A Smart Patient Monitoring System for Improved Healthcare

By

Md. Fanir-Al-Mamun 011 161 142
Dill Mahzabina Tabila 011 161 274
Sifullah Sajib 011 161 185
Abdullah Al Mamun 011 161 186
Sanjida Akter Shimu 011 161 195
Khandakar Sharmin Sara 011 161 197

Submitted in partial fulfilment of the requirements
of the degree of Bachelor of Science in Computer Science and Engineering

November 17, 2021

Department of Computer Science and Engineering
United International University

Abstract

Bangladesh is a country with one of the highest population density in the world. As a developing country, there is a great scarcity of resources in the health sector. One of the problems is the low ratio of doctors and nurses compared to the number of patients. As a result, a lot of time patients do not get response timely from the medical personnel. In this paper, we have proposed a patient monitoring system based on Internet of Things (IoT) that will help management and monitoring of large number of patients automated. IoT devices are becoming more reliable and less expensive as technology improves over the year. Therefore, it is possible to improve patients monitoring system using the emerging technologies like IoT and cloud computing. In the proposed system, patients will use wearable sensors that will collect data and will be relayed to the nurses and doctors and also to the patients' attendants through cloud server and mobile application. The developed IoT based monitoring system can track patients' health status and response in real time and notify expert doctors in case of emergency.

Acknowledgements

This work would have not been possible without the input and support of many people over the last two trimesters. We would like to express my gratitude to everyone who contributed to it in some way or other.

First, we would like to thank our honourable academic supervisor, **Assistant professor Mohammad Mamun Elahi** sir for his valuable time and guidance.

Our sincere gratitude goes to our honourable course teacher **Professor Dr. A.K.M. Muzahidul Islam** sir for his valuable suggestion and logistic support.

We are also thankful to **Azim Uddin Chowdury** for his support to complete our thesis. We would like to thank **Mohammad Mirazur Rahman** for his support. Last but not the least, We owe to our family including our parents for their unconditional love and immense emotional support.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

In this chapter we discussed about Project Overview, Motivation, Research Framework, Problem Statement, Objective, Methodology, and Project Outcome.

1.1 Project Overview

In this paper, we want to elaborate on a smart patient monitoring system that is based on IoT. This system will give a common platform for efficient interaction between patients and doctors. It will be used to collect patients' information like heart rate, body temperature, blood pressure, level of oxygen through different sensors. Using this system doctors can easily monitor patients even if the doctor is not present in the hospital. In critical situation the doctor will be informed automatically through a mobile application. We will use a gateway to process the collected data and decide which data to forward to the cloud for user apps.

1.2 Motivation

In this paper, we want to prompt the major concepts of the Internet of Things which is renowned as IoT regarding with smart patient monitoring system for improved healthcare. For the time being, we want to modify our patient monitoring system which is testified as illustrious exhilaration about IoT. We live encompassed by electronic devices in all respects such as at home, at the workplace and in any other place. Further, we have surrounded in naive environments in spite of inside the human's bodies where IoT is representing several roles for improved healthcare and patient monitoring system. It's a common problem in any country, when pandemic situation is arisen, patients are not getting proper services due to lack of doctors and nurses. Because of the economical, political or other purposes, sometimes it happens that if any patient dies, it wouldn't be informed to the patient's relatives about the patients. Besides authorized doctors are not present due to many several reasons when the patient's condition is not stable. For these circumstances, we are motivated to implement a system that will collaborate to find out the status of the patient's

body in real-time monitoring and always deliver the current condition of patients to their relatives time to time. Currently, we want to find an uncovered system and motivated the technological solutions where patient's relatives, authorized doctors can access the patient's account. The system will build up impressively in the clinical situation or whole medical care system which is noticeable for a monitoring system in genuine time. So this journal will maintain on patient monitoring system which is based on IoT and the advantages of IoT are completely dependable when it comes to skillful diagnosis.

1.3 Research Framework

We have created our research framework so that we can track our research work. First, we got familiar with IoT in the healthcare system. After that, we have found a problem in the current situation of the medical monitoring system. Then we have proposed a solution to overcome the problem and analyzed our idea. After that, we implemented our proposed solution which is IoT based, and check the validation result with others.

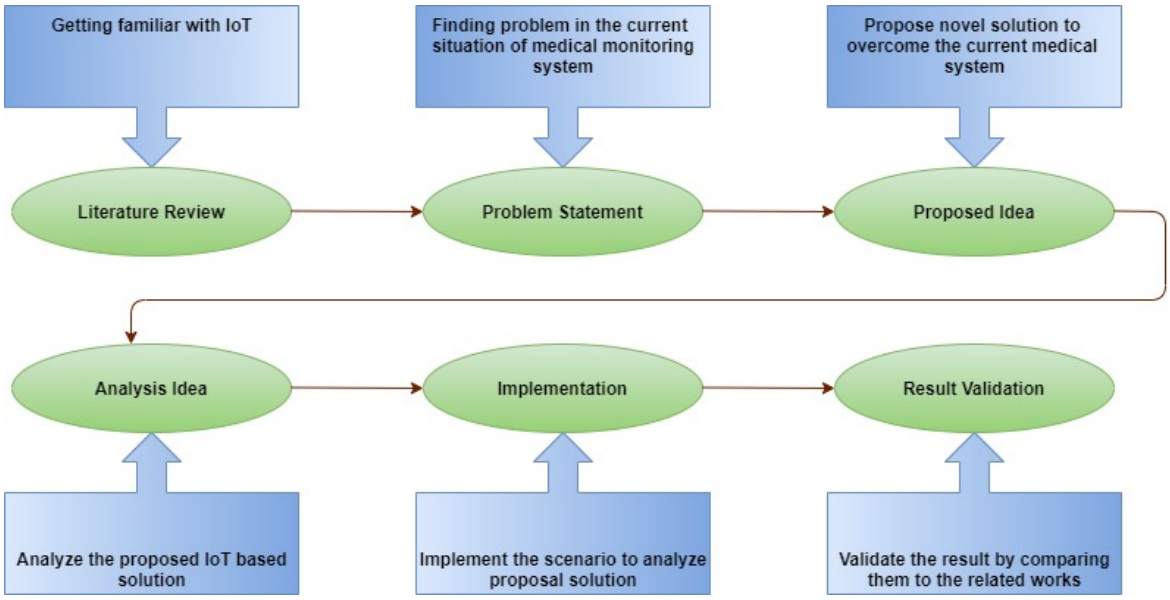

Figure 1.1: Research Framework

1.4 Problem Statement

Our proposed system will help to reduce the following problems.

- Shortage of medical personnel: Bangladesh is the country with one of the highest population density in the world. Here, the ratio of doctors and nurses compared to patients is very low.

- Hospital system mismanagement: Overall hospital management system in our country is not good enough to handle critical situations or heavy patient load. Lot of the time patient do not get proper observation. Our system will observe patient health condition 24/7.
- Inexperienced new medical personnel: Due to the lack of experienced doctors, sometimes the intern doctors are tasked with the monitoring of the patient. But their lack of experience increases the chance of mistakes in monitoring. Our system will use different sensors to monitor patient body status which will decrease the possibility of mistakes being made.
- Medical personnel absenteeism: Sometimes we see that patient dies because of the absence of doctors. In our system, the assigned doctor will be informed automatically when a patient is in critical condition and if he can not be present in time ,he can notify another doctor.

In the healthcare system, the specific work as heart rate, temperature, blood pressure, etc done before. If we completed the project then we need to be considered healthcare-related problems. For our improved system, sensors collect the data from the patient's body and inform the doctor and the doctor will update the condition of the patient in the database.

1.5 Objectives

- To review literature
- To design a system for collecting a patient's body status at regular intervals through sensors.
- To develop an web-based application to monitor critical patient conditions 24/7.
- To provide a common platform for efficient interaction between patients and doctors.

1.6 Methodology

The methodology is the structured, conceptual analysis of a specific problem. In this project, we will develop a device that is used to collect data from the patient body. This device is implemented by some specific sensors for collecting specific data such as body temperature, heart rate sensor, oximeter sensor and pulse sensor. Sensors collect the data and send it to database through micro-controller that is NodeMCU. We will use a database that is based on Django administration. Also, develop a web application that is developed by Django Framework.

1.7 Project Outcome

Through this project, we developed a patient's monitoring system to observe the patient's health condition. This monitoring system is divided into individual departments. Each department has specific web page to know about the patient's and doctor's information. This system is also capable of recording the continuous evaluation of patient's health condition. Using the recorded data, the system can monitor patient's status and inform the assigned doctors and relatives automatically through a web application when a patient's condition is unstable.

1.8 Organization of the Report

This report is about an IoT based smart health monitoring system. This proposed model becomes an easier medical system to update patient's health condition data. This report contains five chapters. In chapter 1 is the introduction of our project. In section 1.4 we discussed the objective of our project. In chapter 2 we review the literature's which are related to our project. This chapter also contains a comparison between reviewed papers. At the end of this chapter, we draw a comparison table. Chapter 3 contains methodology, system architecture of our project. Chapter 4 contains implementation and result. First we describe the setup procedures of the hardware, then we discuss result and validation. In chapter 5 mentions the standards and design constraints. Last chapter of this report provides a conclusion and future work related to this project.

Chapter 2

Literature Review

In this chapter, we have read the paper on IoT based that is related to the smart health monitoring system and we have summarized the paper. Finally, we have shown the comparison table.

2.1 Literature Review

In paper[1], they proposed an extending system that can send patient's physical sign to remote medical applications in real-time. In their system, they focused on mainly two parts: the data acquirement part and the data dispatch. The patient's physical status is monitored by doctors. In this paper, they proposed a heart disease monitoring system which is based on IoT. Figure 1 illustrates the architecture of an IoT based monitoring system which is for heart disease patients. In their application, they divided their architecture into three layers: the sensing layer, the transport layer, and the application layer. Table 1 discuss the monitoring scheme, the heart rate is calculated from ECG signals. Long-distance wireless communication technologies are very costly. For this reason, they divide their architecture for two sub-processes are Bluetooth technology that is used by cellular technologies(e.g GSM and GPRS) and the second one is broadband wired technologies(e.g ADSL). In the monitoring system, there are four modes. In mode one is the highest monitoring level is used for a high risk of heart diseases. In mode two sends data in a special period which is determined before. Mode three the data is stored first, then the data will prepare for remote access. Mode four is the low-level monitoring system and depends on the patients' demand. When patients feel sick and request to doctor for treatment. The prototype is implemented by some wireless sensors and connectors.The connector is the main part of the prototype. In their prototype the used the SpO2 sensor device, the android smartphone and SpO2 monitoring data mention in Figure 3.

In paper[2], they proposed an IoT based model that is used for sensing and monitoring pulse rate and body temperature. Wireless sensors collect the data and send it to the database and this data is used to keep track of the patient's condition. In their proposed system they divided into three major modules: The sensing module, the main module, and the interaction module. Figure 1 elaborates on their proposed architecture. Sensing module sense the data from the patient.It has two sub-modules: sensor node and brain node. They established a gateway between the sensor node and the brain node. Pulse sensor measures the heart rate which is plug-and-play heart rate sensor. For measuring temperature they used analog sensors which LM35. The wifi module is used for transfer data from the brain node to the main module. The main module collects the data from the sensing module and stores the data in the database or storage. The main module delivered the data different branch node and doctors or patients monitor the condition of health by using an interaction module. In interaction, the module needs the patient's information(e.g date, time, location, etc) to verify. Only authenticated users can use the interaction module. They use IoT application with HTTP protocol. Figure 2 illustrates the flow of data from the sensing module to the interaction module. The experimental result of the pulse sensor they have been considered when the patient is sitting idle, the patient is asleep, the patient is running and abnormal condition of the patient. LM35 creates analog output and converts to a digital signal using a microcontroller and displays the temperature in Celsius. They developed their proposed architecture using the Arduino Uno microcontroller which is not fully developed for wifi access that's why the used wifi module which is a drawback in their system. Another drawback is they used analog temperature sensor LM35 that takes analog input and an analog output that is not feasible to monitor.

In paper[3], they designed a smart health monitoring system which is assembled various kinds of sensors. This device is wearable and real-time sensor data from patients. The device collects data and stores the data. The main focus of healthcare is more reliable for all people everywhere. In figure 1 represents system architecture. The sensors collect data and Arduino fio transmits the data. Arduino fio receiver receives the data and shows the patient side computer. This computer use as a local server. The doctor monitoring the data over the internet. Arduino Fio is based on the ATmega328P AVR microcontroller and Zigbee development platform. It is also 8-bit development platform. The LM35 is a precision integrated-circuit temperature sensor that is analog and shows the output is also analog. IR LED and photodiode which is used for pulse rate measurement. The Sphygmomanometer measures blood pressure. They also proposed a LabVIEW software that is used for monitoring the data. The realtime monitoring LabVIEW software used Telnet protocol and store and retrieve the data from the FTP server. In figure 9 block diagram of experimental and result. The sensor is connected to the Arduino fio and visualized by LabVIEW software. The result displays and stores the result after typecasting. The resulted values are compared with the threshold values to check the patient's critical condition.

In paper[4], they proposed healthcare system that is compact of a wireless sensor network in an IoT environment with cloud computing. They ensure Quality of Experience, trust management, decision making, and energy management. They use a gateway to monitor the base station. The smart sensor node is connected by sensors or actuators. In figure 1 elaborates on the architecture of WSN based IoT. The human body is connected with sensors and data send to medical service in the cloud through the gateway. Figure 2 has shown the architecture of a source node. The sensor connected with ADC. The memory is connected with ADC in two-way. The sensor node has a power source. In a wireless sensor network, the power supply is the most important thing. They try to reduce power in the sensor node. Cloud computing ensuring the network equipment, firewall, and security devices. Using cloud computing reduces power consumption, reduces cost, data mobility. In paper[5], they proposed a Provider Interface(PHI) and wearable health technology (WHT). This device is for those who are not connected to the doctor. It is easy to connect the doctor from anywhere. Figure 1 has shown calculating the total health index. First getting data and normalizing measurements. After this calculate the health index. In figure 2, They measured pulse, blood pressure, oxygen saturation, BMI, ECG signal, Glucose, Body Fat, EMG signal, EEG signal, GSR signal. Their IoT devices are pulse and SpO2 sensor, BP sensor, weight scale, ECG sensor, Glucometer, EMG sensor, EEG sensor, GSR sensor. Their proposed architecture is maintained three layers: The detecting layer, The transport layer, and The application layer. For measurement, the body temperature is used by temperature sensor DS18B20. The sensor measures the real-time temperature of the body. SpO2 sensor is used for calculating heart rate. ADXL335 measures body position. In their architecture AD8232 is used for ECG. Finally, they implemented a cloud system by using ThingSpeak Server. In paper[6], their main focus is on heart disease. They developed a device that is monitor heart rate. The heart disease problem symptoms are temperature related and dehydration. Their proposed architecture is a wearable device that is assembled by pulse sensor, GSM module, Atmega328 Microcontroller, Arduino Uno and temperature sensor LM35. In figure 2, has shown their flowchart of how to system work. The pulse sensor senses the data and a machine learning algorithm analysis of the data. After analyzing the data it makes a decision what is the heart condition. Then display the heart condition result. Using the GSM module message is sent to the family member. If the result is over the threshold value the heart attack alarm is sent to the family and doctor. In figure 7, shown the analysis data of two different groups. This group is divided into the age parameter. The data analysis in five types: before sleep, after waking up, after exercise, resting and work.

In paper[7], they designed an IoT base In-hospital healthcare system that is used by the Zigbee mesh protocol. This system monitors patient real-time activity. In the health care system, every patient has a personal digital identity. In the eHealth care system, the patient is monitored by remote access over the internet. In a personal area network, a Zigbee protocol is used because it maintains a low data rate. Intel Galileo Generation 2 is the microcontroller board that acts as a gateway. This device controls the data processing

when the data transmit and receive. Arduino IDE is used for coding which is based on Linux software stack. The temperature sensor is connected with the XB24-B XBee S2 module. This protocol is used to collect patient real-time data. They calculated the body temperature of the patient. An application is used for monitor temperature.

In paper[8], They proposed a hardware device that is monitors the patient's body temperature, respiration rate, heartbeat, and body movement using Raspberry Pi. The Raspberry Pi is a smart Linux based microcomputer. In figure 1, a block diagram of the patient monitoring system using Raspberry Pi. The sensors are connected with the Pi board and the Pi board is connected with the output device and power supply. In this system, the patient's condition is monitored in real-time. The patient is monitored through the internet. They used a transformer in their model because all sensors do not use the same power. The heartbeat is calculated by an IR transmitter and IR receiver. The thermistor senses the body temperature in their proposed model. Accelerometer sensor MMA7260QT measures body movement. Their main focus was they designed a monitoring system that is smart and connected with Raspberry Pi.

In paper[9], they designed an efficient device that is connected machine to machine. For personal healthcare, they use RFID technology. In this system, they use Raspberry Pi as an IoT device. They proposed a model that senses glucose level, ECG, blood pressure, body temperature, oxygen saturation. GPS is more important for IoT technology. Medicine bar code labeled by GPS which is connected with RFID. IoT maintains machine to machine communication. The sensor senses the data and store in the database and another side is monitored by mobile application or web application.

The given literature[10] review briefly narrates, how technology can be used for better health care system. Specially, in a country like India where only 30 percent people are getting quality treatment, and rest of the 70 percent are surviving through poor health care condition. Now, this literature has shown the idea of using IoT (Internet of Things) to enhance the health care system. In medical sector, we can call it IoMT (Internet of Medical Things) which refers to a collection of medical devices and applications that can connect to different healthcare IT systems through online mediums like cloud services and WiFi. Crucial medical information or any information become easier to collect as IoT works from anywhere, for anyone, through any path, for any subject matter. According to the literature, IoT can improve the implementation of different biometric sensors that captures the human body parameters. And that sensor data can be used many ways to provide smart health care. A smart health care or remote monitoring system is a combination of hardware and software. The hardware is the sensors and microcontrollers, and cloud system is the software part. It can be done by three steps: 1) Data acquisition, 2) Cloud system, 3) Real time health portal. Firstly, system temperature and heartbeat sensor is used for data acquisition. The system senses body temperature according to a certain function and then with the help of micro controller (Arduino uno ATmega 328P) the data can be stored and processed for further use. Secondly, My SQL database server can be used as cloud system for providing both way communication, to sender and receiver. Here,

Real Time Health Portal is the receiver. An Android app (written in JAVA programming language) can be used for interactions as android apps are available in a lot of devices like mobile, PC, tablet. Lastly, we need an Ethernet Shield for internet connection and for sending data in real time. The literature also shows a block diagram of the complete transmitter and receiver flow. Where two sensors are connected to Arduino Uno: (1) DS18B20 digital temperature sensor, (to measure the temperature of patients' body). It has a digital output. (2) Heartbeat sensor (to measure heart rate of the patient bodies). This sensor is connected to Ardino Uno as well as HLK-RM04 Serial to WiFi Module which provides serial communication. Then the data is stored in the MySQL database for the access of the real time users. Here IoT plays its part because IoT connects two different object at a time such as high-end and low-end computational devices like Desktop and mobile respectively. The literature concluded that future work can be done by inventing more sensors as hardware and creating more settings as android apps. It will make the system more user friendly and more task can be done automatically rather than manually.

In paper[11], using the Internet of Things, we are now getting a new life because of IoT is providing us the smart medicine and physical healthcare system as IoT is the interconnected devices to prepare an IoT-based network in real time. One of the most important fact is that, by applying this IoT-based system, doctors are able to observe the patient's medical case easily, thereafter doctors can prescribe the related medicines for these problems instantly. Though IoT improves those system and ability, an Ontology based automating design methodology is needed for providing smart medicines and physical health system which supports to generate a rehabilitation strategy. At present, IoT devices are accepting more challenges as these are more rehabilitate which goal is to provide useful and faster treatment. Now for implementing the ontology-based system, we have to need following the several characteristics. For ontology evaluation, we assemble the data from patient's body and those inputs are converted into functions. Classes and sub classes are the two forms of the functions. When any patients will entire the hospital first time, classes will put basic physical characteristics and sub classes will put the details information of patient's diseases. We also store the patient's disease information by global ontology. Disease ontology and resource ontology are the two parts of global ontology. Disease ontology covers the patient's basic medical history and medical resources are contained by the resource ontology. For flexible and accessible results, well-ordered knowledge base system will more easier to find out the syndromes of disorder quickly.Design optimization is the last stage of processing the smart devices. Here automatic design will construct a system where patients could be monitored rapidly.

In paper[12], health is the most significant things that human is needed.At present, modern technologies like internet and wireless sensor networks usually acquainted as internet of things which has three primary level features are anything communicates, anything is identified and anything interacts. Sensor node (SN) is the most fundamental objective of IoT, or more than exactly, Sensor Web (SW) framework which defines a suite of web service interfaces and communication protocols abstracting from the heterogeneity of sensor

(network) communication. For human health, e-health system could able to manage the patient's information, or their doctor's information and also provide their locations. Eventually, e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related new technologies. It's important to know which sensors or tools are needed for collecting the evidence of patient's body. In the normal manner, sensors are used as wearable devices and these are collecting the data. Body sensor network connects with patient's body which is always monitoring and connected with essential parameters. Tools are used through any applications. These all are self-monitoring devices which has the most advantage that they can throw out any third party's interruption. Do-It-Yourself (DIY) system is such a system where using low costing hardware and uncovered software via IoT and e-health. IoT is the another form of electronic devices. It is monitored the data that are interconnected with private or public cloud. Economic impacts of IoT applications that are more efficient, heighten in patient's monitoring system, capacity to collect the accurate informations, long-standing disease maintenance, and supply the medical services to decrease the costs. Requisites of e-health applications are, 1. Interoperability : The ability to exchange and use information in a large heterogeneous network made up of several local area network. 2. Limitations of invisibility and reliability. 3. Validating the authenticity, maintaining the privacy and integrity and these are compulsory when interchange any data.

In paper[13], through using the Cognitive Internet of Things or CIoT, we are getting the intellectual consequences of a patient's health condition in time based on the cloud. Actually, IoT is not provided unlimited storage and this power capability processing is not much high. So using cloud computing, IoT will be provided more storage capacity and higher power processing capability. As the author's target is to monitor real-time update of patient's condition from distant places with proper healthcare services and also have to provide the services with low-cost probability, cloud-based IoT is beneficial in this healthcare framework. Brain-powered CIoT would be processed the improved level of information and will make the decision to comfort the patients. This CIoT healthcare framework will helpful for big data analysis of healthcare services for any smart city. Sometimes any epileptic patient who has needed immediate medical services because of certain body jerking, in that case, this smart system will monitor the patient time and in any emergency cases, this smart city services system will provide insistent medical assistant to patients. This framework will address the patient's health status through body movement or voice recognition or facial expression or any complex medical data analysis. Here try to recognize the emotion and other sensitive part of the human body. Through machine learning determined the convolutional neural network or CNN, we can extract the good features. The stacked encoder is developed the some appointed features and their exactness. Researchers have proposed an advanced and automatic method for detecting the seizure which is EEG-based which evaluated with deep learning and stacked encoder. Therefore, they are using the cognitive healthcare Internet of Things or CHIoT

framework. Sensors and devices in CHIoT are connected with each other and associate to get on the physical status and social circumstances, stock and prepare the learned data, and extracted the good features. If the CHIoT method has confidence that the patient will need to have a seizure, it will provide the information to stakeholders and transmits the EEG data to CNN module. In case seizure identification will happen in the cloud. Then signal processors are categorized as the patient will need the seizure or not through the feasibility score.

In paper[14], the authors proposed a system that is based on the cloud for a smart healthcare monitoring system. In this paper, smart devices are used to collect health-related signals. This signals are transmitted to the cater. In this system, two types of inputs are used. One is voice signals and another is EGG signals. The smart devices transmit the input signals to the cloud. These signals will be classified as either normal or pathologic after processing the input signals. And this result will be transferred to the registered doctors to take the appropriate action.

In paper[15], the author proposed the benefit of networking technologies for the healthcare system. Healthcare is pass through an impetuous transformation from the traditional hospital. Nowadays smart healthcare systems are widely used in existing 4G networks. By using the 4G network, smart healthcare technologies are improved than before. If we want to get the best result from smart healthcare technologies then we must ensure ultra-low latency, high bandwidth, ultra-high reliability, high density, and high energy efficiency. By using the 4G network we can not get the best result. Therefore, the emerging 5G network will fulfill most of the requirements. 5G network can give us a higher data rate, mobility, spectral efficiency, energy efficiency, and device density. Smart healthcare has an effective role in the economy. It reduces healthcare costs. 5G and IoT are awaited to become monumental drivers of the next generation of smart healthcare. By using 5G technologies, we can use device-to-device (D2D) communication mmWaves, the macro cell, and small cells. We make a wearable device using IoT which support smart healthcare application like remote monitoring, remote medical assistance. The wearable device can collect information about heart rate, amount of sleep, and physical activities from the patient's body and send it to the cloud server through the internet. 5G and IoT can boost the use of smart healthcare applications. For congestion control in low resource bandwidth, we proposed a priority rate based routing protocol(PRRP). We can optimize the resources and energy efficiency of the network by using the Software-defined Network(SDN) and Network function virtualization(NFV). In smart healthcare, for connecting billions of devices a huge amount of data and information can produce for analysis. By using Intelligent algorithms and techniques we can analyze this huge amount of data. We ensure the privacy of patients and monitor the security of the network layer.

In paper[16], most of the IoT based patient monitoring systems, especially at smart homes or hospitals, there exists a bridge(i.e., gateway) between a sensor network and the internet which often translating between the protocols. In this paper, they are exploiting the strategies position of such gateways to offer several higher-level services such as

local storage, real-time local data processing, embedded data mining, etc, proposing thus a smart e-health gateway. A successful embodiment of smart e-health gateways enables large deployment of ubiquitous health monitoring systems.they are proofed that concept design clarify an IoT-based health monitoring system with enhanced overall system energy efficiency, interoperability, security, and reliability. IoT is a promising instance to integrate several technologies and communication solutions. Wireless sensor networks (WSN) are extended to a network commonly called Ubiquitous Sensor Networks(USN). It is integrated into a system of IoT. USN technologies can provide great possibilities for the field of healthcare. Rational wireless networks can assist patients and their caregivers by providing for continual hospital monitoring, memory enhancement, control of appliances, medical data access, and instant communication. For Ubiquitous computing, all the healthcare system entities can be monitored and managed continually. In a smart home or hospital, where the location and mobility of patients are obstructed to the hospital facilities or the building, gateways can play a key role. Actually, gateways commonly act as a focus between body/personal/local area networks and remote health centers. In this paper, they present the concept of a smart e-health gateway able of enhancing IoT architectures used for healthcare applications in terms of energy-efficiency, performance, reliability, interoperability. This paper's proposal motivated by the fact that in a smart hospital or in-home healthcare, the gateway is in the singular position between both the BAN/PAN/LAN and WAN. Security is one of the important perspectives of the system. In most cases, the data received from sensor nodes are transmitted as plain text which can be recognized easily by a third party. Leaking information would have some serious operation on the person engaged especially in e-health applications where confidentiality is necessary.

In paper[17], Edge-of-things(EoT) based healthcare services are oncoming patient-care improvements related to autonomous and persuasion healthcare so that an EoT representative normally works as a middleman between the Healthcare Service Consumers(HSC) and Computing Service Providers(CSP). Sensor observations from a patient's body area networks(BAN) and patient's medical and genetic historical data are very sensorial and have a high degree of inter-dependency. Hence, this paper proposes a file optimization solution for the virtual machines(VMs) of edge or cloud computing service providers. And a comparative study shows the cost-effective provisioning for the healthcare data through file optimization and ADMM methods over the traditionally equivalent and griping approach.Edge-of-things(EoT) based telehealth-care is a cost-effective solution for decreasing per capital healthcare costs by the improvement of EoT agency to assure count services from cloud service providers to healthcare service providers. These telemedicine and e-healthcare scenarios where patient's data are collected with the help of wireless body area networks(BAN) and sensor observations are resolved with respect to medical history, diagnostic results, and genetic history in the cloud. ANd this paper analyzes patient data, cloud service providers charge for their per second CPU utilization time. The representative based edge-of- things(EoT) computing framework for smart-healthcare data

provisioning. This framework is three principal entities: 1.consumers or enablers. 2.EoT service broker and 3.EoT service providers. The healthcare service consumers are the end of the patient-care system including patients or relatives. And healthcare service enablers are a doctor, nurse, hospital, and diagnostic center. The EoT service providers are infrastructure, platform, or software application providers. Though, the security and privacy of the healthcare data are assumed to be ensured with the help of blockchain or public key infrastructure-based security module between the edge and cloud computing frameworks.

In paper[18], the author worked on a smart health care system by using Cloud computing, Fog computing, Internet of Things Healthcare, and Big Data. For high scalable computing platform, the cloud works on Big Data processing at the root level. But it is can't fulfill the main requirements of IoT applications such as minimum response time and low latency. Nowadays almost everything is available on the internet by the kindness of the Internet of Things(IoT). In cloud computing sometimes it takes so much time to perform successfully because of the large number of data and the delay caused by transferring the vast data to the cloud and back to the application. But in deadline-oriented cloud applications like health monitoring systems for a heart patient, it's highly needed the lowest latency and response time. Sometimes network congestion has occurred for huge data transactions and processing. To reduce latency, resource contention and network congestion Fog computing is a paradigm of IoT. It is an intermediate layer between the end devices and the cloud server and it instantly analyses the data before going cloud server. It uses network switches and routers, gateways, and mobile base stations to provide cloud service with minimum possible network latency and response time. To get efficient computing service between heart patient users and centralized cloud databases, Fog computing-based model is required to deliver healthcare as a fog-assisted cloud service. In this paper, they proposed an IoT-based fog-enabled cloud computing model for healthcare, which can manage the data of heart patients successfully without delay. It can also identify the heart diseases of a heart patient. It delivers healthcare as a cloud service using IoT devices. The model efficiently manages the data of heart patients and the iFogSim toolkit is used to analyze the performance of the proposed model in the Fog-enabled cloud environment. To implement their idea they use some modules like "Body Area Sensor Network", "IoT Devices", "Fog Server", "Resource Manager", "Cloud Data Center". In this research work, it provides healthcare as a cloud service and it can successfully manage the huge data from different IoT devices of heart patients and also solve the latency problem.

In paper[19], author introduced the fog technology. The technology of IoT is blessed to the health monitoring system. Recently there are developed many applications that require real-time data analysis and decision making especially mobile health and remote patient monitoring. But cloud computing can't fulfill all the requirements based on real-time data analysis. By using cloud computing IoT creates a huge amount of data to process. The data is transferred to the cloud and back to the application and this process takes a lot of time that is unexpected for a real-time remote health monitoring systems. To solve

this kind of problem advanced techniques and services are applied in this proposed model. Fog computing is an innovative solution to reduce the delay of a large number of data to process. It can handle real time-sensitive data at the network edge. Data mining is also a good technique to collect the necessary data from a huge amount of data which is generated by IoT. And distributed storage, and notification services, Temporal Mining, Temporal Health Index (THI), Bayesian Belief Network (BBN) are also great techniques for remote patient monitoring in real-time. Here they use fog computing services to identify patient health conditions as safe or unsafe and also reduce the amount of data that is transferred to the cloud for processing and analysis. Real-time events are monitored at the fog layer to compute the unfriendly event. The event triggering mechanism is adopted to transfer the patient's health-related vital signal to the cloud layer whenever the patient condition switches to a critical condition. To determine the urgent situation of the patient Temporal health index (THI) of the patient is computed at the cloud layer. There are different events for effective decision making. For handling medical emergencies Information deliverance to the responder from the cloud layer plays an important role. In case of emergency here generates a real-time alert, which plays an important role in the present healthcare system based on IoT.

2.2 Summary

Table 2.1: Summary Of Matrix table

Paper Title	ML Algo	Device	Area	Common Standard
The IoT-based heart disease monitoring system for pervasive healthcare service(Ref-1)	N/A	SpO2 Sensor device, Android smart phone	Heart disease monitoring	N/A
IoT based Heart Attack Detection, Heart Rate and Temperature Monitor(Ref-2)	N/A	Arduino Uno, Heart rate sensor,Wifi Module ESP8266, Temperature sensor LM35	Heart and Temperature monitoring	N/A
Internet of things (IoT) based smart health care system(Ref-3)	N/A	Arduino Fio, Temperature sensor, pulse rate sensor, blood pressure sensor	Measure body condition	N/A
IoT based Generic Health Care System(Ref-4)	N/A	Blood Suger sensor, Heart pressure sensor, Weight scale sensor	Integrated Cloud computing with IoT	N/A
Health Monitoring & Management using IoT devices in a Cloud Based Framework(Ref-5)	N/A	DS18B20, pulse sensor, ADXL335, AD8232	Body temperature, pulse rate, body position, ECG	N/A
Study and Implementation of IOT based Smart Healthcare System(Ref-6)	Neural Network	Pulse sensor, GSM module Atmega328 micro controller, Arduino Uno, LM35	Heart	N/A
An Implementation of IoT for Healthcare(Ref-7)	N/A	Intel Galileo Generation 2, XB24-B XBee S2 Modules, LM35 Temperature Sensor	Body temperature	N/A
AN IOT BASED PATIENT MONITORING SYSTEM USING RASPBERRY PI(Ref-8)	N/A	Raspberry Pi, Temperature sensor, Pulse rate sensor, MMA7260QT, Thermistor,	Pulse rate, Temperature, respiration rate, movement	N/A
A REVIEW PAPER ON SMART HEALTH CARE SYSTEM USING INTERNET OF THINGS(Ref-9)	N/A	DS18B20 temperature sensor, heartbeat sensor, arduino Uno, wifi module	Body temperature, Heart beat	N/A
Smart Health Care System Using Internet of Things(Ref-10)	N/A	Temperatue sensor, Hear rate sensor,GPS	Body temperature, ECG, blood pressure, Oxygen level	N/A
Smart Medicine and Physical Health System Using IoT(Ref-11)	N/A	N/A	Ontology based automating design methodology	N/A
A Custom Internet of Things Healthcare System(Ref-12)	N/A	Pulse, SpO2, GSR, Sphygmomanometer, accelerometer,EMG	Heart beat, Body movement, body temperature, Oxygen level	N/A

Chapter 3

Project Design

In this chapter, we will discuss methodology and design, hardware and software tools.

3.1 Methodology and Design

In figure 3.1, a wearable smart device has been shown. The device is assembled by some sensors like pulse sensor and temperature sensor.

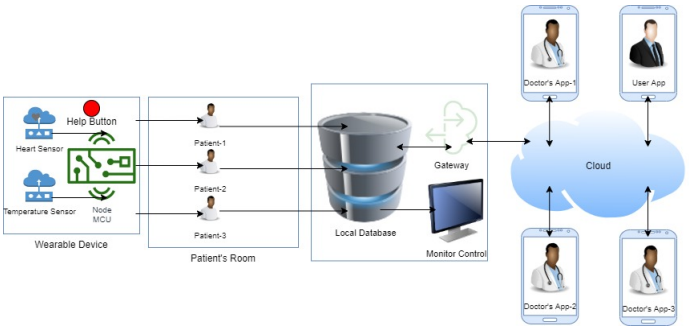

Figure 3.1: Project Architecture

This is the proposed system architecture. Our Proposed project will be used especially in clinic and hospital. In figure 3.1, we can see a device that is assembled with some sensors and a micro-controller. These sensors will collect data from patient's body and sends them to local database through micro-controller. These data will be stored and saved in the local database. In our system different patients will have different patient's ids. The data will be stored and updated using this patient's id. In figure 3.1, we can see the monitor control room. Nurses or doctors will be monitoring patient data from monitoring control room. In the monitor control room, the doctors or nurses can see the critical patient's list through a monitoring display.Doctors and nurses will also be notified if a patient will send an emergency alert through an alert button which is attached to the wearable device. From the local database, the data will be sent to the cloud through a gateway. Our system will be dealing with huge data. So, We will use a gateway to process the collected data and decide which data to forward to the cloud for user apps. Every patient has an assigned

doctor. Doctors will get notification of their specific patient. The doctor can monitor the patient condition using our web application. If a patient fall in a critical situation the doctor will be notified through the email and doctor can also give emergency suggestions using this web application. Relatives can also monitor the patient's condition through the internet using this mobile app.

3.2 Hardware and Software Tools

3.2.1 Hardware Tools

Temperature Sensor

The temperature sensor in figure 3.3 senses the temperature which is a digital sensor. The model of this sensor is DS18B20. It has one wire bus protocol that is only one data line communication with node MCU.

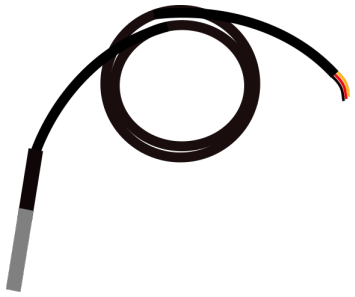

Figure 3.2: Temperature Sensor

Features Of Temperature Sensor

- This sensor measures the temperature from -55 degree C to 125 degree C.
- The accuracy is from -10 degree C to +85 degree C.
- The sensor has a programmable resolution from 9 bits to 12 bits.

Oximeter

The oximeter measures the amount of oxygen in patient's body.

Features of Oximeter Sensor

- Ultra-low power operation.
- Resilience integrated ambient light cancellation.
- High sampling capacity.
- Quick data output capacity.

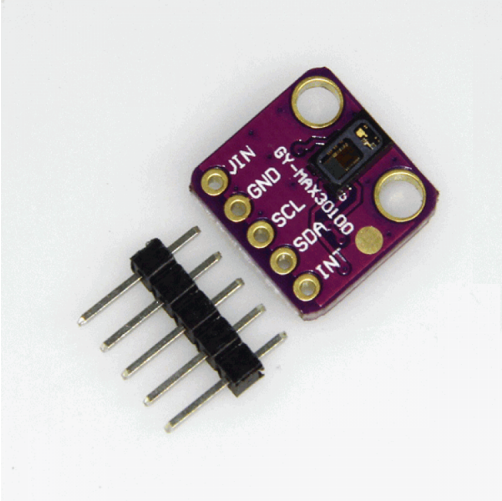

Figure 3.3: Oximeter Sensor

Pulse Sensor

It measures pulse of human body.

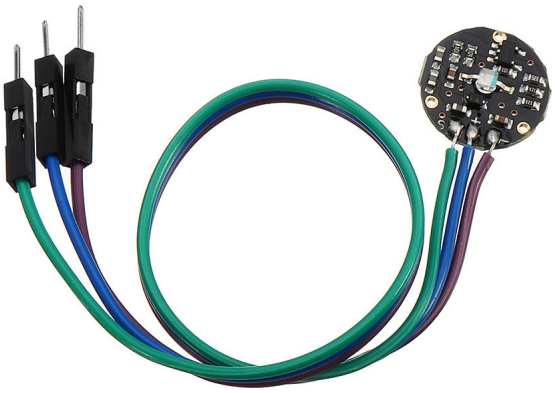

Figure 3.4: Pulse Sensor

Features of Pulse Sensor

- Plug and play capability.
- It operates +5v or +3.3v.
- Electricity utilization 0.004A.

- Thickness level 0.3175 cm

Node MCU

Node MCU is a programable microcontroller which is ESP8266 and wifi module is connected with it. Node MCU is an open-source development board and firmware based.

Figure 3.5: Node MCU Microcontroller

Features of Node MCU

- Connected with programmable Wifi module
- It has software defined hardware IO.
- PCB antena.
- The API is used for network application.

3.2.2 Software Tools

Arduino IDE

In figure 3.6, has shown Arduino IDE. Arduino is an open-source software. It runs on the Windows pc, Linux based platform, iOS platform. We can easily write code for microcontrollers and upload code to the microcontroller. This IDE is run on a java environment.

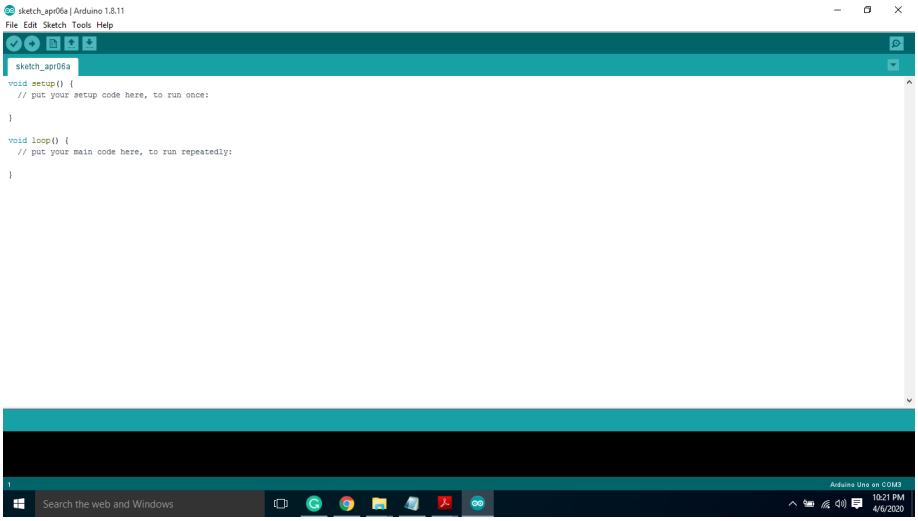

Figure 3.6: Arduino IDE

3.2.3 Atom

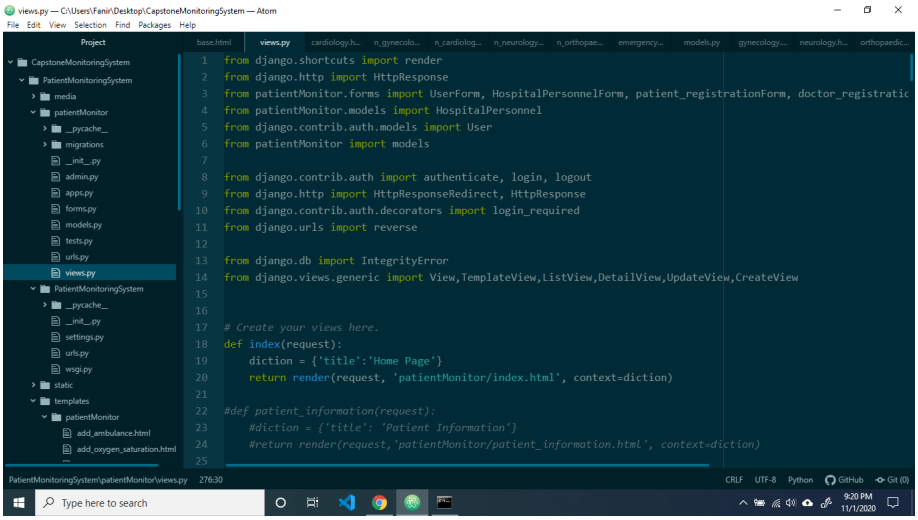

Figure 3.7: Atom IDE

In figure 3.7, has shown Atom that is a open source and free software which is used any operating system. Atom is used in built a website. This software is directly used in git control.

Chapter 4

Implementation and Results

In this chapter, We will discuss about environment setup, Implementation and result.

4.1 Environment Setup

First of all we have collected all the sensors those are fully functional and by assembling them together we made a wearable device. We downloaded the Arduino software for the coding part of the sensors. For developing monitoring system we have setup django and python environment. To write the code, We have downloaded atom IDE and installed it.

4.2 Algorithm

We have considered the normal body temperature which is generally accepted as 35.3 degree Celsius to 37.7 degree Celsius[20]. We have converted temperature as Fahrenheit (95.54 to 99.86).

```
for patients in allPatients do
    if patientDepartment EQUAL DepartmentName AND PatientMonitor EQUAL MonitorType then
        for sensors in Allsensors do then
            if sensorValue EQUAL LastValue then
                if ( Temperature GRATERthanEQUAL 99.86 AND Temperature LESSthanEQUAL 95.54
                    OR PulseRate GRATERthanEQUAL 90 AND PulseRate LESSthanEQUAL 60
                    OR OxygenSaturation LESSthan 90 OR EmergencyButton EQUAL YES ) then
                        Patient in Emergency Monitoring
                else
                    Patient in Normal Monitoring
                end if
            end if
        end for
    end if
end for
```

Figure 4.1: Emergency patient monitoring Algorithm

Formula:

- **F = (C * 9/5) + 32**[21]

Normal heart rate for adults adjusts from 60 to 100 beats per minute. We have used heart rate values which keeps between 60 to 90 beats per minute[22].

Normal oxygen saturation level lies between 95 to 100 percent which is considered as norm value. Here we have used the value is 91.322[23].

4.3 Implementation and Results

4.3.1 User Interface and Functionalities

The outlook of our monitoring system is shown in figure 4.1. Here is the home page where our system is categorized in different navigation bar. We have classified our monitoring display with several departments (Cardiology, Neurology, Gynecology, Orthopaedics). We will be monitoring the display through department-wise which will maintain by our trained nurses who can operate the system. In different departments, individual nurses will monitor the patient's monitoring display.

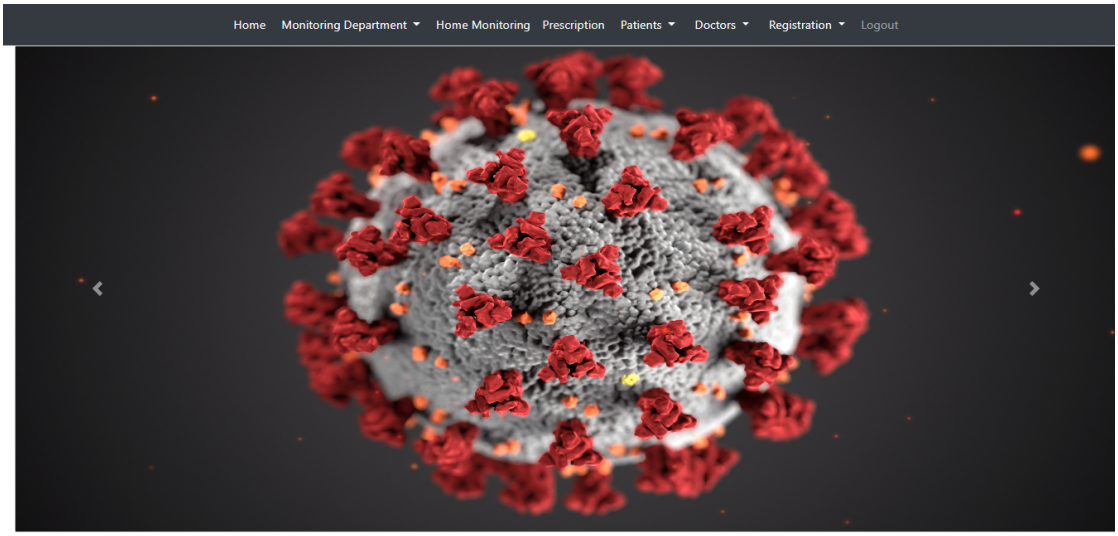

Figure 4.2: Home Page

Registration

In figure 4.2, the hospital admin registration is shown. This page is for the people of the hospital administration. There are 6 input criteria which are as follows: First name, last name, username, email address, password and phone number. The username is a required field which means without is the registration can not be completed. A username can only contain letter, digits and any of these @/./+/-/_ symbols.The username also has to be within 150 characters. The email address field is for the email of the admin. The password

is also another required field And an admin should use a password which is known only to him/her. Finally the phone number field should be filled with an active telephone/cellular phone number belonging to the admin.

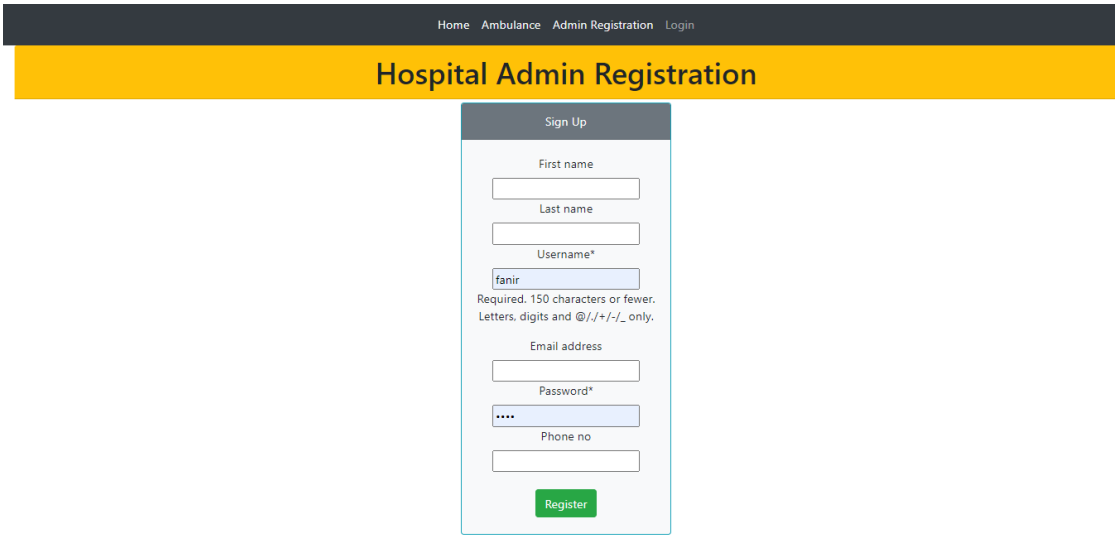

Figure 4.3: Hospital Admin Registration

The doctor's registration is shown in figure 4.4. Hospital admin can register the doctors through this page. Doctor's registration form has 8 input criteria which are the followings: Doctor Name, Designation, Department, Hospital Name, Blood Group, Phone No, Password and Username. Department field is categorised in specific department whom are required for this position. Doctor has their own login credential for access this system those are username and password. Username and Password are unique for individual doctor.

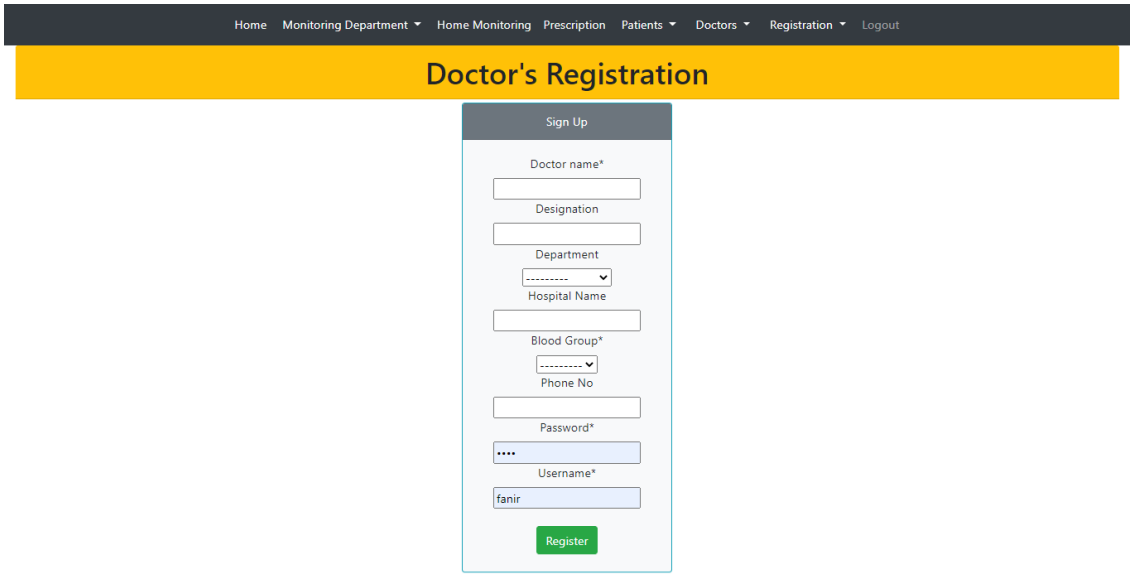

Figure 4.4: Doctor's Registration

Figure 4.2 shows the patient registration page. Hospital administration can use this page to register new patient. There are 14 input criteria which are Patient name, Age, sex, Blood Group, Weight , Height, Ward No, Room No, Bed No, Phone No, Patient ID, Department, Monitoring, Doctor name. The Ward No, Room No and Bed No is used to quickly and accurately locate the patient in the hospital. Department is to select in which department (eg: Cardiology, Neurology etc) the patient is admitted. The doctor field contains the assigned doctor's name for that patient.

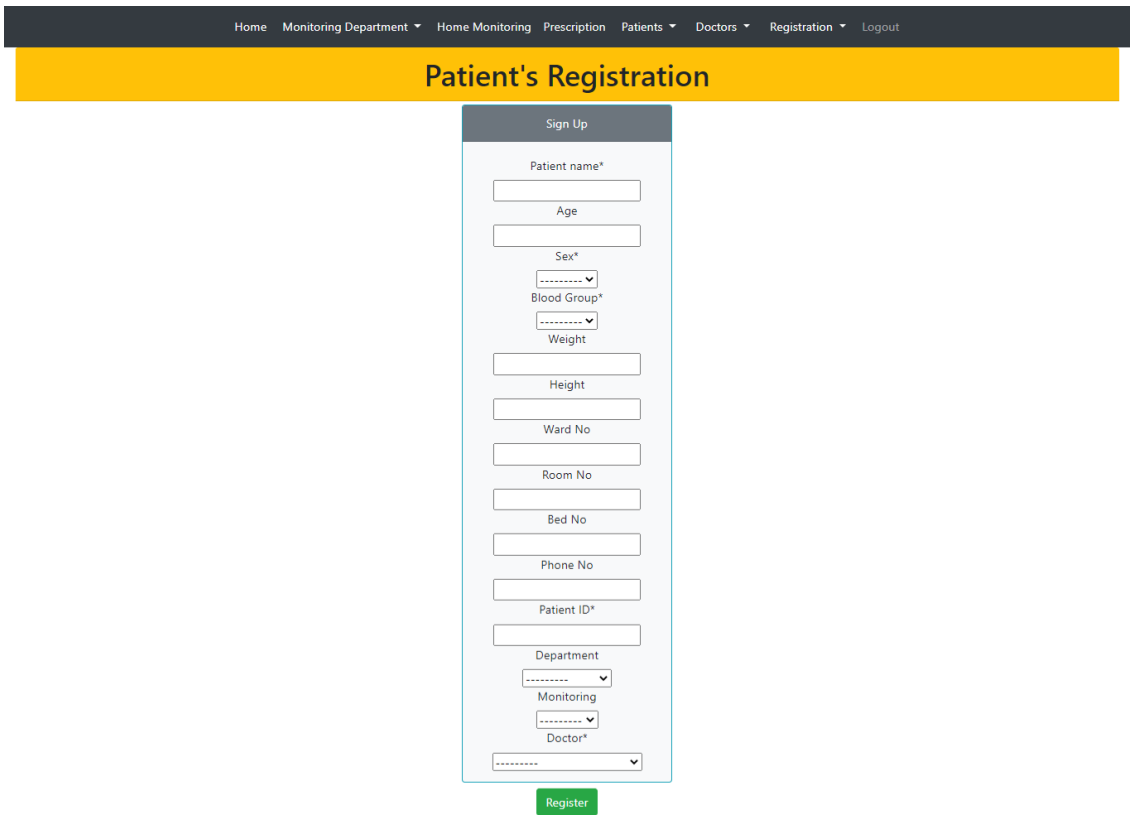

Figure 4.5: Patient's Registration

The login page is shown in figure 4.6. Only the registered admin personal and the registered doctors can log in using their username and password through this page.

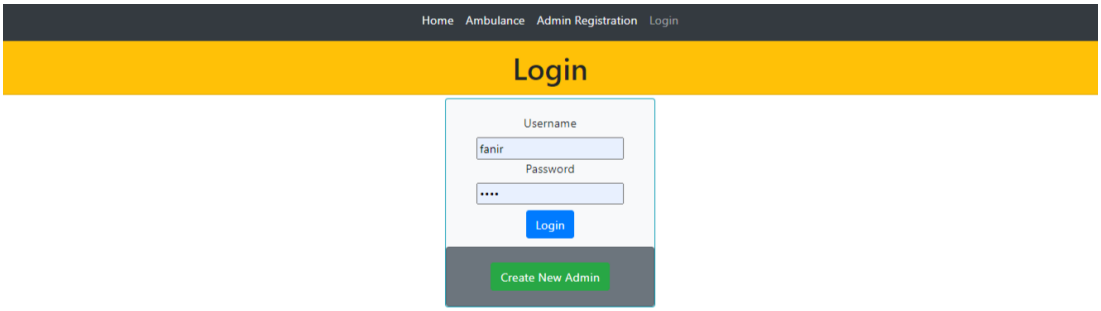

Figure 4.6: Login

Doctor

The doctor list page provides a list of all the doctors of the hospital which is represented in following figure 4.7.

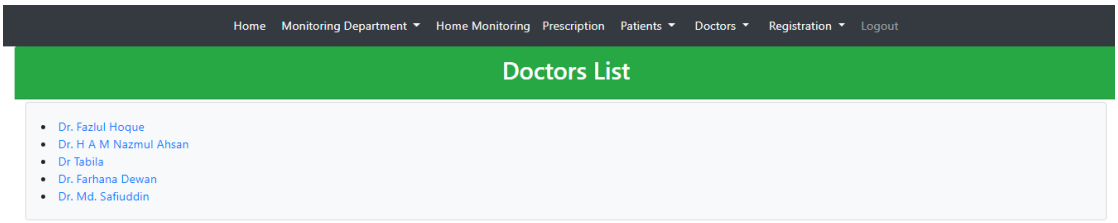

Figure 4.7: Doctors List

There are also individual pages foe each department of the hospital with the doctors working in that particular department. Figure 4.8 shows an example of these department wise doctors list pages.

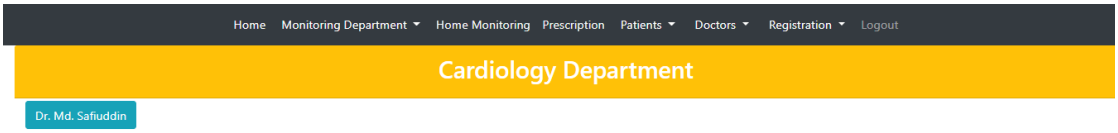

Figure 4.8: Individual Department wise Doctors

From any doctor list page, clicking a doctor's name opens the page with the detailed information of that doctor which is shown in figure 4.6. This figure also shows that each doctors information page contains a "Assigned patient" section. This section lists the name of the patients to whom that doctor is currently assigned.

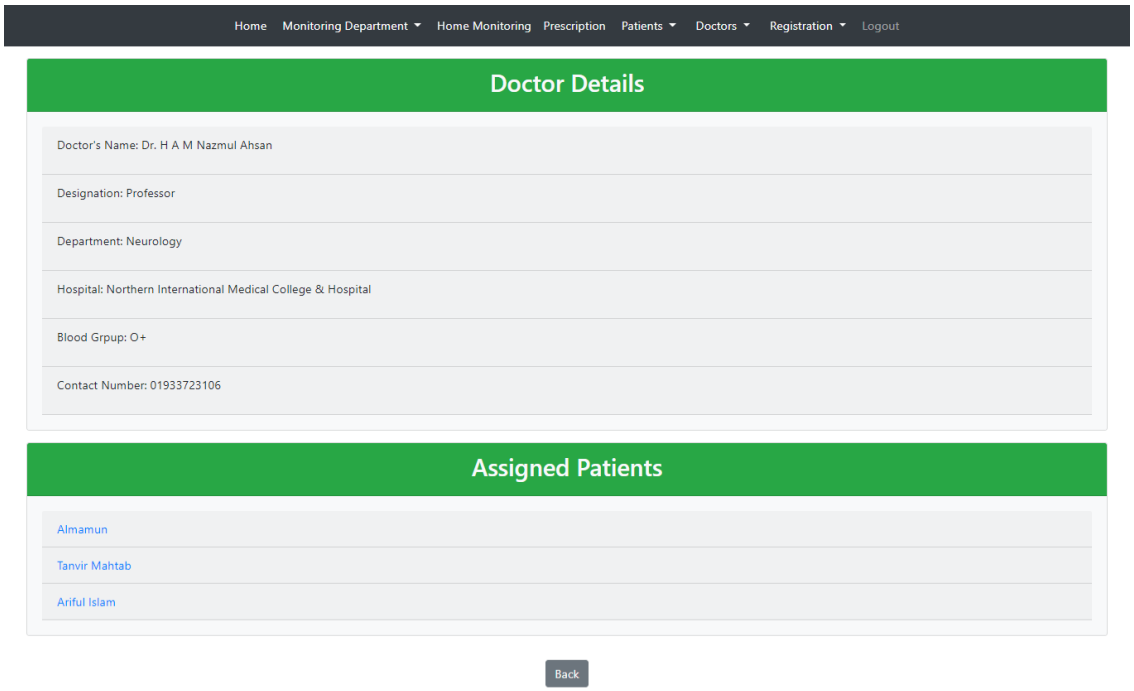

Figure 4.9: Doctor's Details

Patient

Similar to the doctor list pages, there are also a Patient list.This general patient list contains all the patient's name who are currently admitted in the hospital as shown in figure 4.10.

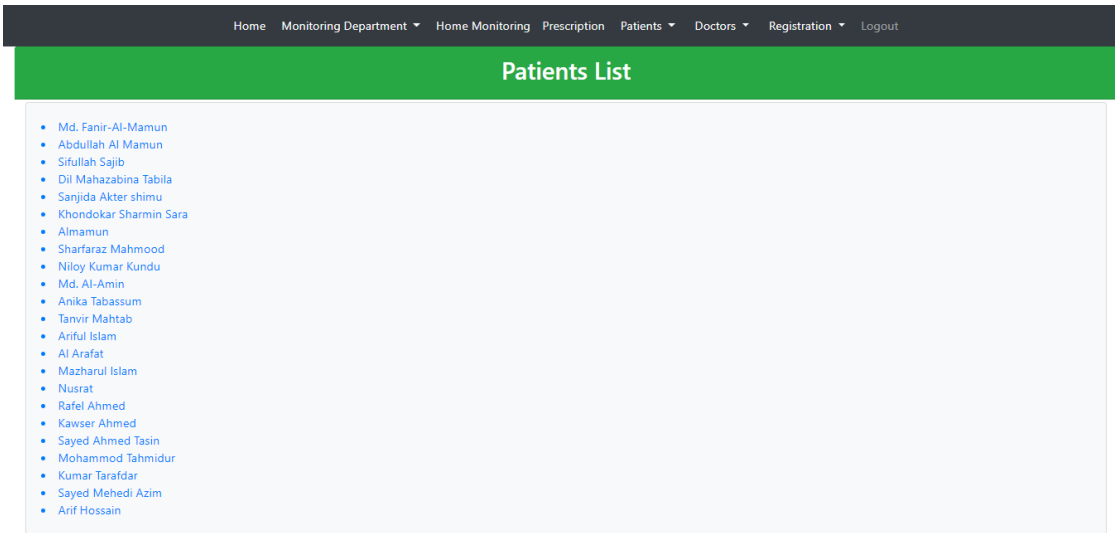

Figure 4.10: Patient List

There are individual patient list pages for each department which is shown in figure 4.11.

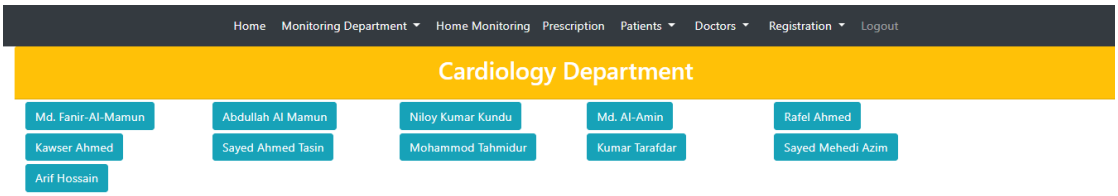

Figure 4.11: Individual Department Patient

A patient's details can be seen by clicking the name from a list. This detailed information page provides thee section. The "Patient details" section list all the stored information about the patient which was recorded at the time of registration.

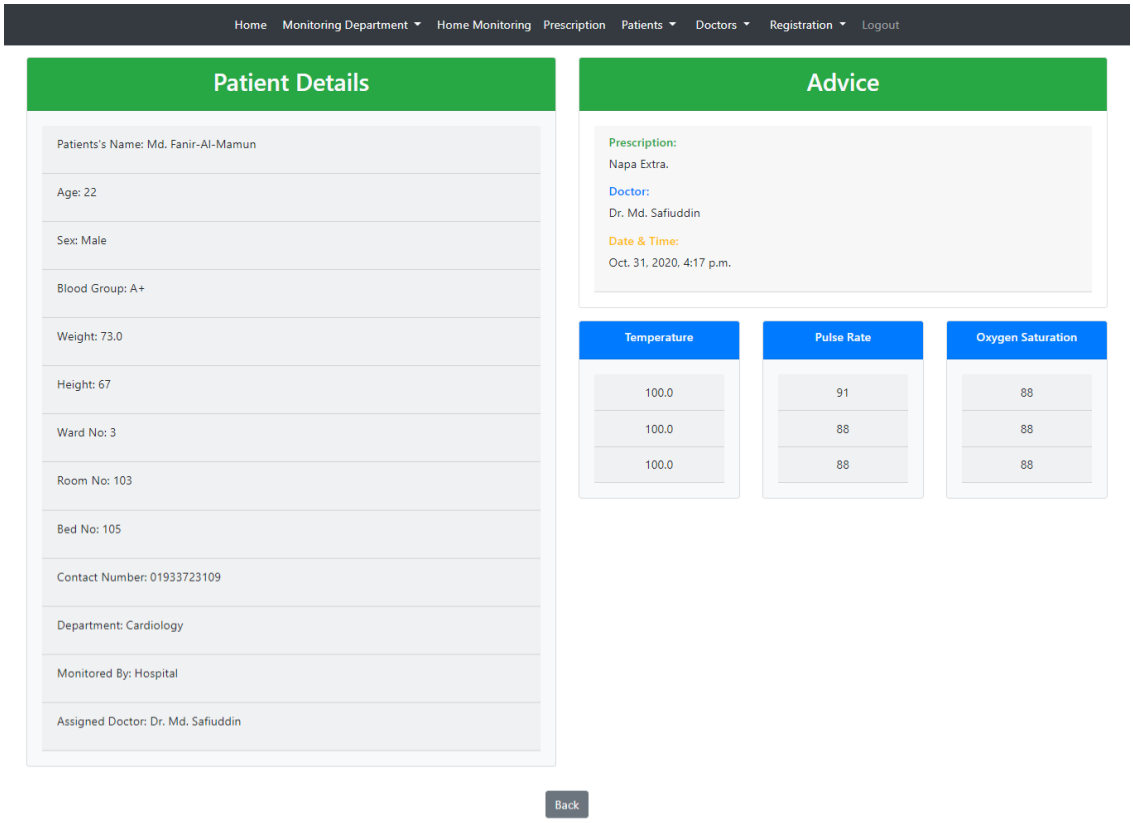

Figure 4.12: Patient Details

The "Advice" section provides any advice prescribed by the doctor for the patient through the prescription page which is shown in figure 4.16. This section also shows the

time of the last prescription. Lastly, the section below "Advice" is for the readings from the sensors attached/used for the patient. Each device has a list for itself. The devices send their readings over the network and these data are shown their corresponding lists.

4.3.2 Monitoring

The figure 4.13 represents individual emergency monitoring department, a nurse can observe the critical patient's information such as temperature, blood pressure, oxygen saturation level etc.

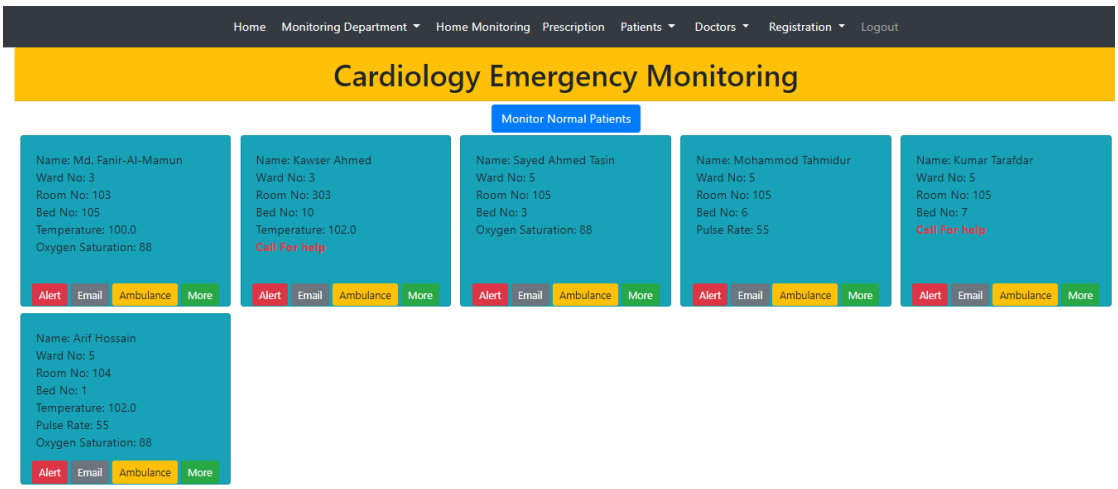

Figure 4.13: Individual Emergency Monitoring Department

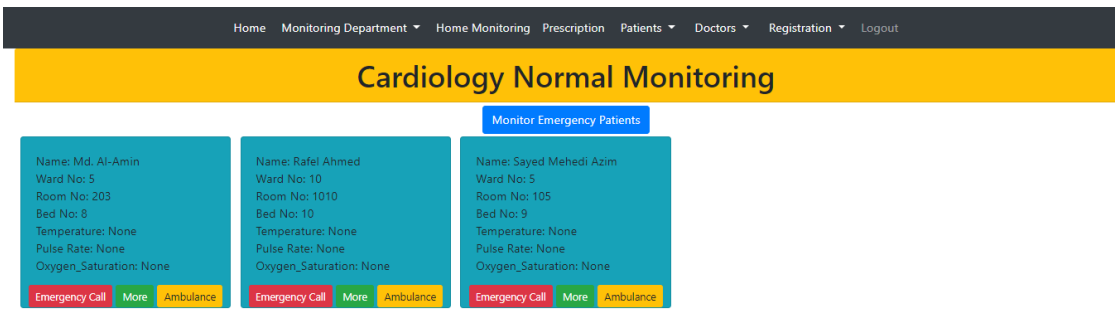

Figure 4.14: Individual Normal Monitoring Department

If the value of these perimeters cross a threshold limit (normal body temperature 95.54 to 99.86 degree Fahrenheit, normal oxygen saturation level 95 to 100, normal heart rate

for adults 60 to 100 beats per minute), an alert signal will be generated automatically through an alert button. A nurse who is monitoring the patients through this web page, can also press the alert button if he/she find any abnormality in patient health condition.

A physical alert system will be activated if the "ALERT" button is pressed that is implemented on our web page. If any duty doctor listens to the alert signal, he/she can checkout the web page and can easily find the patient for whom the alarm is generated. Because when the alert is generated for a patient,the alert button will turn into red to black. After hearing the alarm when a duty doctor enter into the web page, he/she can easily detect the patient by seeing the black alert button. Afterwards the duty doctor

Figure 4.15: Emergency Alert

will see the patient information (word no, bed no) by clicking the "MORE" button. After checking the information, doctor will take necessary step which will be suitable for the patient for that time. Figure 4.15 shows the emergency case alert notification page.

4.3.3 Prescribing

If duty doctor does not understand patient condition, they can call the assigned doctor. But there is also a system in our system that will send an email to the assigned doctor automatically when the alarm button will be activated. If the assigned doctor is notified through the email or by the duty doctor, he can suggest a prescription by our system. There is a system called "PRESCRIPTION" where a doctor can prescribe for that patient and this prescription will be sent to the patient's "ADVICE" list. Figure 4.16 shows this system. This prescription will be stored and can be accessible by the duty doctor so that he/she can take proper step if the assigned doctor is absent at that moment.

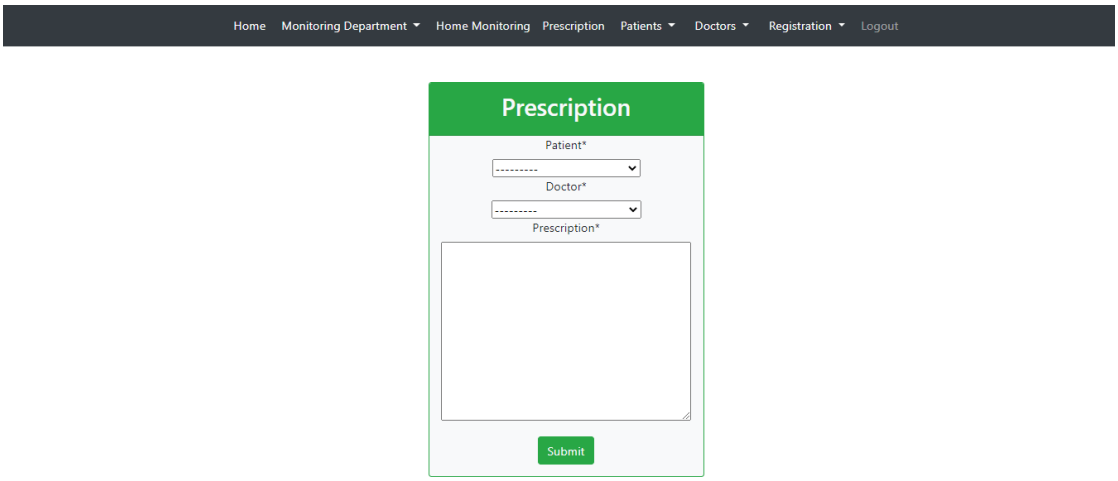

Figure 4.16: Prescription

4.3.4 Ambulance

There is a page for registering new ambulance for the hospital administration. Figure 4.17 is a capture of this page.

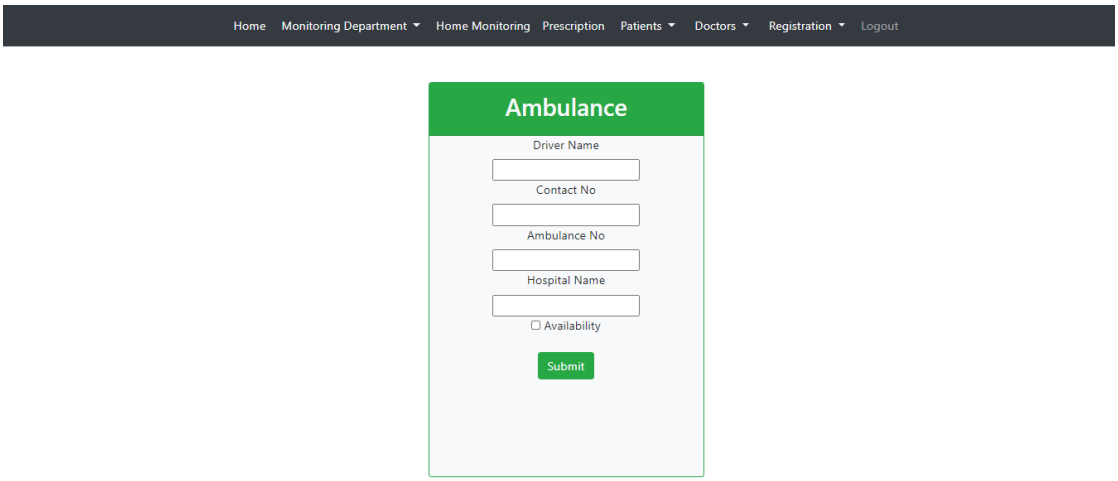

Figure 4.17: Ambulance Registration

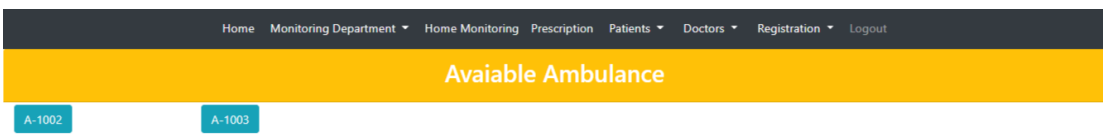

Figure 4.18: Available Ambulance

In our system there is also a sub-system for booking an ambulance that is shown in

figure 4.18. For the reason that, if a patient is in serious condition, he/she may need to be transferred to another hospital or when the patient is discharged from the hospital, he/she may need for ambulance help.

From the available ambulance list page user can see the details for each individual ambulance which can be seen in figure 4.19. In the details page of the ambulance the option to book/unbook can be found below the details list. This option takes the user to the booking/unbooking page. Figure 4.19 and 4.20 gives an example view of this process.

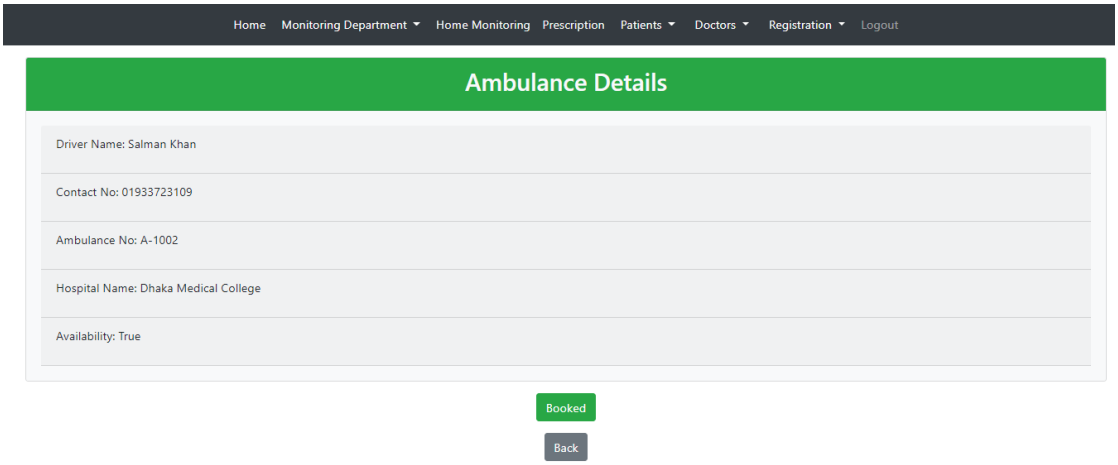

Figure 4.19: Ambulance Details

Figure 4.20: Ambulance Booking

4.3.5 Home monitoring for the Doctors

Due to this pandemic situation, we added a separate feature home monitoring for a certain period. When a patient is discharged form the hospital, there is also a sub-system called "HOME MONITORING" is shown figure 4.21. Here, an assigned doctor will supervise the patient's health condition whether it is stable or the condition become in rogue state for 72hours. By this time period, patient information will be monitoring through our system. If the system can find any abnormality in patient's health condition, the patient's relatives can book a ambulance using our system to take the monitoring patient back to the hospital.

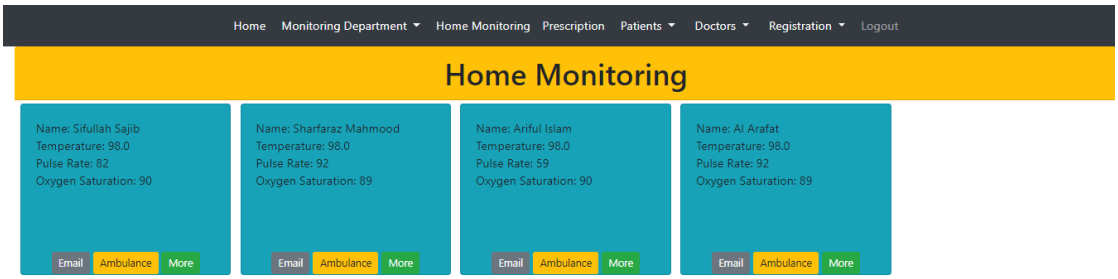

Figure 4.21: Home Monitoring

4.3.6 Database

Entity Relationship Diagram

In figure 4.22 is shown an entity-relationship diagram. This is a relational database of our system. There are seven tables. Doctor registration, Patient registration, Hospital personnel, Sensors, Prescription, User, and Ambulance. The user table is a build-in the table of Django. This table is connected with doctors and hospital personnel. Hospital personnel can anything manage this system. Doctor table and patient table connect with many to one relationship. The patient table and sensors table has many to many relationships. The patient table has established many to many relationships with the prescription table. The ambulance table is a floating table. There is no relation to any table.

Django Administration

In figure 4.23 is shown Django administration which is controlled by super admin. This is a Django admin database. Django admin database uses SQLite. Here, all the tables and

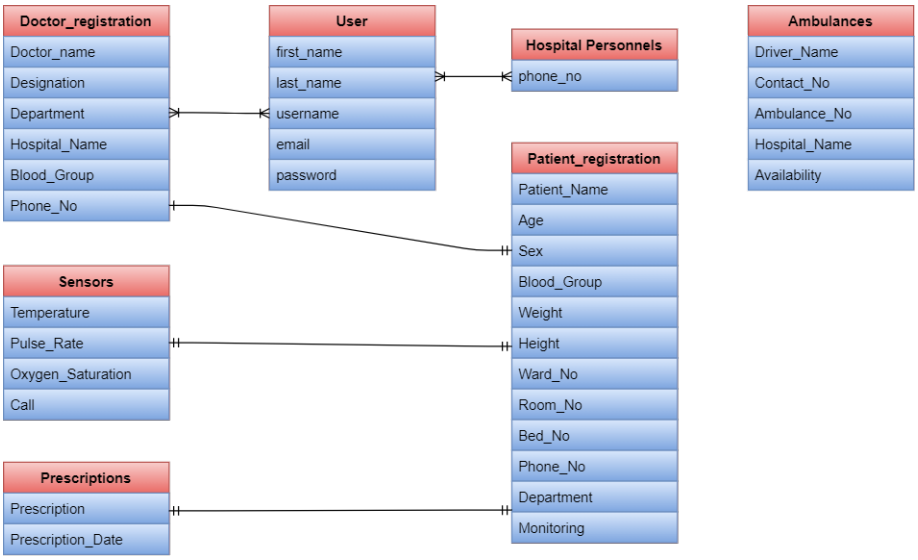

Figure 4.22: Entity Relation Diagram

their data are shown. We have used Django admin because here is used dummy data of sensors.

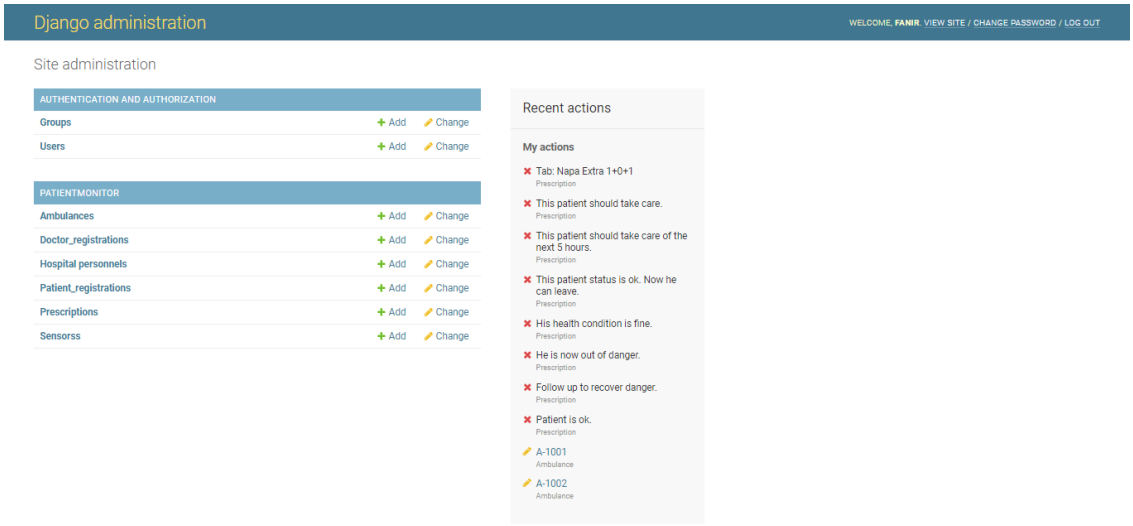

Figure 4.23: Django Administration

Chapter 5

Standards and Design Constraints

In this chapter, we will discuss about compliance with the standards and design constraints.

5.1 Compliance with the Standards

We have mention the standards that are related to our project.

5.1.1 Software Standard

- The Linux Standard Based(LSB).
- International Organization for Standardization(ISO).

5.1.2 Hardware Standard

- IEEE 1451

5.1.3 Programming Language

- Python
- C
- C++
- Arduino Programming Language

5.1.4 Framework

- Django

5.1.5 Database

- SQLite
- MySql

5.1.6 Communication Standard

- IEEE 802.11

5.2 Design Constraints

5.2.1 Economic Constraint

Moreover, a health care services recognition to increase the benefits of health. Due to budget restriction we are not able to use better hardware components for getting more appropriate results. If we want to introduce our hardware components in population based hospital, we could be faced funding problem to contain hardware costs.

5.2.2 Environmental Constraint

To run this system we will use some energy which will put out some extra Carbon-dioxide to the environment. After setting up, the system will use some electric power to run.

5.2.3 Ethical Constraint

As our system will be provided as secure software based so there have no probability of leaking patient's health information. We are ensuring the patient's confidentiality that informs about a patient's medical condition which is considered as private. Therefore, our system has no ethical constraint to Violet the system.

5.2.4 Health and Safety Constraint

We are so conscious about our device that the device will not cause any harm to the users. As much the device is so user friendly, so this wearable device is not detrimental for patient's body.

5.2.5 Social Constraint

As this is an automated system, so the system will reduce some medical personnel in the hospital and clinic.

5.2.6 Manufacturability and Cost Analysis

Though manufacturing cost of our device is very high, but manufacturing the device in large number will be very cost effective for the users. Throughout the manufacturing process, medical device can easily find out the patient's information faster and more efficient with using these cost effective tools.

5.2.7 Sustainability

Our device is so sustainable that it can long last and rapid updates will not be necessary.

Chapter 6

Conclusion

In this chapter, we will discuss conclusion and our future work.

6.1 Conclusion

Our goal was to create a system that will improve the monitoring of the patient's health condition and we have implemented the complete system that realizes the objectives that we had defined. This system is a fast and real-time tracking using IoT applications for improving healthcare system. With the integrates monitoring and ambulance booking process, this system can help the full medical structure. Our system also provides a common platform where patients, doctors and medical administrative communicates with each other conveniently.

6.2 Future Work

As for future work, we plan on improving this work in multiple ways since are many criteria to improve upon. Our future plans can be described as follows:

- Firstly, We plan to improve this work by using more advanced sensors. We also want to add more features which can be done bay adding more sensors/devices to the system.
- We have implemented our proposed system using a website. Our next approach will be to develop a mobile application as mobile can provide a more convenient way to monitor the patients.
- Our system reads a lot of data from different sensors/devices which provides a lot of data. These data can be use to implement machine learning models such as neural network for analyzing patient's health condition.
- There is a lot of scopes to improve in the system where the requirements of the hospitals can implemented.

References

[1] Chao Li, Xiangpei Hu, and Lili Zhang. The iot-based heart disease monitoring system for pervasive healthcare service. *Procedia computer science*, 112:2328–2334, 2017.

[2] S Gowrishankar, MY Prachita, and Arvind Prakash. Iot based heart attack detection, heart rate and temperature monitor. *International Journal of Computer Applications*, 170(5):26–30, 2017.

[3] Vikas Vippalapalli and Snigdha Ananthula. Internet of things (iot) based smart health care system. In *2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)*, pages 1229–1233. IEEE, 2016.

[4] JV Alamelu and A Mythili. Design of iot based generic health care system. In *2017 International conference on Microelectronic Devices, Circuits and Systems (ICMDCS)*, pages 1–4. IEEE, 2017.

[5] Anirvin Sharma, Tanupriya Choudhury, and Praveen Kumar. Health monitoring & management using iot devices in a cloud based framework. In *2018 International Conference on Advances in Computing and Communication Engineering (ICACCE)*, pages 219–224. IEEE, 2018.

[6] Naina Gupta, Hera Saeed, Sanjana Jha, Manisha Chahande, and Sujata Pandey. Study and implementation of iot based smart healthcare system. In *2017 International Conference on Trends in Electronics and Informatics (ICEI)*, pages 541–546. IEEE, 2017.

[7] Ravi Kishore Kodali, Govinda Swamy, and Boppana Lakshmi. An implementation of iot for healthcare. In *2015 IEEE Recent Advances in Intelligent Computational Systems (RAICS)*, pages 411–416. IEEE, 2015.

[8] R Kumar and M Pallikonda Rajasekaran. An iot based patient monitoring system using raspberry pi. In *2016 International Conference on Computing Technologies and Intelligent Data Engineering (ICCTIDE'16)*, pages 1–4. IEEE, 2016.

[9] K Natarajan, B Prasath, and P Kokila. Smart health care system using internet of things. *Journal of Network Communications and Emerging Technologies (JNCET)*, 6(3), 2016.

[10] Zankhana Mehul Kalarthi. A review paper on smart health care system using internet of things. *International Journal of Research in Engineering and Technology*, 5(03):8084, 2016.

[11] P Elanthiraiyan, Dr S Babu, et al. Smart medicine and physical health system using iot. *International Journal of Computer Science and Mobile Computing*, 4(3):333–338, 2015.

[12] Mirjana Maksimović, Vladimir Vujović, and Branko Perišić. A custom internet of things healthcare system. In *2015 10th Iberian Conference on Information Systems and Technologies (CISTI)*, pages 1–6. IEEE, 2015.

[13] Musaed Alhussein, Ghulam Muhammad, M Shamim Hossain, and Syed Umar Amin. Cognitive iot-cloud integration for smart healthcare: case study for epileptic seizure detection and monitoring. *Mobile Networks and Applications*, 23(6):1624–1635, 2018.

[14] M Shamim Hossain, Ghulam Muhammad, and Atif Alamri. Smart healthcare monitoring: A voice pathology detection paradigm for smart cities. *Multimedia Systems*, 25(5):565–575, 2019.

[15] Abdul Ahad, Mohammad Tahir, and Kok-Lim Alvin Yau. 5g-based smart healthcare network: architecture, taxonomy, challenges and future research directions. *IEEE Access*, 7:100747–100762, 2019.

[16] Amir-Mohammad Rahmani, Nanda Kumar Thanigaivelan, Tuan Nguyen Gia, Jose Granados, Behailu Negash, Pasi Liljeberg, and Hannu Tenhunen. Smart e-health gateway: Bringing intelligence to internet-of-things based ubiquitous healthcare systems. In *2015 12th Annual IEEE Consumer Communications and Networking Conference (CCNC)*, pages 826–834. IEEE, 2015.

[17] Md Golam Rabiul Alam, Md Shirajum Munir, Md Zia Uddin, Mohammed Shamsul Alam, Tri Nguyen Dang, and Choong Seon Hong. Edge-of-things computing framework for cost-effective provisioning of healthcare data. *Journal of Parallel and Distributed Computing*, 123:54–60, 2019.

[18] Sukhpal Singh Gill, Rajesh Chand Arya, Gurpreet Singh Wander, and Rajkumar Buyya. Fog-based smart healthcare as a big data and cloud service for heart patients using iot. In *International Conference on Intelligent Data Communication Technologies and Internet of Things*, pages 1376–1383. Springer, 2018.

[19] Prabal Verma and Sandeep K Sood. Fog assisted-iot enabled patient health monitoring in smart homes. *IEEE Internet of Things Journal*, 5(3):1789–1796, 2018.

[20] Ziad Obermeyer, Jasmeet K Samra, and Sendhil Mullainathan. Individual differences in normal body temperature: longitudinal big data analysis of patient records. *Bmj*, 359, 2017.

[21] Colin Hester. Celsius to fahrenheit—quick and dirty. *Journal of Chemical Education*, 72(11):1026, 1995.

[22] Robert Avram, Geoffrey H Tison, Kirstin Aschbacher, Peter Kuhar, Eric Vittinghoff, Michael Butzner, Ryan Runge, Nancy Wu, Mark J Pletcher, Gregory M Marcus, et al. Real-world heart rate norms in the health eheart study. *NPJ digital medicine*, 2(1):1–10, 2019.

[23] Gözde Ateş and Kemal Polat. Measuring of oxygen saturation using pulse oximeter based on fuzzy logic. In *2012 IEEE International Symposium on Medical Measurements and Applications Proceedings*, pages 1–6. IEEE, 2012.