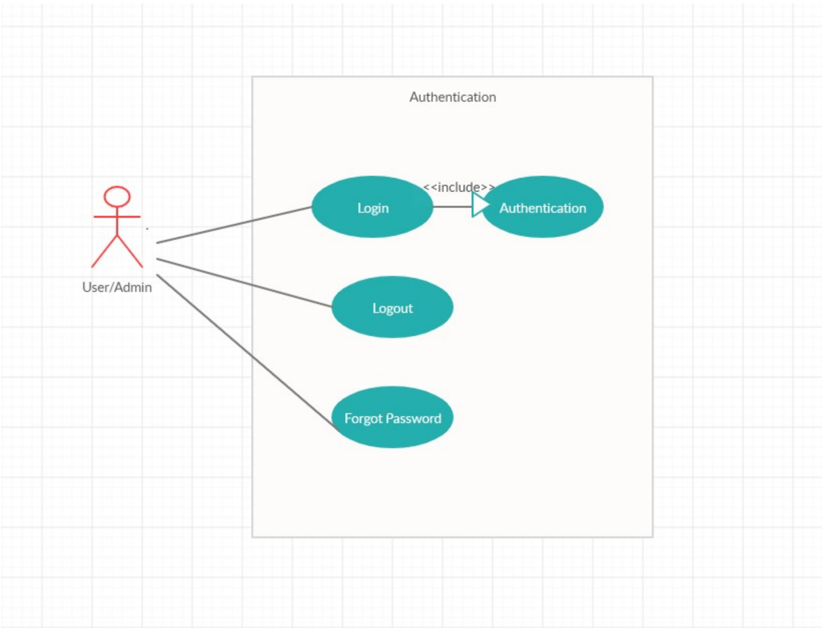

Figure 8.11: Level 1 Authentication Use Case Diagram

Actors: User/Admin/Doctor

Scenario: Using the 'Authentication' system, the user/admin/doctor will input a particular username and password assigned to them. The system will then perform an authentication check in order to check if the entered username and password is valid. Only then, access will be granted, and login will be complete. He can request for Forgot password feature and reset his password using necessary credentials. He can log out anytime.

8.4.3 Level 2 – Authorization Level using Middleware

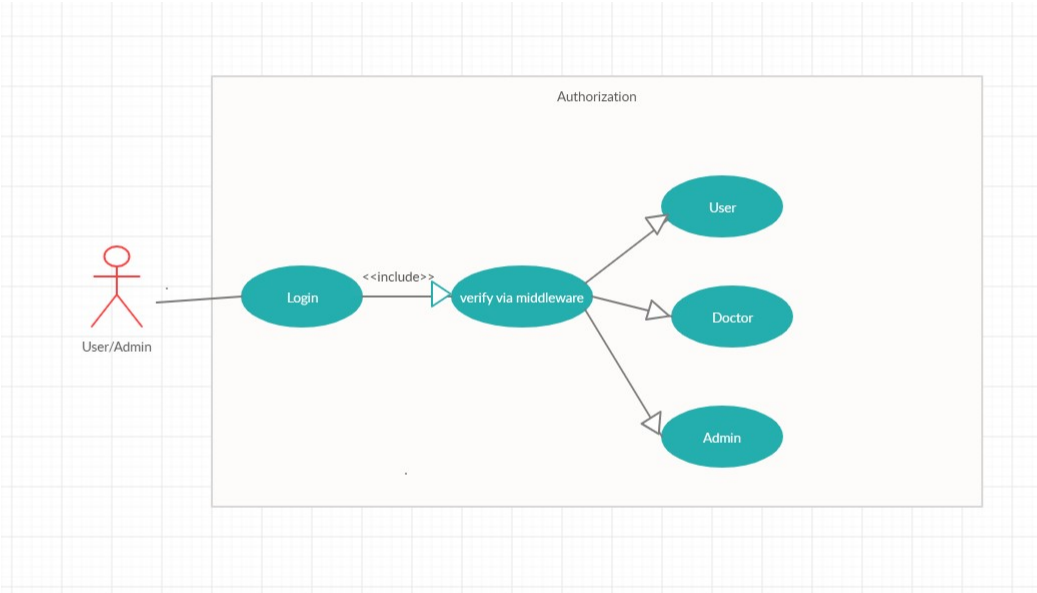

Figure 8.12: Level 2 Authentication Use Case Diagram

Actors: Admin/user/doctor

Scenario: The admin can log in using their unique password and username. Similar goes for the doctors and users. After that, a middleware will verify which UI is for them to access and which not to access. Filtering will take place, and different authorization level user will have different UI and functions that they can use.

8.4.4 Level 3 – User Interference level

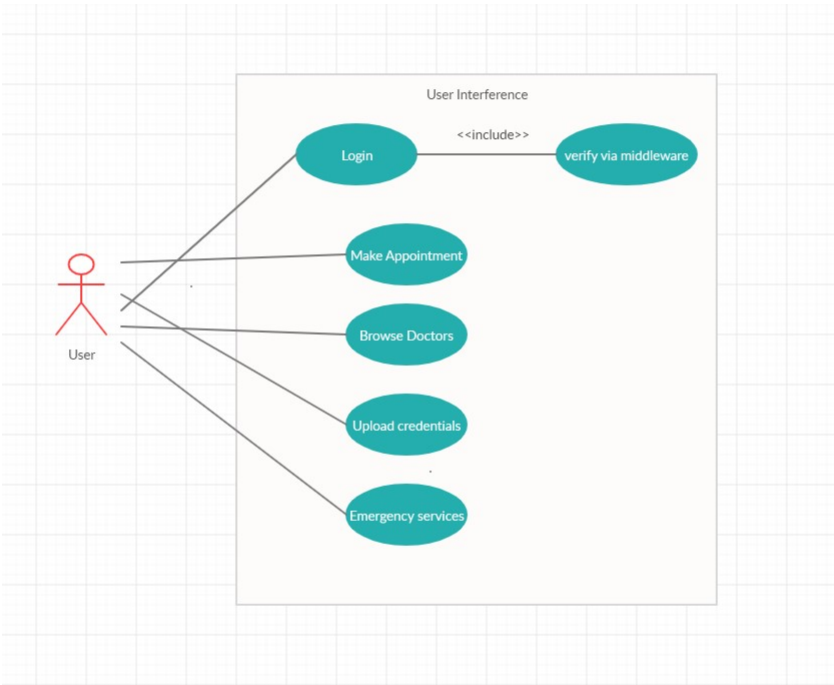

Figure 8.13: Level 3 User Intereference

Actors: User

Scenario: User can make an appointment, browse doctors and perform all other actions. Also, he can request for a doctor appointment, manage or edit the appointments and edit his profile if necessary.

8.4.5 Level 4 – Doctor Interference level

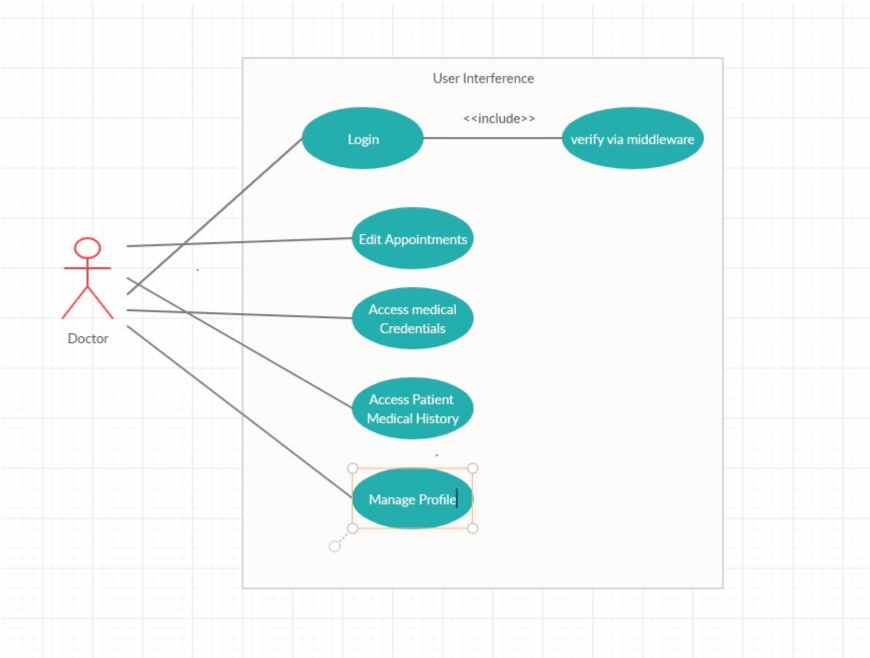

Figure 8.14: Level 4 Doctor Interference

Actors: Doctor

Scenario: Doctors can edit their profile credentials. Also, they have access to patient's medical records. They can reschedule their appointments.

8.4.6 Level 5 – Admin Interference level

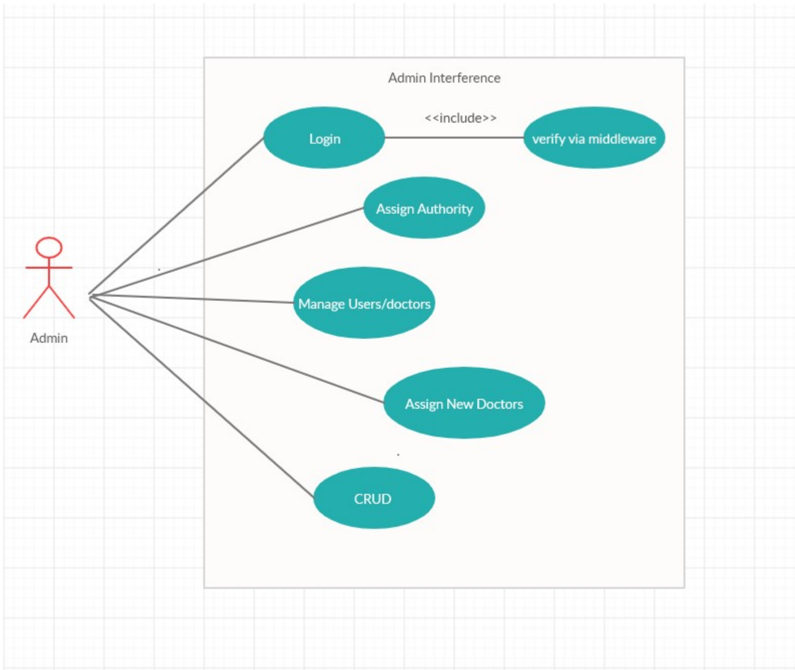

Figure 8.15: Level 5 Admin Interference

Actors: Admin

Scenario: Admin is the superuser of the system. He has access to every class alongside the ability to perform all sorts of CRUD operations. He can also assign different authority levels.

8.4.7 Full system use case diagram

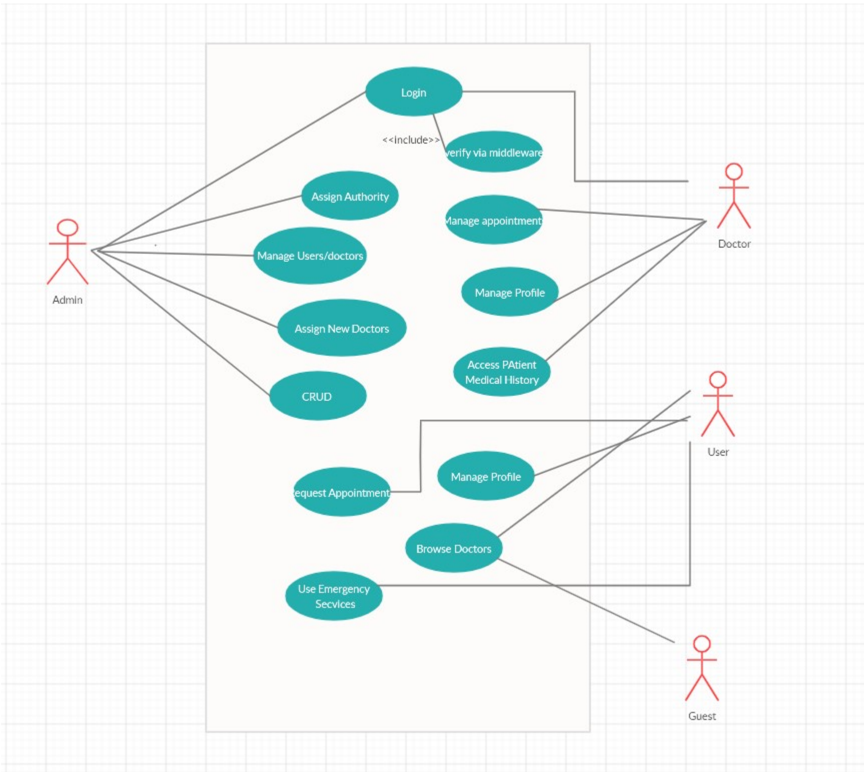

Figure 8.16: Use Case Diagram of Full System

8.5 Class Diagram

A category diagram within the UML that can also be a kind of static framework diagram which defines a system's configuration by displaying the classes of the entity, its properties, processes, and so the relationships between artefacts.

8.5.1 Class Diagram for Our System

Selection of potential class is performed by considering six selection characteristics.

- Retained information: within the study, it'll be useful for the imaginary class to supply information on the way to be remembered for the system to run.
- Required services: The class must have a collection of spot able operations which can change the different values of it's attributes according to the system needs.
- Different attributes: During the analysis of requirements, the main target should be on the main information. A category with only one attribute may be useful during design,but on the implementation it might be better as an attribute of another class.

- Similar attributes: a collection of attributes that are going to be defined for a common class, and those attributes will apply to every or any of the similar category instances.
- Common operations: a collection of operations are visiting be defined for the potential class and these operations apply to any or all instances of the category.
- Absolutely necessary requirements: Some outside entities that appear within the matter space to the execution of any solution for the particular system will very much always be stated as classes within the required model.

8.5.2 Potential Class Table

Potential Class	6 Checking	Analysis Class
Admin	1,2,3,4,5,6	Check
User	1,2,3,4,5,6	Check
Doctor	1,2,3,4,5,6	Check
Guest	5	Check

Table 8.1: Potential Class Table

8.5.3 Class Diagram Using Class Table

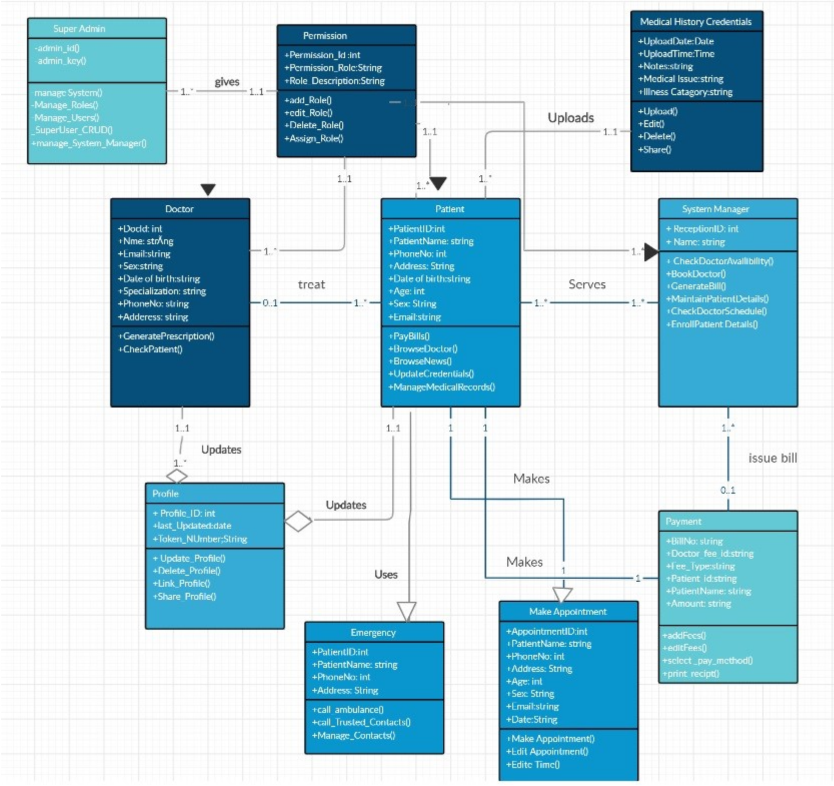

Figure 8.17: Class Diagram

Chapter 9

Result Analysis

9.1 Overview

The most important aspect of the whole system is the interface showing us the analytics. The analytics will include all the health-related aspect of the patients giving an array of sensor data sets along with their generated prediction. The analytics will also include graphs generated from data taken for a specific period of time.

9.2 Analytics

The GUI will open a dimension for both the doctors and the patients to see the recorded sensor data in a period of daily, monthly, quarterly and annually. Among the unchanged data for a patient will include their gender, age, height, weight. These sorts of data can be changed manually by the doctor upon the doctor's requirement and upon the patient's request. The analytical data will include a table of date changing data for pulse rate, blood oxygen level, body temperature and finally the ECG data.

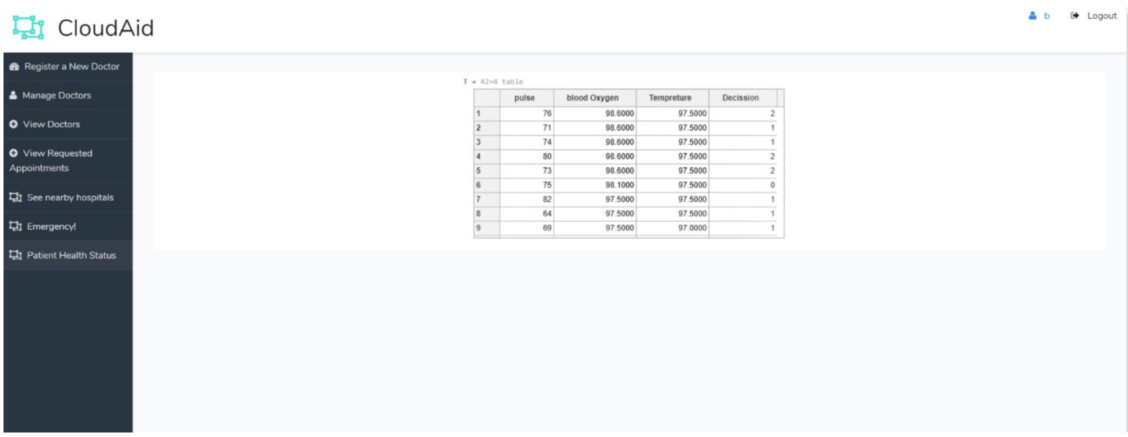

Figure 9.1: Sensor data history on GUI

9.2.1 Pulse rate

The pulse rate generally ranging from a region of (60-100) are collected and a graph generated for the doctors to observe the changes and anomalies. The GUI is updated each time a new set of data is received.

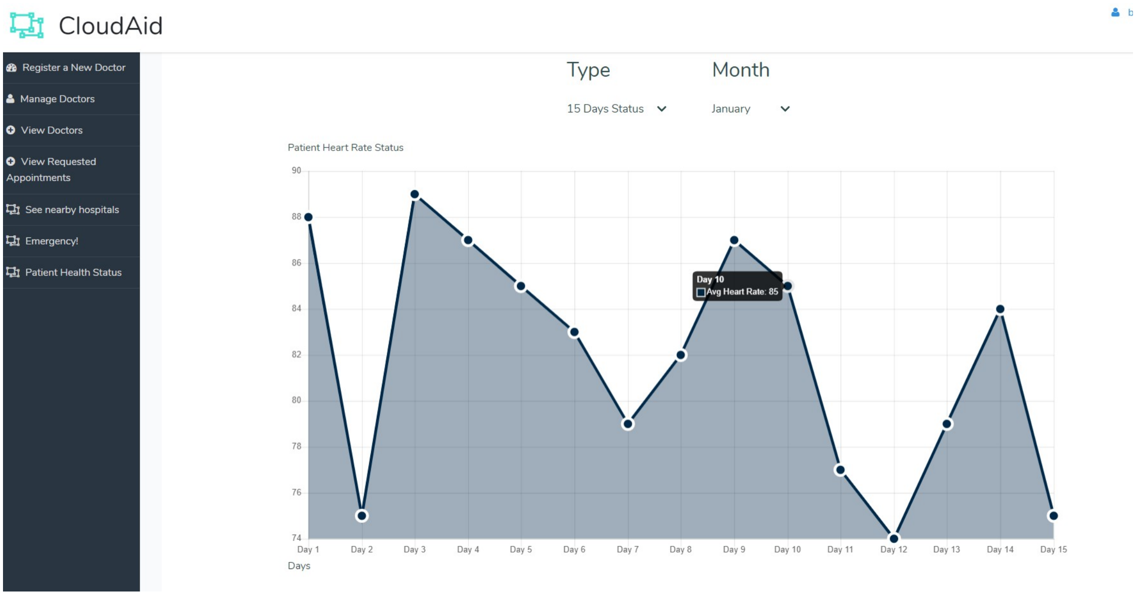

Figure 9.2: Pulse rate graph (15-day period)

9.2.2 Blood Oxygen

A heartbeat oximeter (beat bull) is a noninvasive gadget that appraises the measure of oxygen in your blood. It does as such by sending infrared light into vessels in your finger, toe, or ear cartilage. At that point, it quantifies how much light is reflected off the gases. A perusing demonstrates what level of your blood is soaked, known as the SpO2 level. This test has a 2 percent blunder window. This test might be marginally less precise.

However, it's exceptionally simple for specialists to perform. So specialists depend on it for quick readings. Things like dull nail clean or cold furthest points can make the beat bull read lower than typical. Your primary care physician may expel any clean from your nails before utilizing the machine or if your perusing appears to be strangely low. Since a heartbeat bull is noninvasive, you can play out this test yourself. You can buy beat bull gadgets all things considered stores that convey wellbeing related items or on the web. Converse with your primary care physician before utilizing a home gadget, so you see how to decipher the outcomes. An optimal value of the oxygen levels shows are between (95-100), and in extreme conditions of asphyxiation, the levels can drastically decrease[26].

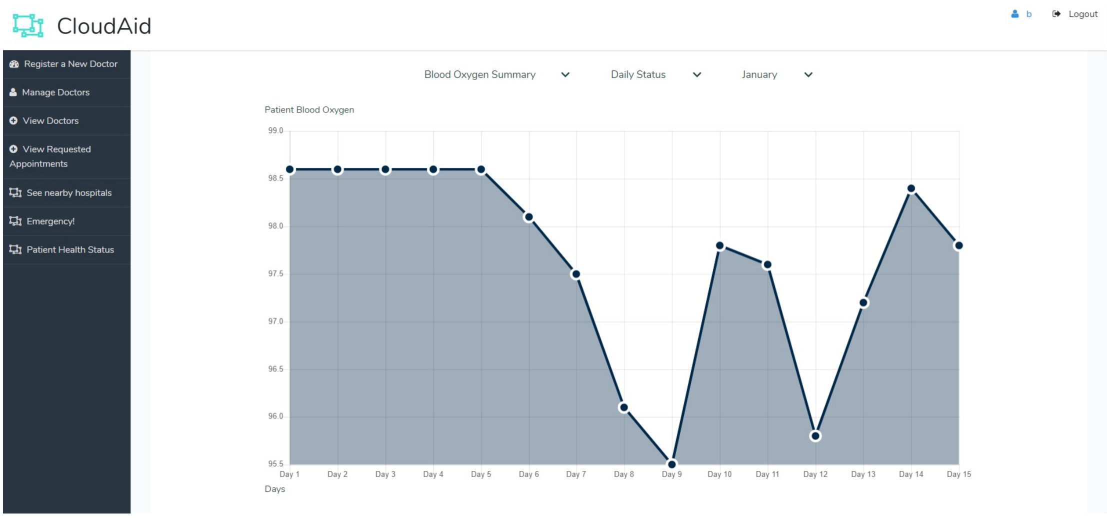

Figure 9.3: Blood oxygen graph (15-day period)

9.2.3 Body Temperature

Similarly, body temperature values will be shown as a graph to see the variation in temperature values. With the variation in period of time in a particular day or how old an individual is we can also observe variation in the human's internal heat levels. Generally a patient suffering from heart difficulties will tend to have a higher body temperature levels compared to standard established levels. Our interface will keeps the records based either on monthly, weekly, daily basis for the doctors to analyze and detect issues. A figure is provided down below demonstrating our interface dealing with the data and generating a graph to provide analytics on a particular patient for a time period of 15 days. A measure of around the ball park of over 100 fahrenheit degrees is considered slight fever due to reason maybe because of a heart problem.[28]

Figure 9.4: Body Temperature graph (15-day period)

9.2.4 Final verdict

For a patient at every interval of time, data will be generated onto tables and graphs are formed. For each set of data, a predicted value will be attained, giving out of the 3 decision risk factors as outputs. When the doctors request a prediction for a patient for a specific time period. Our system will generate the mean of all the predicted values and give out an average answer giving out only the highest ranged value from no risk to low risk to high risk then the doctor can provide his/her opinion and provide a necessary medical suggestion.

Chapter 10

Conclusion and Future Planning

As the world is moving forward at a very fast pace, we are getting less time to look after ourselves. Health hazards are becoming more common cases around us, and often these hazards go undetected. Our proposed model can actively monitor people at risk of sudden health accidents and provide a platform for doctors to keep tabs of their patients remotely. This reduces the distance between patients and doctors virtually with our well-sorted and user-friendly interfaces and web implementation. The IoT based device enables us to remotely monitor risky patients, and our prediction mechanism alerts doctors if any hazardous circumstances arise.

Our project can be considered as an innovative platform in the field of IoT and cloud computing. In developing countries like ours, this kind of efficient and cost-effective project can improve the sector of remote health services. So, we intend to refine our project further and take it to the next stage of mass production. We intend to integrate more sensors to our device so we can develop a more accurate prediction mechanism and provide services to a wider range of health hazards. In future, we want to affiliate with government hospitals and military hospitals so they can provide their services in remote places with ease. We want to build a large database that will help doctors diagnose people from different areas remotely. In addition to these, we want to bring the price of our device and services down to a minimum so people of our country can afford quality healthcare services at the minimum price.

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