ASHESI UNIVERSITY

HEALTH KIOSK: AN IOT BASED COMMUNITY HEALTH CENTER

CAPSTONE PROJECT

B.Sc. Computer Engineering

Francis Aweenagua

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CAPSTONE PROJECT

Capstone Project submitted to the Department of Engineering, Ashesi University in partial fulfilment of the requirements for the award of Bachelor of Science degree in Computer Engineering.

Francis Aweenagua

2021

DECLARATION

I hereby declare that this capstone is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

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Candidate's Name:

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I hereby declare that preparation and presentation of this capstone were supervised in accordance with the guidelines on supervision of capstone laid down by Ashesi University.

Supervisor's Signature:

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Supervisor's Name:

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Date:

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Abstract

Timely access to quality healthcare is an essential part of the well-being and health of individuals in any community. However, access to healthcare has been a significant problem throughout the world. The WHO estimates that over 50% of the world's population do not have access to needed healthcare services. This reveals the massive gap between the available healthcare facilities and the demand for healthcare. In Ghana and most developing countries, the lack of health facilities has resulted in overcrowding in hospitals and pressure on the available facilities. It is against this backdrop that this project seeks to design and develop an IoMT Point of Care (POC) system (called the Health Kiosk) to bridge the gap between the availability and demand for healthcare at a relatively lower cost. The Health Kiosk is comprised of a hardware component that collects patient's vitals and transmits them to an online database. The vitals can then be accessed from a web application that collects patient health records and enables doctors to provide diagnoses and prescriptions. This system also hopes to enable doctors to track their patients' medical history while allowing patients to monitor their health on the go.

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Chapter 1: Introduction

1.1 Background

The Internet of Things (IoT) has introduced a new technological paradigm where the remote collection, transmission, management, and analysis of data from diverse sources has become not only easy but also more efficient. In simple terms, IoT refers to establishing connections between unconnected objects or systems and enabling them to communicate with similar or different objects, systems, or people [1]. Additionally, IoT helps us sense and manage or control the physical world through smart objects and networks between them [1]. This involves connecting different sensors to measure or sense changes in a system or environment, using a communication device to transmit sensor data, and responding to the change using an actuator [1]. However, to make these functionalities possible, there is a need for a processing unit and some form of data storage [1]. Kevin Aston initially coined the term in 1999 [1] and has since seen immense development and growth over the past 20 years. Its applications now span diverse fields and domains ranging from agriculture, transportation, healthcare, security, and many more. The unimaginable and immeasurable potential of IoT has made it ubiquitous and has therefore attracted many researchers over the past two decades. One field of science that has not been spared by the advancements in IoT is medicine and healthcare. Multiple research activities have been conducted over the years to explore IoT's beneficial applications and how they can be enhanced to improve healthcare delivery [2]. These research explorations fall under a model of healthcare called e-Health [2].

The term e-Health is a concept that refers to a new healthcare system that embraces the combination of health science and technology by utilizing Information and Communication Technology (ICT) to provide and enhance healthcare delivery to individuals and communities [3]. In other words, it encompasses the idea of adopting Information and Communication Technology (ICT) to provide solutions for healthcare and healthcare-related fields, including healthcare delivery, services, research, surveillance, education, among others [4]. Research into the applications of e-Health generally focuses on improving healthcare services and the cost of delivery together with enhancing communication among patients, health professionals, and other stakeholders [2]. Several significant breakthroughs have been made in this field over the past years, and researchers are continuously working to enhance the current state of technologies.

An amalgamation of IoT and e-Health introduces a new branch known as the Internet of Medical Things (IoMT). This involves applying IoT in medical devices to monitor and transfer medical data with little or no patient to health specialist physical interaction [5] [6]. This paradigm introduces limitless opportunities in real-time remote patient monitoring, improved emergency response, remote access to healthcare, and many more [5]. Among the many advantages of IoMT, it brings to the table a cost-effective and time-efficient approach to delivering healthcare. Besides alleviating the demand for hospital facilities such as hospital beds, and devices like ECGs, it also has the potential to reduce the overcrowding witnessed in many hospitals drastically.

1.2 Problem Definition

IoMT solutions can be classified into remote health monitoring devices, ingestible sensors or smart pills, fitness wearables, among others [6]. This range of solutions tends to be proprietary and expensive. They are usually affordable to only the middle and upper class in society. Additionally, these devices are designed for private or individual use and do not benefit a wider population. Therefore, poor and deprived communities that lack health facilities such as hospitals and clinics are unable to take advantage of IoMT devices due to its financial and private use constraints. This presents a significant problem for developing countries and poor communities where healthcare access is a serious challenge.

According to WHO, half of the world's population does not have access to the needed health services [7]. Indicating that over 3.5 billion people lack coverage for essential health services across the world. This shocking information reveals the huge gap between the availability of healthcare facilities and the demand for such resources. In Ghana and most developing countries, the lack of health facilities has resulted in overcrowding in hospitals and pressure on the available facilities. Inevitably, this challenge leads to avoidable health complications and casualties since patients are unable to obtain the medical care they need. Moreover, about 800 million people worldwide spend at least a tenth of their household budget on healthcare costs [7]. According to the WHO, this sends approximately 100 million people into extreme poverty [7]. Intuitively, this can be attributed to the high cost of healthcare delivery in many countries across the world. Therefore, the need for cheaper and more accessible means of delivering healthcare services cannot be overemphasized.

1.3 Project Objectives

One cost-effective healthcare delivery model that can be adopted into IoMT is the Point-of-Care (POC) system. The POC system has been in use for healthcare service delivery for some time now and has primarily been used as testing centers in communities [8]. This system involves offering healthcare services or clinically actionable information close to the patient [8]. This model sometimes comes in the form of health kiosks set-up in communities to provide essential services like disease testing and drug dispensing to patients. Point of Care models of healthcare service delivery has been found to provide rapid information results, reduced visits to hospitals, increased, and cost-effective access to healthcare services [8]. In most developed countries, this model is used as testing centers to support traditional laboratories [8]. Therefore, this model provides a viable opportunity to bridge the enormous gap between availability and demand for healthcare services.

The aim of this paper is to integrate the healthcare model of Point of Care systems into IoMT. This adopts POC systems' availability and cost effectiveness into IoMT models to make healthcare delivery much cheaper and available. This promises to help bridge the considerable gap between the availability and demand for healthcare at a relatively lesser cost to individuals, hospitals, stakeholders in the health sector, and governments.

To accomplish this aim, the key objectives and deliverables of this project are listed below.

1. **Design and build an IoT health kiosk equipped with sensors to collect vital signs of patients and transmit to a health professional.**

   – This objective seeks to guide the design and development of the hardware component of this project.

   – It entails building a housing unit (Kiosk) to contain the required sensors and other devices. It will also provide a conducive environment for collecting user/patient vitals.

   – This unit will contain a functioning setup made of a microcontroller, appropriate sensors and actuators, and communication devices to collect, process, and transmit patient data.

2. **Development of a web-based Control panel for health personnel and patient's web application.**

   – The objective seeks to guide the development of two web applications to facilitate this project's operation.

   – The web-based control panel will help health professionals access patient data and provide a means for communicating back to the patient with diagnosis, prescriptions, and recommendations.

   – The patient's web application will serve as a platform for collecting the patient's information, including symptoms and ailment duration, among others. It will also enable the patient to receive feedback, prescription, and recommendations from doctors.

3. **Ensure seamlessly integrated hardware and software systems for efficient healthcare delivery.**

   – This objective will ensure that this project's hardware and software components are smoothly integrated and coordinated to function effectively and efficiently in providing uninterrupted healthcare delivery to patients.

Chapter 2: Literature Review and Related Work

The IoMT research space has seen several research works geared toward improving the technologies available. These research works have been the reason for the massive improvements and developments evident in this field. Although quite a number of these research works are targeted at improving the present technologies, several are also geared towards applying such technologies to develop solutions for individuals and communities. In retrospect, a good majority of such solutions are monitoring systems to help communicate patient data and vitals to health professionals. This chapter discusses and presents a critical review of a selected number of related work. The underlying limitations of these works will also be highlighted to serve as insight for this project. These research works seek to solve diverse patient–health personnel problems in different parts of the world and offer great insight for this project.

2.1 eSmart: An IoT based Intelligent Health Monitoring and Management System for Mankind

The increasing demand for health care monitoring for people worldwide is making it more and more difficult for several patients to afford frequent monitoring by health personnel. However, this paper seeks to solve this problem by designing and developing an IoT system to monitor and report patients' vitals, including oxygen saturation (SpO2), heart rate, and body temperature [9]. The paper develops a hardware unit to collect the required data from patients using appropriate sensors [9]. The data is then transmitted to a mobile application on the patient's phone using Bluetooth technology and another mobile application on the doctor's phone using web technologies [9]. The project's main objective is to establish reliable communication between patients and doctors for regular monitoring [9]. The researchers accomplished this aim and managed to measure and transmit heart rate values similar to modern equipment used in hospitals with minimal error [9]. In future works, the researchers hope to include a patient-doctor chatting feature in the application making it more convenient to use [9].

2.2 IoT Based Emergency Health Monitoring System

Monitoring admitted hospital patients 24/7 is increasingly becoming impossible for several hospitals due to the cost it comes with and the resources it requires [10]. In this paper, the researchers take on this problem by designing and developing an IoT based health system to monitor admitted patients 24/7 and communicate with health practitioners [10]. The device uses a blood pressure sensor, body temperature sensor, and an ECG sensor to monitor patient vitals [10]. An Arduino Mega was used to control the system while a Wi-Fi module transmitted the collected data to the cloud [10]. Thingspeak cloud server was used to host patient data because it is secure and easy to use [10]. The system was tested by observing a patient's vitals during rest and after exercise and compared to the corresponding pathological values [10]. The system showed promising results with a maximum error of 3% for the ECG data, 1.60/1.17% for blood pressure, and 2.52% for body temperature [10].

2.3 IoT based Real-Time Health Monitoring

Many health facilities lack adequate skilled health professionals and the needed tools and equipment to provide essential health services for chronic disease patients [11]. Unfortunately, the increasing population and demand for such services have only made matters worse [11]. This paper aims to design and implement an efficient but low-cost system to collect and transmit patient vital signs during health emergencies [11]. The system mainly consists of a pulse sensor, ECG sensor, temperature sensor, and an Oxygen Saturation sensor to measure the patient's respective physical signs [11]. An LCD screen is also interfaced to display information to the user. Wi-Fi and GSM modules are integrated to communicate data to the cloud and a mobile application for both patients and doctors [11]. The researchers used an Arduino as a controller for the system [11]. The system ensures that the doctor receives an alert whenever the patient's vitals exceed their respective threshold values [11].

2.4 R3HMS, An IoT Based Approach for Patient Health Monitoring

In a country like Bangladesh, research indicates a huge lack of health personal to manage the country's population [12]. While IoT health monitoring appears to provide a solution to this problem, it is unsuitable for a country like Bangladesh, according to [12]. This limitation can be attributed to the complexity, maintenance difficulty, and high cost of the devices [12]. This paper proposes a Remote, Reliable, and Real-time Health Monitoring System (R3HMS) [12]. The proposed IoT system measures the patient's heartbeat, respiration rhythm, and blood oxygen saturation (SpO2) [12]. An ATmega328p is used to control the unit and its functionalities [12]. According to [12], to ensure reliability in communicating user data, it uses an ESP8266 Wi-Fi module to transfer data through MQTT protocol with the Amazon AWS IoT platform as a gateway to an MQTT server. The system was tested by running it for a 96hour (5760 minutes) period to examine its reliability [12]. The results showed that the system disconnected for a total time of 17 minutes and stayed connected for 99.7% of the examination time [12]. It was also found that there was no data loss throughout the period yielding data reliability of 100% [12].

2.5 Lessons from Related Work

The related work discussed above provide significant lessons for designing the solution for this project. To begin with, these projects generally implemented temperature sensors, heart rate sensors, oxygen saturation (SpO2) sensor, among others. These sensors provide vital information for aiding in diagnosis and monitoring. Additionally, across the systems implemented in [12], [11] and [10], each had a central database for keeping patient information online. This is vital in promoting availability of information and uniformity. This suggests that an online database which can be accessed by both patients and health professionals will be essential for this project. Furthermore, it is important to note that [9], [12], [11] and [10] provided an interface or software system to enable at least health professionals or both health professionals and patients view the recorded information and provide feedback. This feature can be classified as a vital component of these projects as it makes the system user-friendly and makes information accessible. In line with this, this project can adopt this feature to enable patients and doctors view patient information and records, while making room for the provision of feedback and diagnosis from doctors. Finally, [12], [10], and [9] took into account the validation of the data recorded by the sensors used in their systems. The validation of data is necessary in ascertaining the accuracy, precision and sensitivity of the sensors and the system at large. This is particularly essential for healthcare systems where the significance of sensor accuracy and sensitivity cannot be over emphasized. Hence, this project will also take into account the validation of data recorded by the sensors. Collected data from this project will be compared to that of hospital grade sensors used by some health facilities in the country. This will be done to determine the accuracy, margin of error and sensitivity of each sensor.

Chapter 3: Requirements and Design Specification

3.1 Requirement Specifications

This chapter will highlight and discuss this project's primary requirements and how it will inspire the system's design and development. It is pertinent to clearly state and define the solution's core requirements in every good engineering design. This requirements specification is essential in helping shape and produce more efficient and user-friendly solutions. In this paper, the requirements specification will be classified under both User Requirements and System Requirements. These system requirements will serve as the benchmark for the successful design and implementation of this project.

3.1.1 User Requirements

User requirements specifications encompass the key features and functionalities the user expects to see and experience in the final version of the solution. The users of this project are mainly patients, doctors, nurses, and hospital administrators. These are individuals or groups of people who will directly or indirectly use the solution for a specific purpose. To obtain the users' requirements, I took a cue from related work and conducted short oral interviews with prospective patients and health practitioners. Appendix I shows some interview questions used during the oral interviews. A summary of the user requirements from the interviews include the following:

1. The kiosk should be close to the user (patient).
2. Easy to locate and identify the closest kiosk.
3. The kiosk should be safe and user-friendly.
4. The kiosk should be comfortable for sick patients.
5. The patient should be able to view their health history.

6. The system should be able to accommodate health insurance.
7. The health kiosk should provide as much information as possible for a doctor to make a basic diagnosis.
8. Sensors must operate with a high degree of accuracy and precision.
9. Patient's data and feedback from a doctor should maintain a high degree of privacy.
10. The system needs to be robust and reliable.
11. The kiosk should be cost-effective for hospitals to purchase and manage.

3.1.2 System Requirements

In this case, the system refers to the various components that make up the IoT Health Kiosk. Often, user requirements neglect the technical expectations of a system. Therefore, it is essential to outline the technical requirements of this project plainly. The system requirements fine-tune the user requirements by outlining the technical standards for implementing the user's expectations. Hence in this section, I will clearly define the technical framework for addressing the user requirements. The following constitutes the system requirements of this project.

1. The system should implement simple to use devices and understandable processes that any user can easily follow with or without any assistance.
2. Provision of a comprehensive map that outlines the various locations of Kiosks in any given community.
3. The system should run on multiple reliable energy sources like rechargeable batteries, solar and national grid to cater to power outages and unfavorable weather conditions.
4. Implement robust security features and measures that ensure data privacy, integrity, authenticity, non-repudiation, among others.

5. Ensure the usage of highly efficient and accurate sensors that can replace hospital-grade sensors and devices for user data collection.

6. Ensure that the system is energy efficient and does not keep running when it is not in use. Also, devices used should be low power to conserve energy for when it is needed most.

7. As much as possible, the system should replicate an OPD set up with the required sensors to collect the vital signs and information from patients to help the doctor make professional diagnoses and recommendations.

8. Data should be stored in a secured, accessible, and organized database to ensure user data security and accessibility. Data should also be timestamped to keep track of a patient's health records and history.

9. The kiosk should be made of durable materials for harsh weather conditions. It should also contain comfortable seats for sick patients who may need to sit.

3.1.3 Vital Signs

Medical Practitioners often need to know the state or status of some of the body's most basic functions. These measurements provide essential information about a patient's body and aids doctors during diagnosis. This is often referred to as the vital signs of the patient. These measurements are referred to as 'vital' because they are "the critical first step for any clinical evaluation" [13]. Conventionally, a patient's vital signs include temperature, blood pressure, pulse rate, and respiratory rate [13]. However, other signs like pulse oximetry and smoking status have been found to have significance on patient outcomes [13].

To make this project relevant for medical examinations and the diagnosis process, some vital signs will be measured and recorded. These vital signs include temperature and heart rate. Also, the device will measure patients' height, which will be essential in tracking growth, especially in children. The measurement of height will also enable the kiosk to be used as an immunization center in communities. The system will be designed to accept blood pressure and weight values from external proprietary sensors as well.

3.2 Design Specification

The user and system requirements specified above are vital in designing a system that solves the problem at hand without causing further problems to the users. They are, therefore, essential in shaping the design specifications of this device. The IoT Health Kiosk is divided into two main components: the hardware and software components. These two components will be designed to interact with each other to make the system more flexible and usable by each type of user (i.e., patients and health workers). Hence, this section highlights the two major components and discusses the various subcomponents under each and how all the system components will interact to form a functioning unit.

3.2.1 System Design Architecture

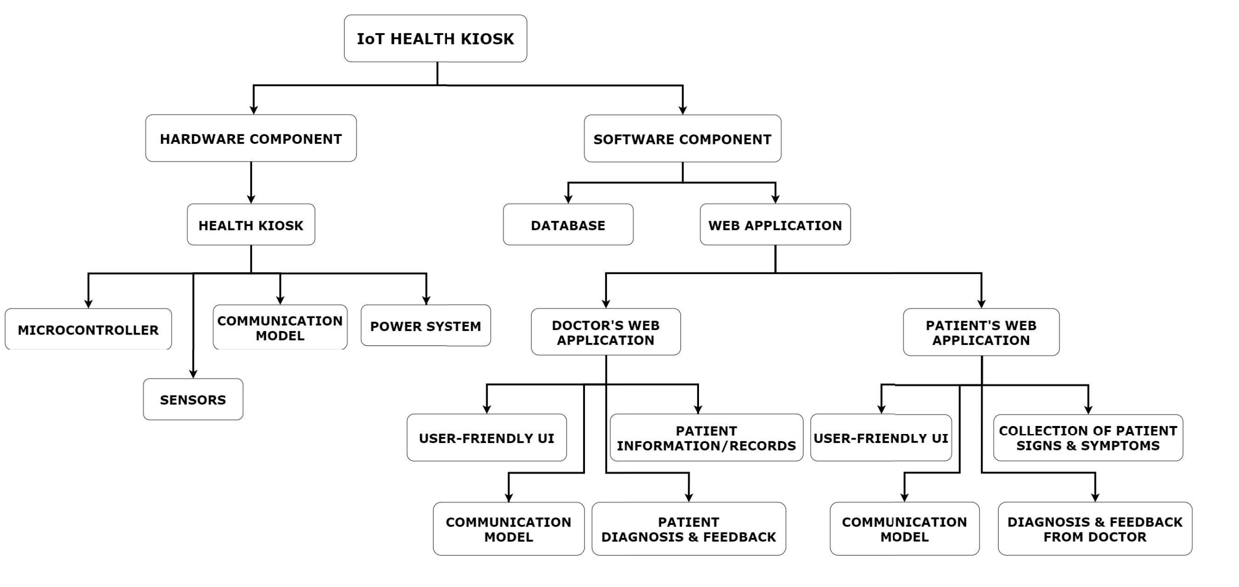


Figure 3.1: Structural architecture of IoT Health Kiosk

The system's structural architecture, as illustrated in Figure 3.1, shows the main components and subcomponents of the system and how they are connected. As indicated earlier and shown in Figure 3.1, the proposed IoT Health Kiosk system comprises software and hardware components. These two major components are further made of several subcomponents, which will be discussed further in this report.

3.2.2 Hardware Component

This project's hardware component mainly consists of the Health kiosk equipped with the needed sensors and other devices to keep the kiosk running effectively and efficiently. The Health kiosk is a physical structure that can accommodate at most two individuals at a time. The health kiosk will contain the appropriate devices to capture a patient's vitals and transmit them to an online server. These devices will include a temperature sensor, pulse rate sensor, height, and weight sensors, blood pressure sensor, microcontroller, power source, GSM module, LEDs, buttons, and an LCD screen.

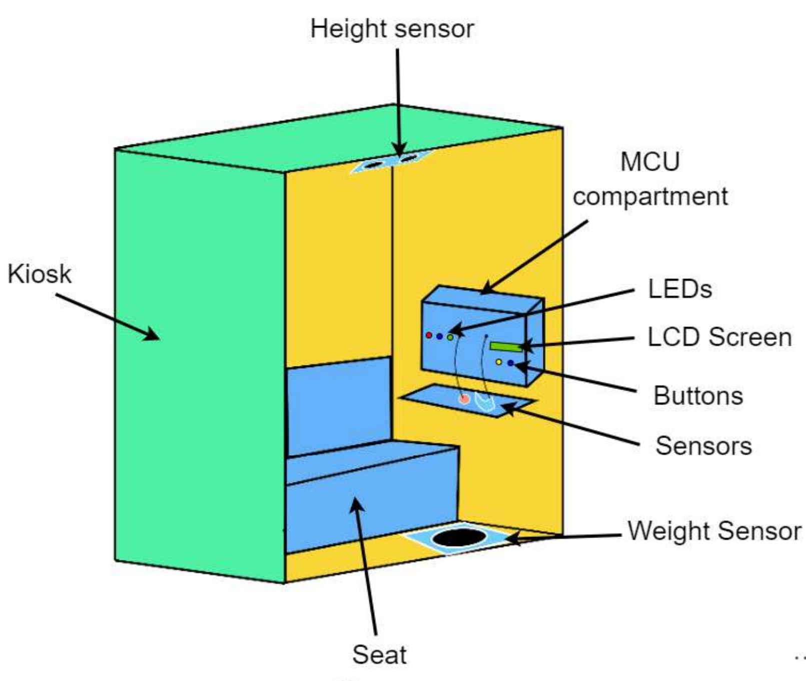


Figure 3.2: Prototype of health kiosk

Figure 3.2 shows a prototype of the health kiosk and how the various devices will be set up. This project will use an ultrasonic sensor to measure the height of a patient. The sensor will be placed at the top of the kiosk, as shown in Figure 3.2, to measure the height of a patient standing right under it. A digital weight scale will also be placed directly under the ultrasonic sensor to measure a patient's weight and height at the same time. The kiosk will contain an MCU compartment, which will serve as an enclosure or protective casing for the microcontroller unit, GSM module, and power source. The compartment will contain and provide outlets for components that interact with the user, including the LEDs, LCD screen, sensors, and buttons.

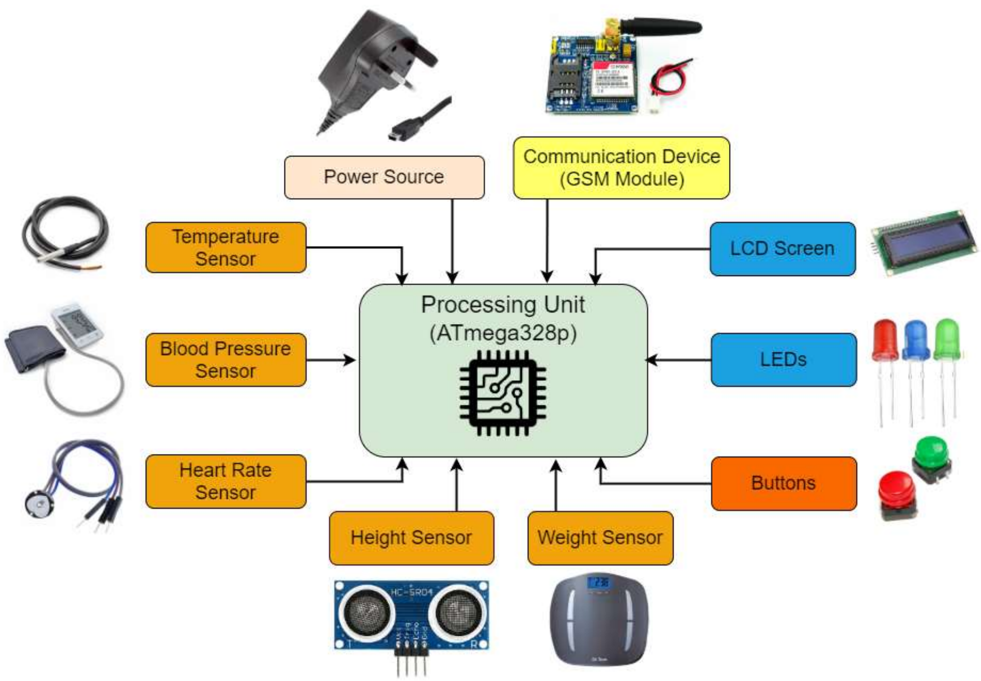


Figure 3.3: General architecture of hardware component

Figure 3.3 illustrates this project's hardware component's general architecture and how the various subcomponents will be connected. The temperature, blood pressure, and heart rate sensors will be used to measure the temperature, blood pressure, and patient's pulse rate, respectively. These are vital information for a medical examination and will be essential in guiding the doctor during diagnosis. Two push-buttons will be integrated to enable the user to control the system. Users will use one push button to wake the system up when it goes into sleep mode after some time of idleness. However, the other button will be used to trigger one sensor at a time to record the user's vital information.

Furthermore, three LEDs will also be set up to act as indicators to the user. A red LED will blink every 5 seconds to indicate that the system is in sleep mode. When the system is awake, a blue LED will be on to show that the device is active and ready to record user information. Also, when user information is successfully transmitted to the online server, a green LED will come on as an indication. Transmission to the online server will be implemented using the GSM/GPRS module. Each device will be set up as a web-client to communicate with the server through HTTP.

Additionally, an LCD screen will be integrated to serve as a user interface to guide the user. It will also display sensor values to the user upon reading the patient's vital signs. Error or success messages will also be displayed to the user via the LCD if transmission or sensor reading fails or is successful. Finally, the entire system will be powered using a 12 – 5 V power source. A voltage regulation circuit will be integrated into the device to ensure that the embedded system always receives a 5v power supply from the 12 – 5V input.

3.2.3 Software Component

This project's software component will serve as an interface to allow health practitioners to access patient information and provide feedback, diagnosis, or prescriptions. It will also serve as a means for patients to receive information from health practitioners and send certain information to doctors.

This system's software section will consist of two main parts: the online database and the web application. These two will work seamlessly with the hardware component to ensure efficient and effective communication of information between doctors and patients. Figure 3.4 shows how the two software subcomponents will be integrated with the hardware component. The hardware component will feed a patient's vital information directly to the database in a simplex transmission mode. The information in the database can then be accessed and updated by the web application.

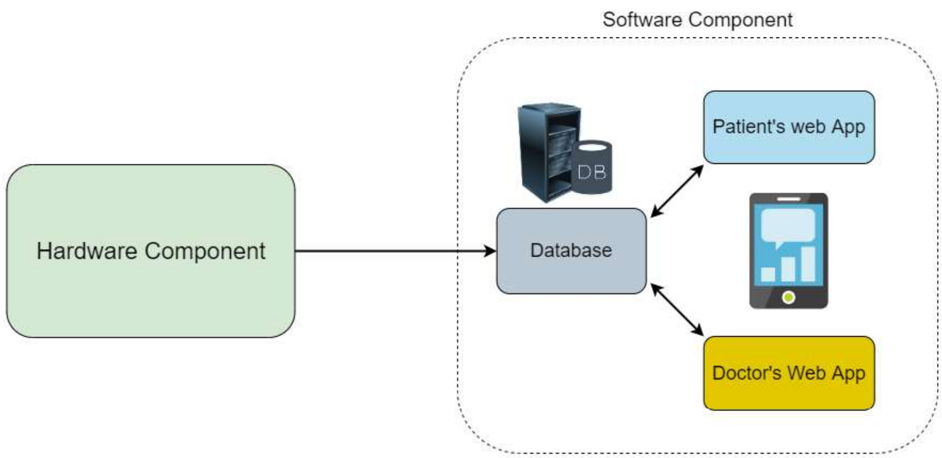


Figure 3.4: Integration of software and hardware component

3.2.3.1 Database

The database will be the primary storage unit of the system. It will be online to ensure that kiosks and users (patients and doctors) can interact with it from different locations so far as internet access is available. MySQL database will be deployed to store data for this system. This is because MySQL is a relational database and hence keeps information in structured tables, making it flexible and easy to retrieve related information. Also, MySQL is a highly secure and reliable database making it the number one choice for huge companies like Facebook, Twitter and Wikipedia [14]. The database will store multiple information required for the smooth and efficient running of the entire system. Such information includes;

- Patient's vital information from sensors
- Patient's information, such as name, age, among others
- Patient's signs, symptoms, and other information collected from the patient web application
- Doctor's information including name, hospital, ID, among others
- Doctor's feedback, diagnosis, and prescription to a patient.

Introducing new sensors and capturing capturing data for very large populations often poses some level of challenge to database systems with poor scalability features. However, according to [14], MySQL is an advantageous database as a result of its scalability features. It permits both horizontal and vertical scaling; in terms of adding new data and extending a database [14]. Also, MySQL allows for the processing of queries on multiple servers and the easy integration of multiple servers to the MySql cluster to handle the processing load of large applications [14].

3.2.3.2 Web Application

This project will include a web application to provide a platform on which doctors and patients can interact. The web application will provide an interface for doctors to retrieve and view patient information, including vitals. Doctors will also be able to send feedback, prescription, or other information to patients through the doctor's interface of the web app. Another interface of the web application will be dedicated to patients. This interface will provide a means for patients to provide additional information when using the health kiosk. This additional information includes the patient's signs and symptoms, number of days since symptoms commenced, and other information required for medical examination and diagnosis.

The web application will be developed using PHP, CSS, HTML, Bootstrap, and JavaScript. HTML, CSS, Bootstrap, and JavaScript will be used for front-end development (i.e., user interface and user interaction). A responsive and user-friendly UI will be a hallmark of this web app; therefore, the Bootstrap framework will be adopted to achieve that. Additionally, PHP (a server-side language) will be used to manage and control the flow of information between the front-end and the server, which holds all user data, making the application dynamic. PHP will also be used to interact with the MySQL database to add, retrieve, delete, or modify data in the database.

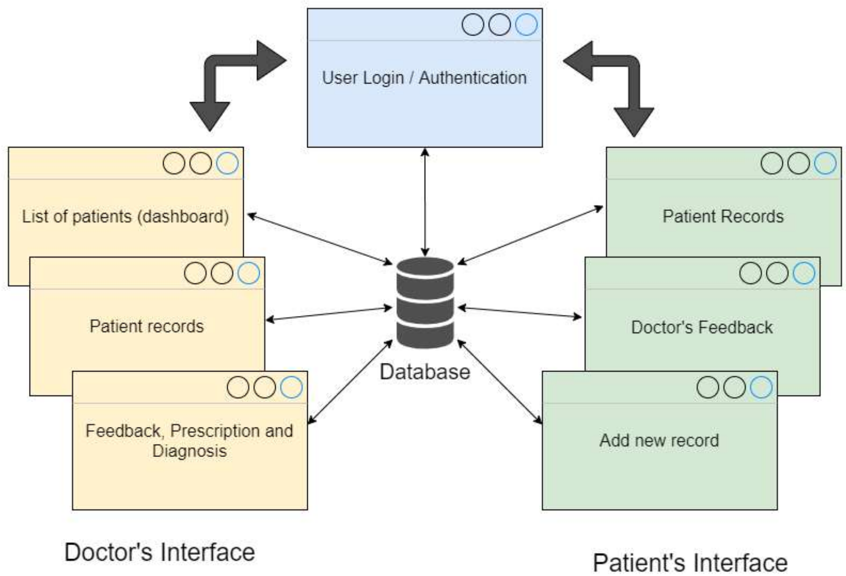


Figure 3.5: User interface framework for web application

Figure 3.5 illustrates the user interface framework of the Health Kiosk web application. The user interface comes in three major sections, the user authentication page, the doctor's interface, and the patient's interface. The user authentication page will be a security checkpoint to ensure that only authorized users access their respective information from the system. After user authentication, patients will be directed to the patient's interface, while doctors will be redirected to the doctor's interface. The doctor's interface will consist of three main pages, a dashboard showing a list of all patients who have used the kiosk and awaiting feedback from the doctor, a page showing the details and records of a selected patient, and a page to provide feedback to a selected patient. On the other hand, the patient's web app interface will also have three main pages, a page to add new records when using the health kiosk, a page to view previous records and patient details, and a page to view doctor's feedback and provide a response if needed. These pages will interact with the database to obtain the needed information and keep the information up to date.

3.2.4 Design Components

The following section discusses the various devices, sensors, and components used in building the health kiosk's hardware component. This project employs six main sensors, one processing unit, one communication device, and two actuators. The sensors include a temperature sensor, a pulse rate sensor, a blood pressure sensor, an ultrasonic sensor, a weighing scale, and push-buttons. The processing unit for the health kiosk will be the ATmega328P-PU, while the SIM900A module will be deployed as the primary communication device. Furthermore, an I2C 16x2 LCD screen and a couple of LEDs will be set up as the system's primary actuators. These devices are discussed in further detail below.

DS18B20 Waterproof Temperature Sensor

Figure 3.6: DS18B20 Waterproof Temperature Sensor

The DS18B20 Waterproof Temperature Sensor will be deployed to measure the body temperature of patients. This sensor has an operating range of -55°C to +125°C (-67F to +257F) [15]. Also, it has an accuracy of ±0.5°C within the range -10°C to +85°C, making it suitable for clinical body temperature measurement [15]. This temperature sensor uses the Dallas 1-Wire protocol making it easy to communicate with other devices [15]. It is a digital sensor and can produce up to 12-bits resolution [15]. It has a query time of 750ms, making it apposite for tracking a patient's body temperature over time [15]. The sensor has a 91cm cable that can enable the sensor to take a patient's temperature away from the processing unit. Finally, this device has a stainless-steel probe head, making the sensor suitable for wet and harsh conditions.

Pulse Sensor

Figure 3.7: Pulse Sensor

A patient's heart rate is recognized as one of the vital signs required for medical examination. Therefore, a pulse sensor will be deployed in this system to measure the heart rate of patients. The sensor is a well-designed plug-and-play device for measuring heart rate. It can either be clipped to the fingertip or earlobe of a patient for effective heart rate sensing. The pulse sensor implements a concept called "hear beat" detection and biometric pulse rate sensing using LEDs [16]. Also, it has in-built amplification and noise-cancellation circuits for signal conditioning [16]. Finally, it has an operating voltage of +5V or +3.3V, with current utilization of 4mA, making it very conducive for this project [16].

HC-SR04 Ultrasonic Sensor

Figure 3.8: HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor can measure how far objects are from it using ultrasonic waves. This model is designed to practically measure distances within the range of 2cm to 80cm but can theoretically measure up to 400cm with an accuracy of 3mm [17]. Its working frequency is 40Hz and a measuring angle of $\leq 15°$ [17]. The HC-SR04 ultrasonic sensor has a working voltage of 5V, making it a good fit for this system [17]. The sensor operates by sending ultrasound waves and measuring how much time it takes to receive an echo from objects in front of the sensor [17]. Figure 3.9 shows a diagrammatic representation of this process. Based on figure 3.9, the distance of the object can then be determined by using the following relation [17]:

$$speed = \frac{distance}{\frac{time}{2}}$$
$$\Rightarrow distance = speed \times \frac{time}{2}$$

where

speed = speed of sound

distance = distance between sensor and object

time = time taken for echo to be received after ultrasound is transmitted

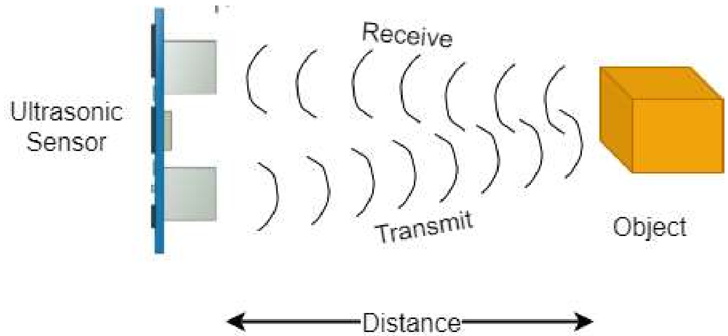


Figure 3.9: Measuring distance with ultrasonic Sensor

SIM800L GSM/GPRS Module

Figure 3.10: SIM800L GSM/GPRS Module

The SIM800L GSM/GPRS Module is a communication device designed for SMS, Voice, Data, and Fax communications. This is a complete Quad-band GSM/GPRS device capable of operating at 850, 900, 1800 or 1900MHz [18]. Additionally, the SIM800L GSM/GPRS Module is a low power consumption device and can be put into sleep mode to manage power [19]. It has a voltage supply range of 3.4 4.4V and a peak current of 2A [18],[19]. It is controlled using AT commands, making it easy to use [18]. For this project, the GSM/GPRS Module will be configured as a web-client to communicate with a web-server using HTTP communication.

LCD 16x2 Display Module

Figure 3.11: LCD 16x2 Display Module

For a system that needs to interact directly with the user, it is pertinent to set up a display screen to serve as a user interface. As such, an LCD 16x2 Display Module will be interfaced with the hardware device to communicate with the user. An I2C interface will be used to reduce the number of connections to the microcontroller. The LCD 16x2 Display Module can display alphanumeric characters, including standard and custom-made symbols [20]. It can display up to 32 ASCII characters in two rows of 16 characters per row [20]. Each character is displayed using 5x8 pixel dots [20]. Furthermore, the screen has an in-built backlight to improve visibility in dark conditions. Finally, the screen's contrast can be adjusted using an external potentiometer connected to the LCD.

ATmega328P Microcontroller

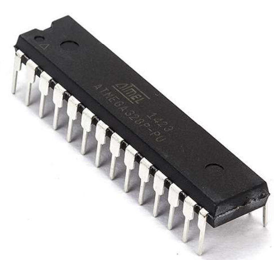


Figure 3.12: ATmega328P Chip

To handle all the processing and controlling of sensors and other devices of this project, an ATmega328P will be deployed. This high performance and low power microcontroller belong to the AVR ATmega family of microcontrollers. It is an 8-bit device designed based on the AVR

RISC architecture [21]. The ATmega328P comes as a 28 pin chip with 23 programmable general-purpose I/O lines and five special purpose pins [21]. With regards to memory, this chip uses a 32Kbytes flash program memory, a 2Kbytes internal SRAM, and a 1Kbyte EEPROM [21]. The ATmega328P's CPU can handle up to 20 MIPS with respect to speed [21]. It is equipped with a six-channel ADC module with up to 10-bit resolution but has no DAC module [21]. This ADC module is vital for working with some sensors this project requires, like the temperature sensor. Again, the ATmega328P comes equipped with two 8-bit and one 16-bit timer, including a programmable watchdog timer with a separate internal oscillator [21]. The features listed above and the low cost and low power consumption characteristics of the ATmega328P makes it a suitable microcontroller for this project.

Chapter 4: Design Implementation

This chapter provides a breakdown of the implementation of the hardware and software components of this project. It begins by looking at the hardware implementation of this project and then the software implementation. Further details are provided by examining the implementation of each subcomponent of the health kiosk.

4.1 Hardware Implementation

The hardware component of this project forms a significant aspect of the system. User interaction and activities commence from this component of the project. It consists of a kiosk structure, a couple of sensors, a processing unit (Microcontroller), a set of actuators, a communication unit, and a source of power. It is particularly essential to set up these subcomponents to seamlessly work together to achieve the desired functionality of this project.

4.1.1 Circuit Design

Figure 4.1 shows the circuit design for the hardware component of the Health Kiosk. This circuit design is developed to interface the various subcomponents of the hardware system and facilitate the necessary functionalities. The design was created using Eagle software and tested with simulation features in Proteus.

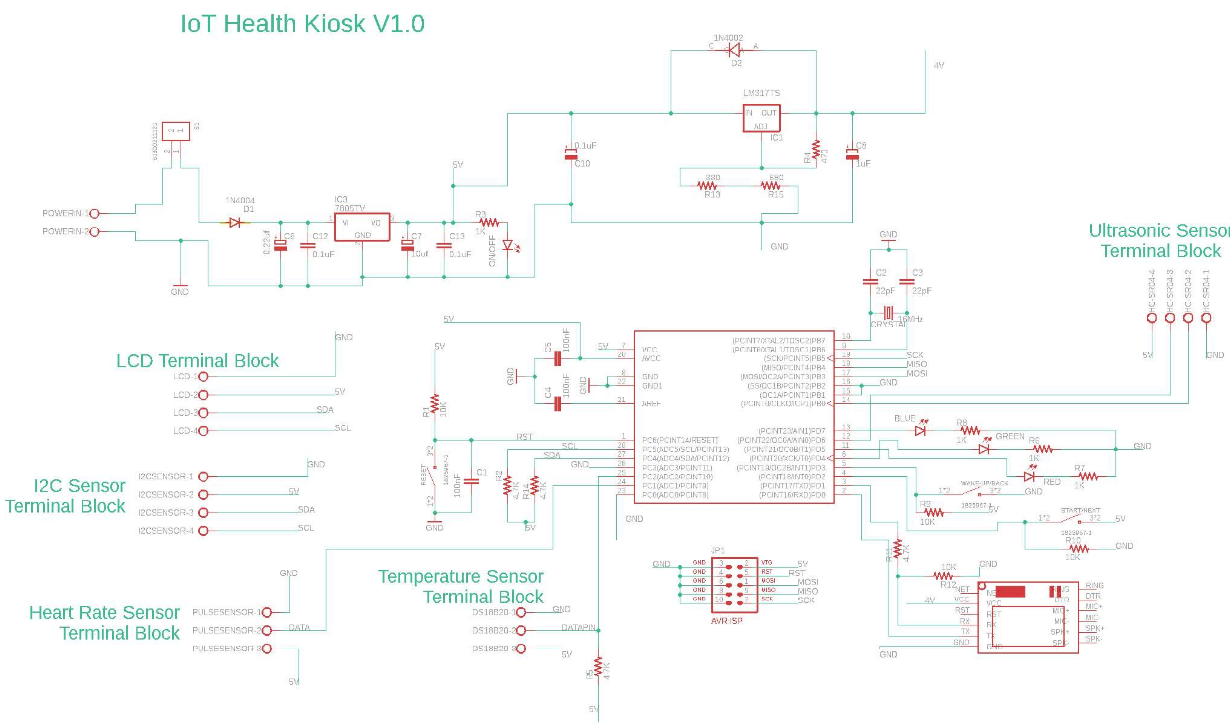


Figure 4.1: Final Health Kiosk circuit design

Table 1 lists the major subcomponents of the circuit design and their functionalities. Some of such components were not used in the circuit design shown in Figure 4.1 but were replaced with terminal blocks to ensure effortless interfacing in the final PCB.

4.1.2 Sensor Calibration

It is sometimes essential to calibrate some sensors to ensure that they fit the context they are used. Therefore, the ultrasonic sensor required some form of calibration to make it suitable for recording patient height in the kiosk. In performing this calibration, the sensor was placed at the top of the kiosk in a downwards-facing position. The height of the kiosk was designed to be 210cm. From that height, the ultrasonic sensor recorded approximately 120cm, which is not surprising because the expected 210cm distance is outside the sensor's operating range. In obtaining a patient's height, the sensor's distance measured is subtracted from the height of the kiosk. This is because the ultrasonic sensor measures how far objects are away from it; hence it reads the distance be-

Table 1: Summary of hardware subcomponents and their function

Subcomponent	Function
Temperature Sensor	This sensor captures the temperature of a patient. This is necessary to aid doctors in examinations.
Heart Rate Sensor	It reads a patient's Heart Rate in terms of Beats Per Minute (BPM) and Inter Beat Interval (IBI).
Ultrasonic Sensor	This is necessary for measuring the height of patients, especially children.
I2C Sensor interface	This terminal block provides an interface for an extra I2C sensor. This provides room for more sensors like a Pulse Oximeter.
LCD screen	It acts as an output device to communicate information to users.
SIM800L GSM/GPRS module	This communication unit transmits information from the hardware component to the online server.
Sleep LED	This red LED stays on when the system is in sleep mode and blinks when the system is in an idle state before entering sleep mode.
Active LED	This green LED blinks when the device is active or being used. It goes off when the system is asleep.
Transmission LED	This blue LED indicates when data is being transmitted to the online server.
Power LED	This yellow LED comes on when the device is connected to a power source and switched on.
Power Unit	The power unit provides an interface for an external power source and regulates the voltage to a conducive level for the system.
ATmega328P	This device acts as the central brain of the system and handles all the processing required to keep the system running effectively.
AVR ISP Interface	This interface provides a means for programming and debugging the system.
Wake-up / Back Button	This button allows the user to move to a previous step when using the system and to wake the system up when it enters sleep mode.
Next / Start	This button enables the user to move to the next step or start recording vitals when using the device.

tween the sensor and the patient's head. Figure 4.2 shows an illustration of how a patient's height is obtained.

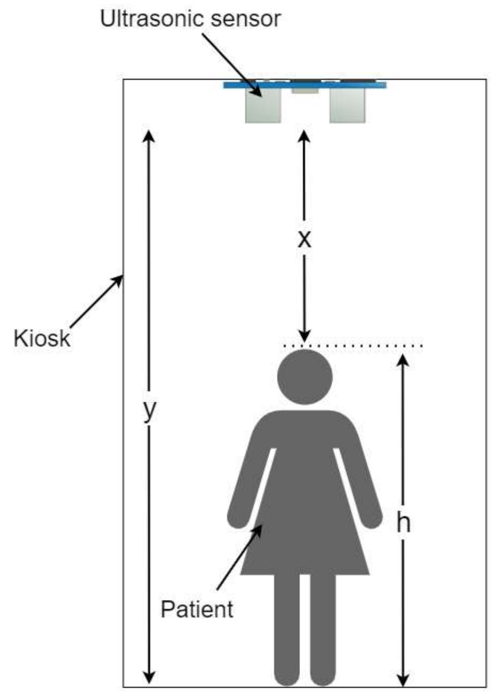


Figure 4.2: Calibrating ultrasonic sensor for height measurement

From Figure 4.2, the height of a patient can be obtained by using the following relation:

$$y = h \times x$$

$$\Rightarrow h = y - x$$

where

y = height of kiosk

h = height of patient

x = distance between sensor and patient's head

4.1.3 Communication Model Setup

In establishing a communication channel between the hardware component and the online database, a communication model is interfaced with the ATmega328P. The SIM800L module, which is used, implements serial communication to establish an internet connection through a mobile service provider. For the initial prototype of this project, an MTN SIM card is used to obtain mobile internet service for testing and validation. The protocol for establishing an internet connection and transmitting data to the online server is outlined below:

1. Setup and initialization of the SIM800L module.
2. Acquire the International Mobile Equipment Identification (IMEI) number of the SIM800L module used.
3. Establish internet connectivity by configuring the GPRS network.
4. Read network connectivity status and verify if the network is registered.
5. Prepare database insert URL by attaching sensor data to it.
6. Send sensor data to the online database using an HTTP request.
7. Receive a ”Data inserted” message to confirm insertion.

4.1.4 System Powering

Every IoT device requires a source of power to keep it running. The IoT Health Kiosk is designed to accept power from multiple sources. It uses a terminal block to interface any DC power source with a voltage supply within the range of 7V to 25V. Therefore, power adaptors like the 9V AC to DC power adopter can power the system. Also, any 9V or 12V battery is equally a suitable power source. For this prototype, a 9V Energizer battery (shown in figure 4.3) was used to test the system.

Figure 4.3: 9V Energizer battery

4.1.5 Proteus Simulation

To test certain aspects of the design before the actual prototype was built, the design had to be simulated in a software environment. Proteus software was used for the simulation process to test specific components and design decisions. This ensured that the design could be tested and validated in an environment where errors and mistakes could not damage specific delicate components. Figure 4.4 shows a snapshot of the simulated design in Proteus.

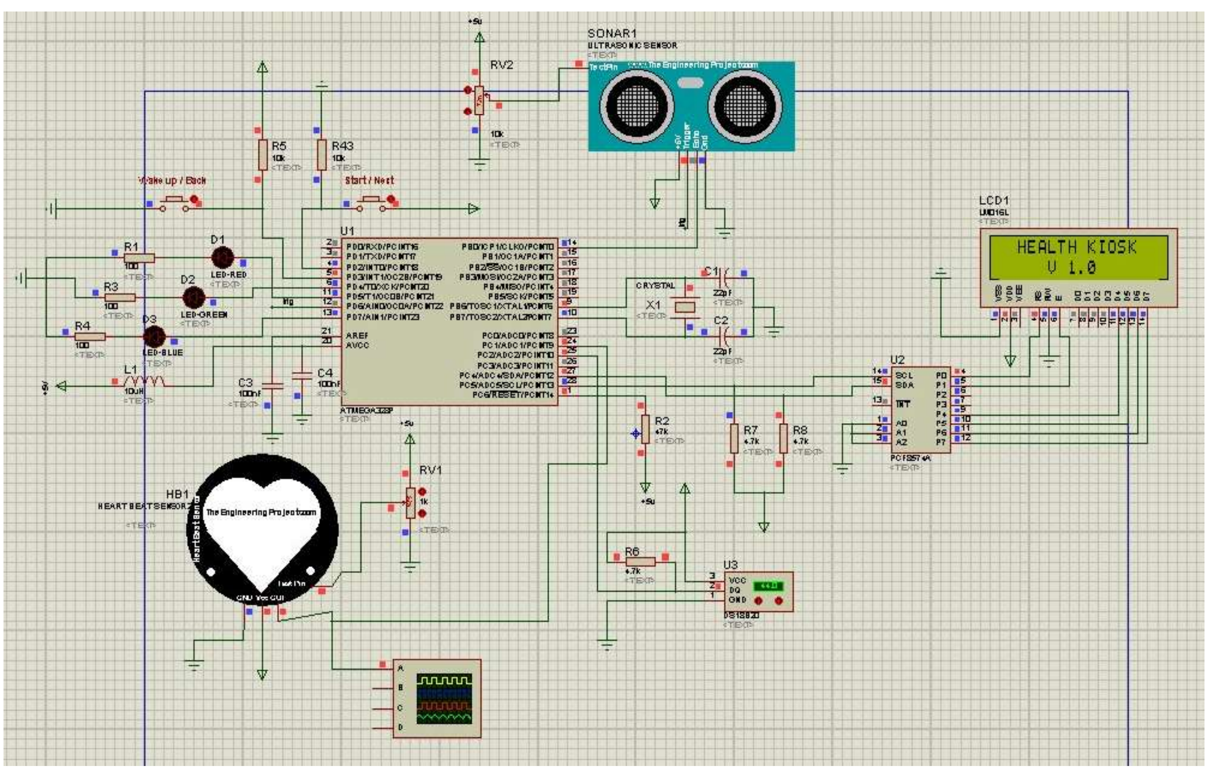
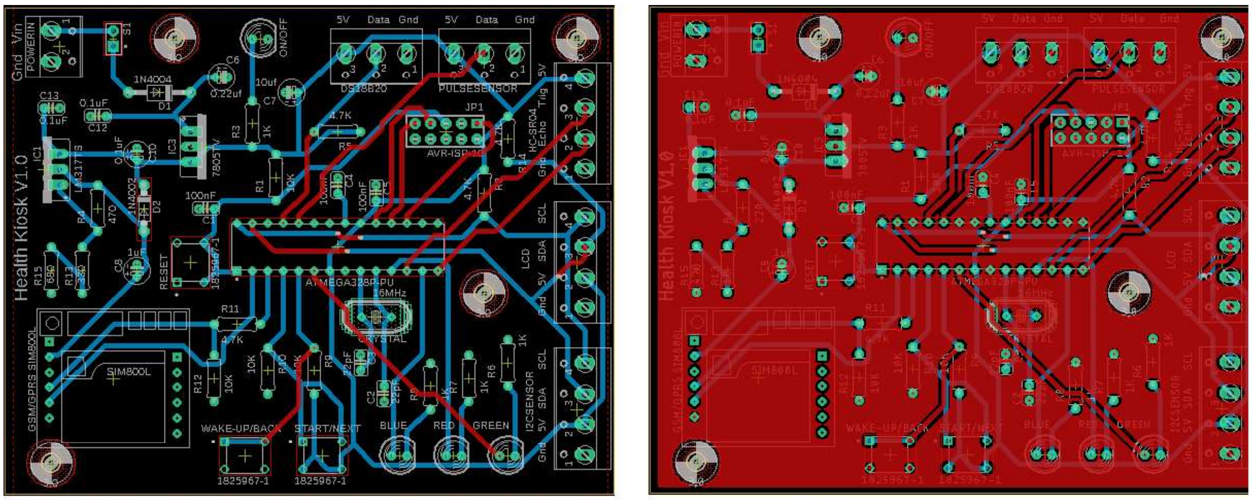


Figure 4.4: Proteus simulation of design

4.1.6 PCB Design

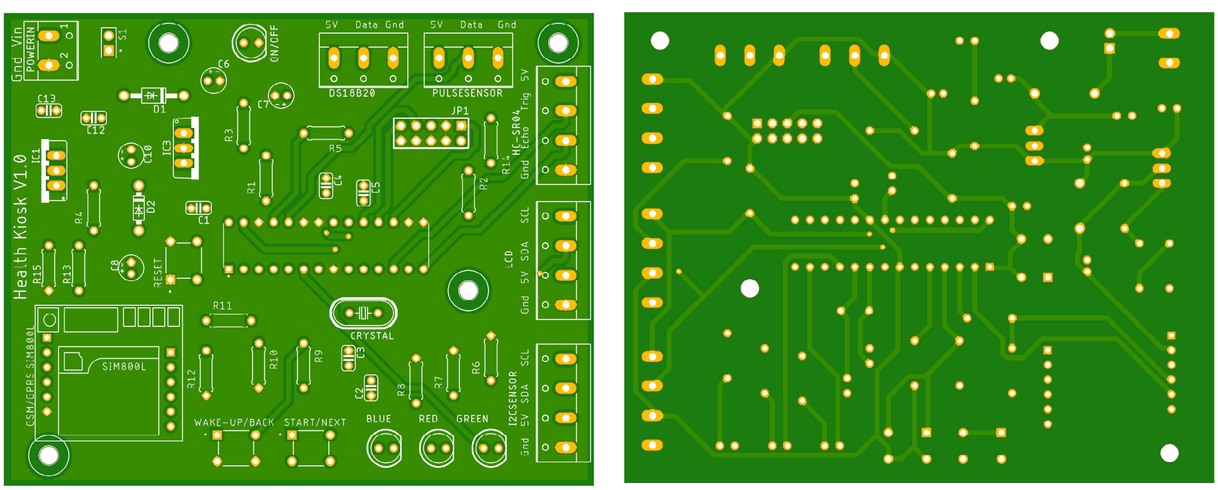
The circuit design for the hardware component is implemented as a Printed Circuit Board (PCB). This is done to make the device easy to handle, user-friendly, and aesthetically pleasing. Figure 4.5 shows the routing diagram with and without the ground copperplate showing, while Figure 4.6 shows the top and bottom sections of the final PCB.



Without ground Copper plate

With ground Copper plate

Figure 4.5: Routing diagram of PCB design



Top

Bottom

Figure 4.6: Top and Bottom sections of final PCB design

4.1.7 Kiosk Design

One significant component of the hardware section of this project is the physical structure where patients can sit to use this device. This physical structure is what has been termed as a kiosk in this project. It is essential to design the kiosk to satisfy the needs of the patient and provide a conducive environment for the collection of patient vitals. Among other things, the kiosk is to have a comfortable chair, compartment for the device, good ventilation, and lighting. The dimension of the kiosk is specified to be 120cm x 140cm x 210cm. This is to enable the kiosk to contain up to two fully grown adults at a time. The kiosk will be constructed using Glass Reinforced Polyester (fiberglass). Fiberglass kiosks are gaining popularity in the country mainly because the material is resistant to corrosion and does not get damaged by harsh weather conditions like rains and hot temperatures. Also, fiberglass does not conduct heat or electricity, making it suitable for keeping the electrical components of this project. Moreover, fiberglass is very durable and can be formed into aesthetically pleasing shapes. Figure 4.7 shows an illustration of the kiosk.

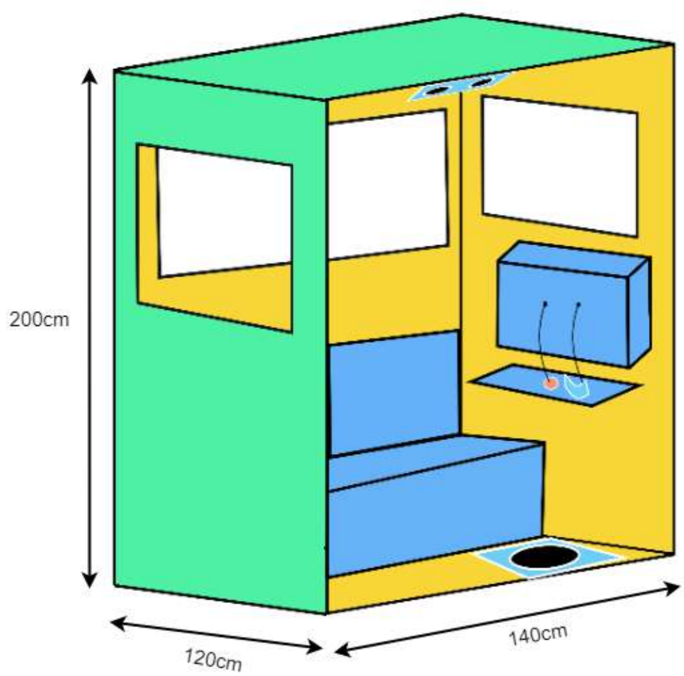


Figure 4.7: Illustration of the kiosk and its dimensions

4.1.8 Hardware System Complete Setup

Upon testing and verifying the individual components of the hardware system, all the components were assembled onto the PCB. Further testing was also carried out to improve the design as well as test the efficiency of the various components. This was to ensure that the system functions effectively and meets the proposed system specifications. The complete setup of the hardware device is shown in Figure 4.8.

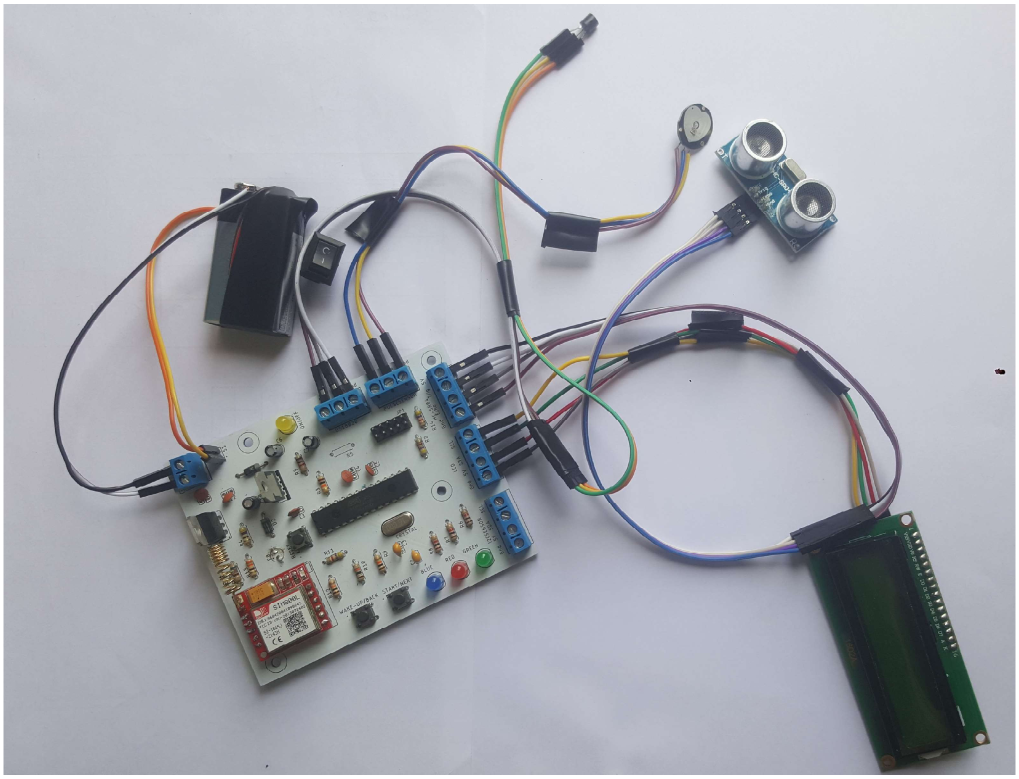


Figure 4.8: Complete hardware device setup

4.2 Software Implementation

The implementation of the software component comprised the development of a web application, an online database, and programming the hardware component to function effectively. This section of the report provides an in-depth breakdown of the various software features and designs put into the software implementation.

4.2.1 Database Management

For a system that manages user data and depends on user information for service delivery, there is a need to store this data in a secure and accessible platform. Therefore, an online database had to be set up to manage user and system information. The design of this database was done based on use cases, system information, and sensor or health data that are needed to be captured. Figure 4.9 shows the various use cases, while Figure 4.10 shows the Entity Relation Diagram (ERD) that summarizes the project's database implementation. The Entity Relation Diagram depicts the relationships between all the tables in the database.

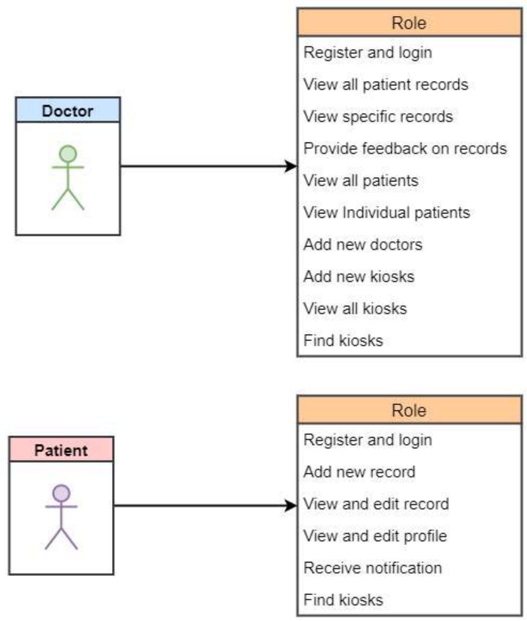


Figure 4.9: System use case diagrams

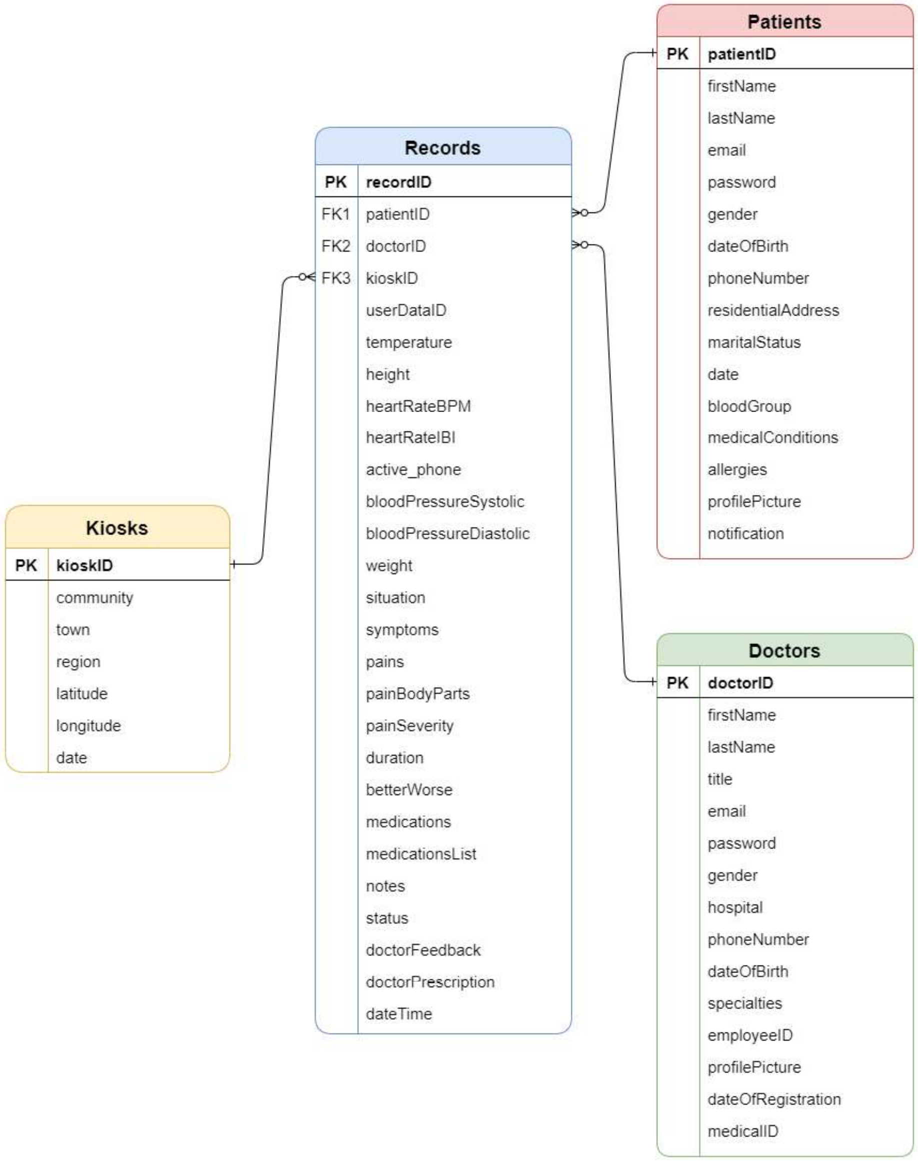


Figure 4.10: Database Entity Relation Diagram

<u>Description of use case diagram</u>

1. **Doctor:** The doctor is mainly responsible for observing pending patient records and providing feedback. To enable the doctor to perform these more effectively, he/she can view all pending and completed records and view all patients, specific patient records, and patient profiles. The doctor can also add other doctors to the database, add new kiosks, and find existing kiosks.

2. **Patient:** The patient's primary role in this system is to provide health records for feedback and prescription from doctors. Therefore, the patient can add new records or just record vitals, view all records, and view and edit previous records. Patients can also view and edit their profiles and find kiosks around them.

4.2.2 Hardware Component Backend Code

In order to make the hardware component operate as effectively as expected, a piece of program was written to manage and control the device. This program was mainly written in C programming language using Atmel Studio. C is used because it is regarded as the best programming language for programming hardware components like those used in this project. To effectively interface some of the sensors and components, third-party libraries had to be integrated into the program. These third-party libraries handled most of the core configurations and controls required for those sensors and components. Towards ensuring the preservation of energy and extending battery life, the sleep mode feature of the ATmega328P was configured. This enabled the system to go into an idle state after two minutes of no activity. In this state, the red LED blinks to notify the user. After three minutes in the idle state, the system enters a form of sleep mode called the power-down mode, where the microcontroller halts all generated clocks except asynchronous modules. When in sleep mode, the system can be reactivated by pressing the wake-up button, which makes it resume to the last point or state before sleeping

4.2.3 Flow Charts

Figure 4.11 illustrates a flow chart of the various steps or states and decisions implemented in the hardware device. It also outlines how a user navigates between the various states while using the system.

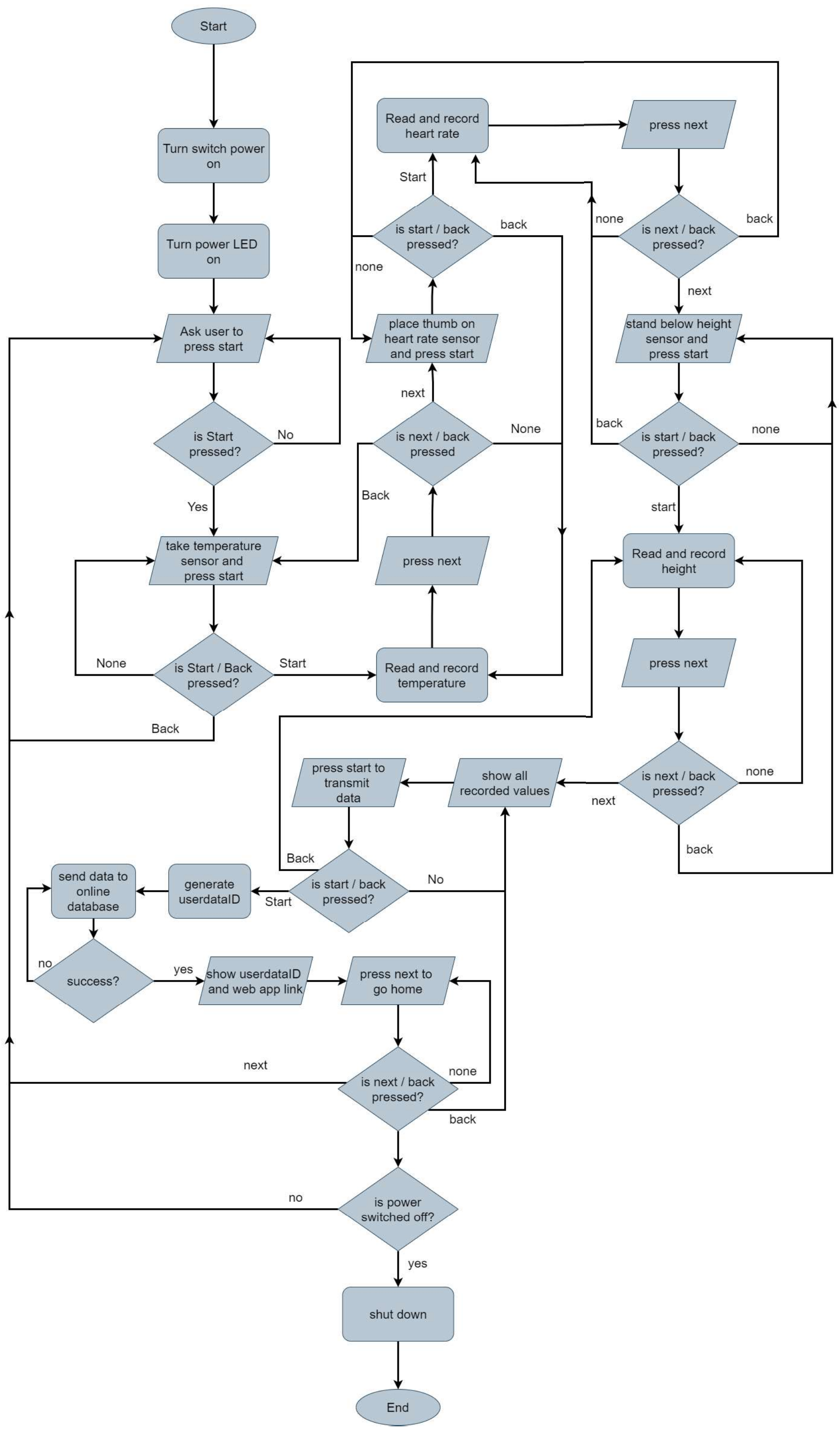


Figure 4.11: Hardware device flow chart diagram

4.2.4 Web Application

As stated in the web application design specification, the health kiosk web application is designed to have two interfaces. One interface serves patients while the other serves doctors. The web application is built using a bootstrap template called Preclinic-Hospital. The Preclinic-Hospital template is specifically designed to be used as a hospital management system and comprises HTML, CSS, and JavaScript files. These files were modified accordingly to obtain the features and interface required to satisfy the doctor and patient use cases. After this, the static (.html) files were made dynamic by replacing some portions of the HTML code with PHP code and changing the file extension to (.php). These files were also connected to the database to interact with user data. Figure 4.12 to Figure 4.22 show some screenshots from the web application.

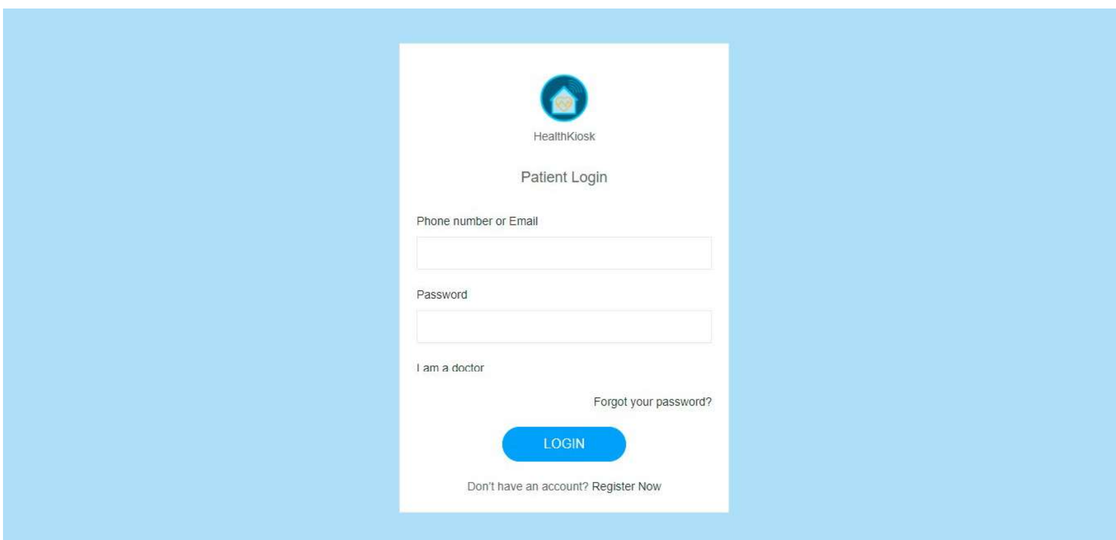


Figure 4.12: User login page

Figure 4.13: Doctor dashboard page

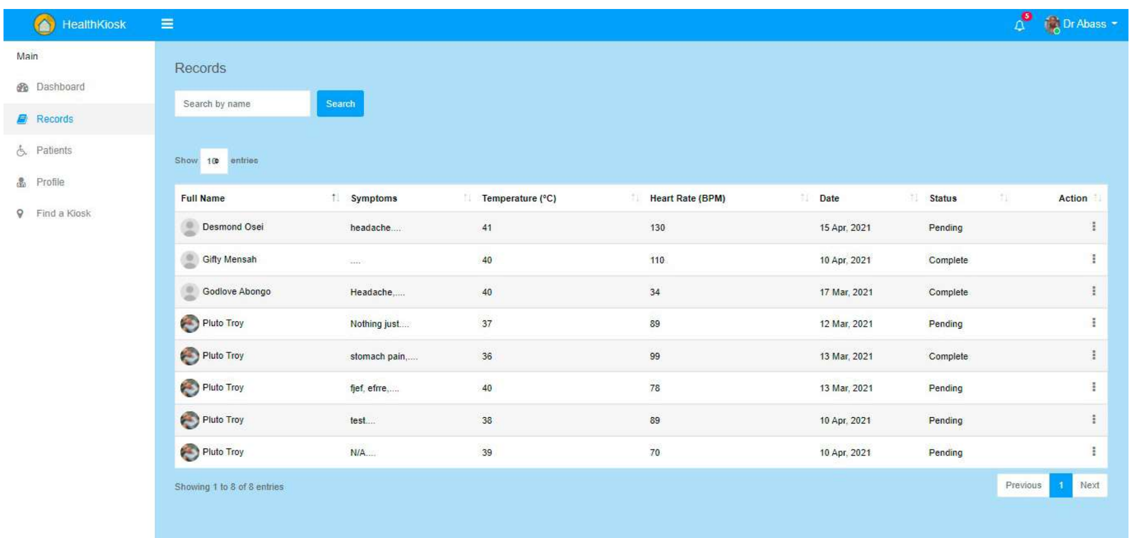


Figure 4.14: Records page for doctor’s interface

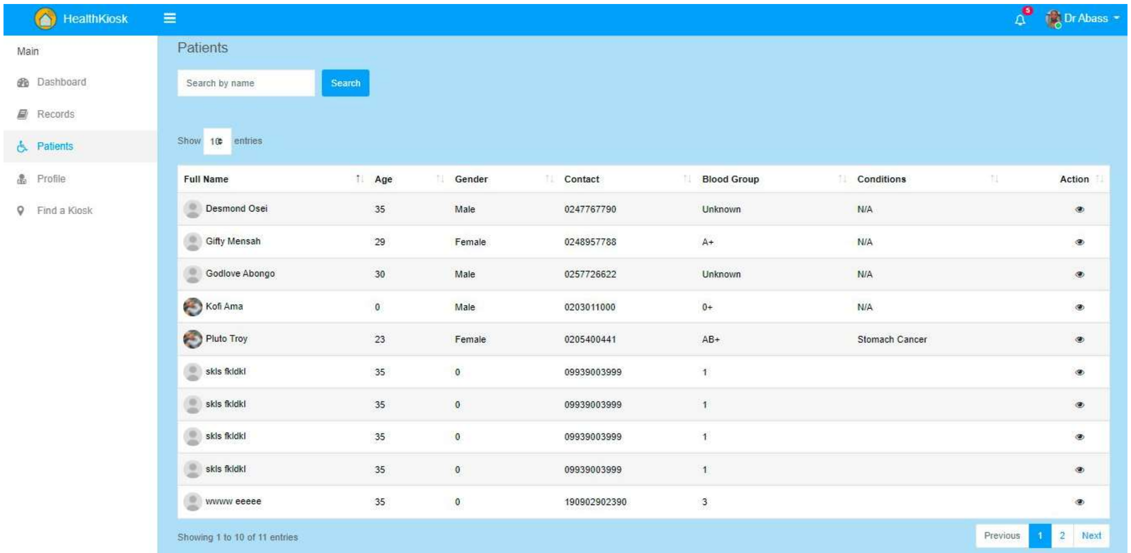


Figure 4.15: Patients page for doctor's interface

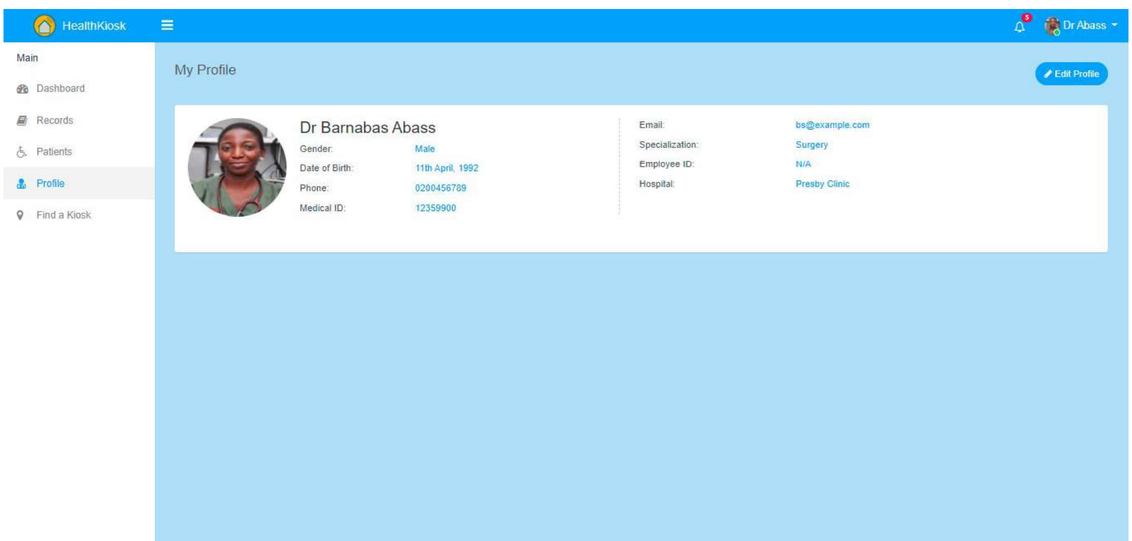


Figure 4.16: Doctor profile page

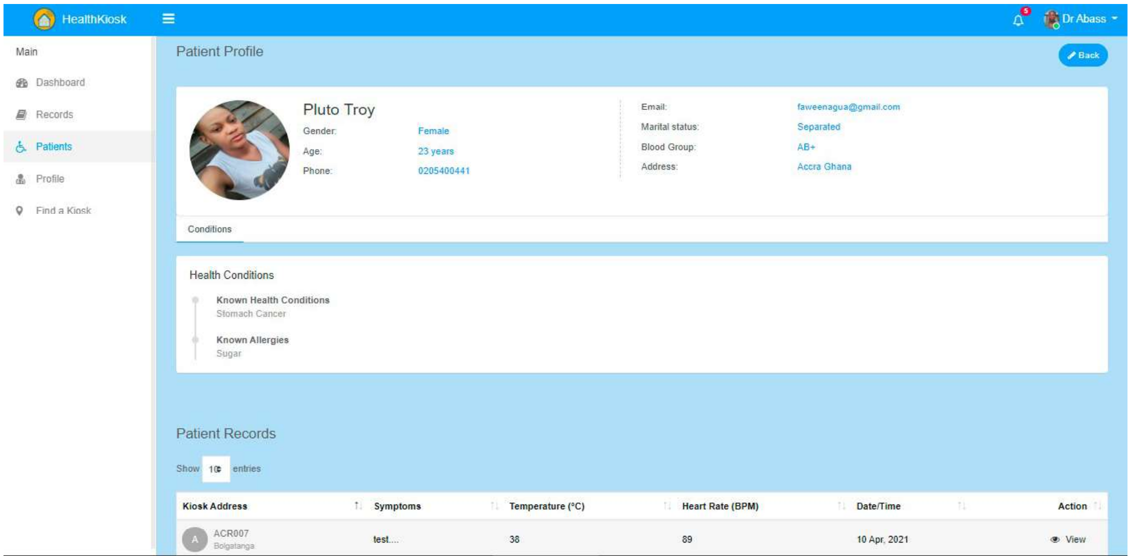


Figure 4.17: Patient's profile page in doctor's interface

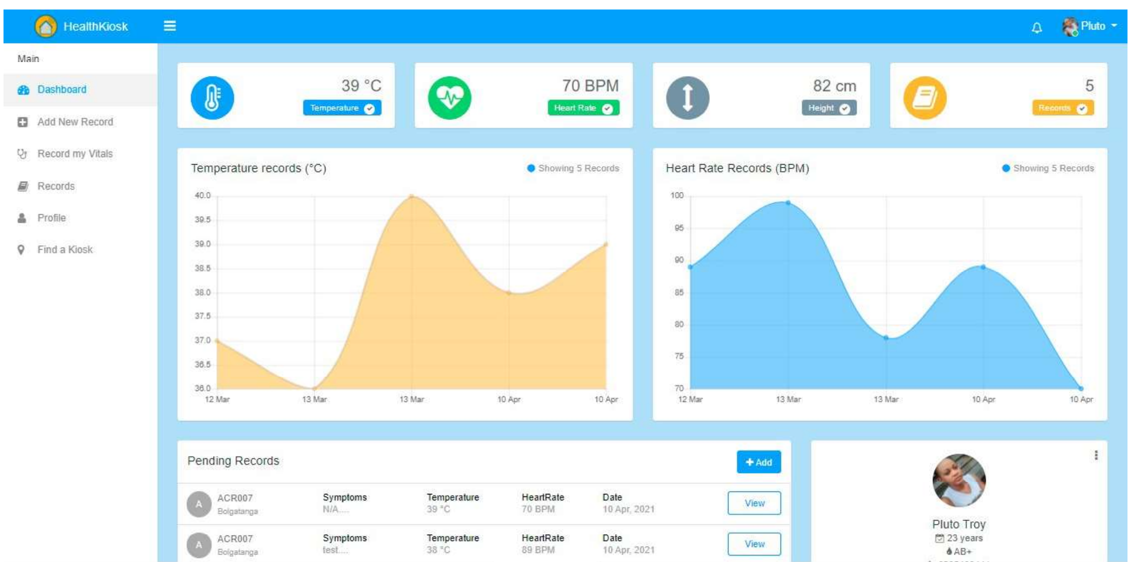


Figure 4.18: Patient's dashboard

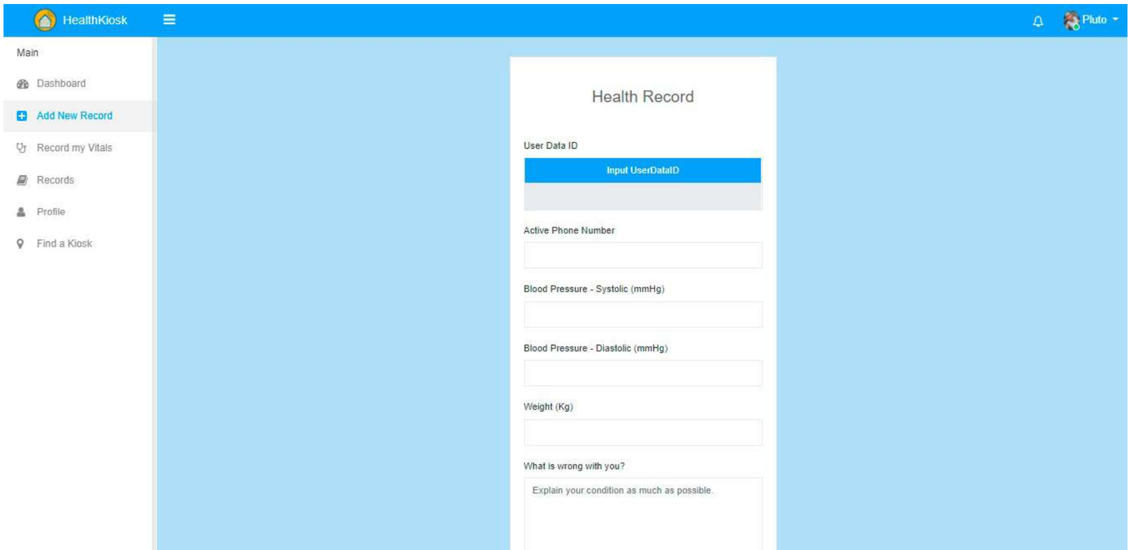


Figure 4.19: Add new record page

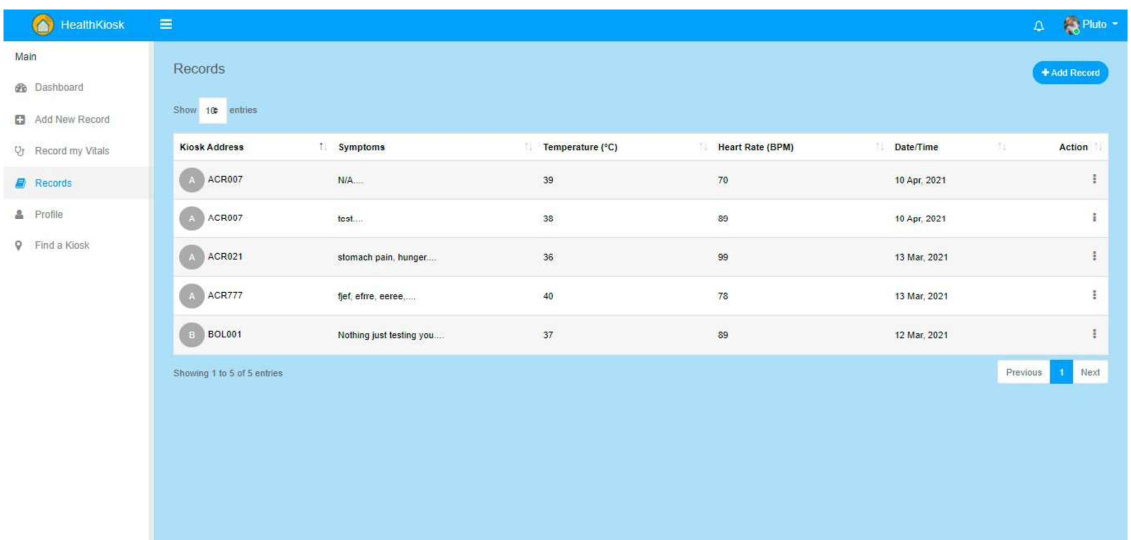


Figure 4.20: Patient's records

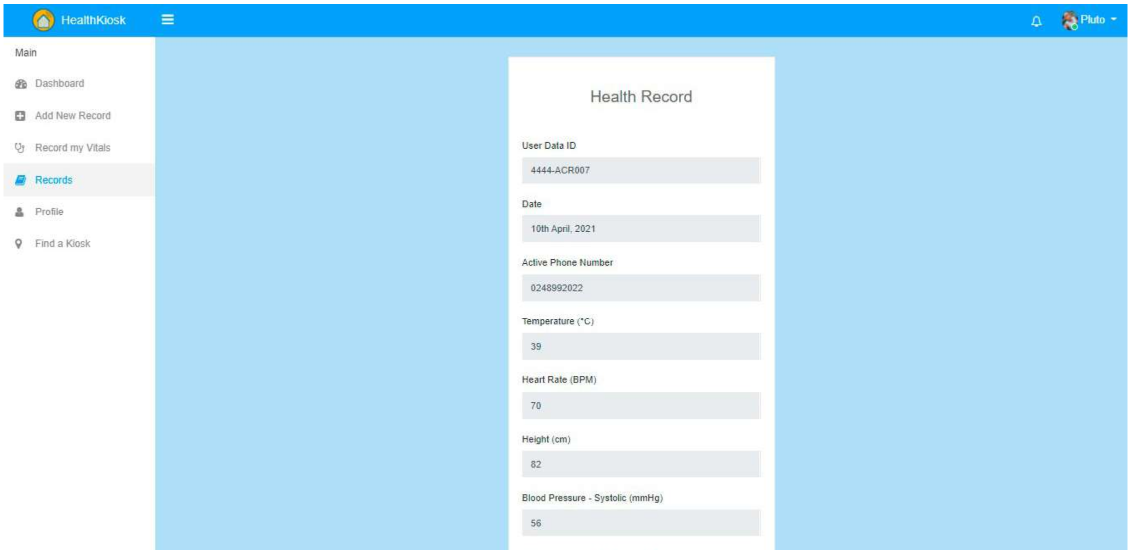


Figure 4.21: View record page

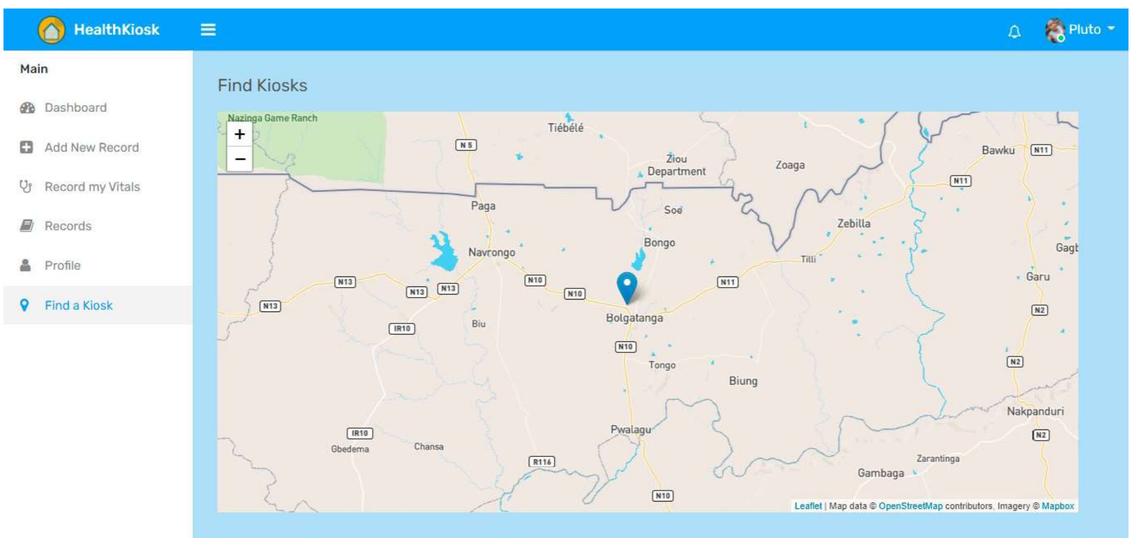


Figure 4.22: Find kiosk page

4.2.5 Web Application Security

For a system that keeps confidential information about patient's health, it is necessary to secure the system against unapproved and unwanted access. Therefore, certain design features had to be enforced to ensure adequate security. These security features include the following:

1. **Login page:** the login page acts as a layer of security by ensuring that only registered users

can access their data on the system. It, therefore, ensures a certain degree of privacy and confidentiality.

2. **Password encryption:** to prevent hackers from directly obtaining raw user passwords from the database, all user passwords are encrypted before storing them in the database. The passwords are hashed using the password_hash() PHP function, a very strong one-way hashing algorithm [22].

3. **Using mysqli::escape_string function:** As a layer of protection to help prevent SQL injection attacks, the mysqli::escape_string function is used throughout the web application to sanitize all user inputs. Although this may not be the best way to prevent SQL injection, it offers some level of protection.

4. **No access to web page unless logged in:** To prevent hackers from directly accessing files by typing file URL in a browser's address bar, the system first checks if a user is logged in before allowing file access. If no user is logged in, the system automatically redirects to the login page without showing the file's contents. However, if a user is logged in, the file is opened and displays information accessible to that user.

Chapter 5: Design Testing and Results

This chapter provides an account of the tests conducted to ascertain the efficacy of some components in this project. The test results were analyzed to help draw conclusions and provide recommendations. As a result of certain challenges and faulty components that were encountered while configuring the hardware device, testing could not be conducted on it. However, testing was instead performed on the Proteus simulation of this project.

5.1 Test Description

Specific components of this project were subjected to some tests to measure the accuracy, precision, and responsiveness of those components. Three major test cases were conducted on this project through Proteus simulation. These test cases or experiments are outlined below:

1. Testing the accuracy and efficacy of the temperature sensor. In determining how well and accurately the system can measure patient temperature, ten different temperature values were specified as inputs to the temperature sensor in the simulation. The corresponding outputs were then recorded for analysis

2. Testing the height sensor's accuracy and precision. The height sensor, which was implemented using an ultrasonic sensor, was tested by incrementally adjusting the distance of objects from the ultrasonic sensor in ten steps as input. Proteus only allows for the input to be specified as percentages. The output from the system was then recorded and analyzed.

3. Testing the heart rate sensor. A test was also conducted on the simulation of the heart rate sensor to measure the system's efficiency in reproducing the input data. In this test, ten different heart rates were specified as inputs to the system, and then the corresponding outputs were recorded and analyzed.

5.2 Test Results and Analyses

This section summarizes the results and analysis of the three test cases outlined above. Each test case had peculiar results and analysis accordingly. The results and analysis of the various test cases are discussed below.

5.2.1 Test on the temperature sensor

<u>Results</u>

The table below (Table 2) shows the results obtained by measuring the ten different input temperature values specified in the simulation.

Table 2: Results obtained from simulation of temperature sensor.

Test	**Input (°C)**	**Output (°C)**	**Error**
1	36.0	36.1	-0.1
2	36.5	36.6	-0.1
3	37.0	37.1	-0.1
4	37.8	38.1	-0.3
5	38.3	38.6	-0.3
6	38.8	39.0	-0.2
7	39.3	39.5	-0.2
8	40.3	40.5	-0.2
9	41.1	41.0	0.0
10	41.6	42.0	-0.4

Figure 5.1 also shows a plot of the temperature values recorded from the test simulation.

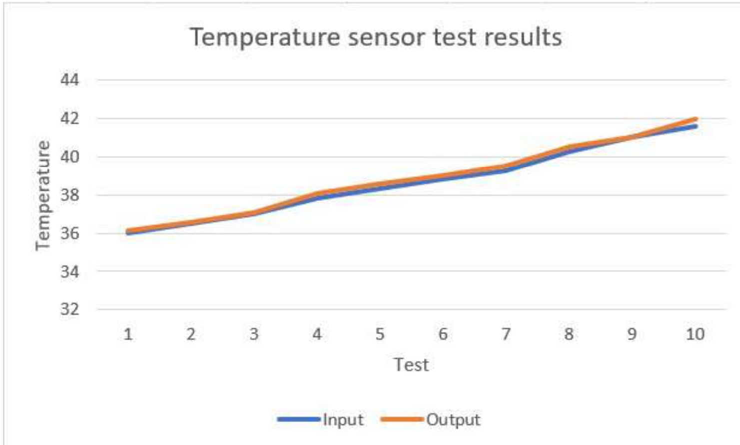


Figure 5.1: Plot of temperature values from test simulation

Analysis

From the results shown in Table 2, the simulation's temperature sensor output values have an average error of -0.19°C. This implies that temperature values obtained from the simulation are likely to be 0.19°C lower than the input temperature. The graph in Figure 5.1 shows a trend and relationship in both sets of temperature values.

5.2.2 Test on height sensor

Results

The table below (Table 3) shows the results obtained by incrementally adjusting the distance of objects (in percentage) from the ultrasonic sensor as input.

Table 3: Results obtained from ultrasonic sensor simulation.

Test	Input(%)	Output(cm)
0	0	103
1	10	0
2	20	110
3	30	110
4	40	63
5	50	35
6	60	33
7	70	67
8	80	84
9	90	84
10	100	110

Figure 5.2 also shows a plot of the height values recorded from the simulation.

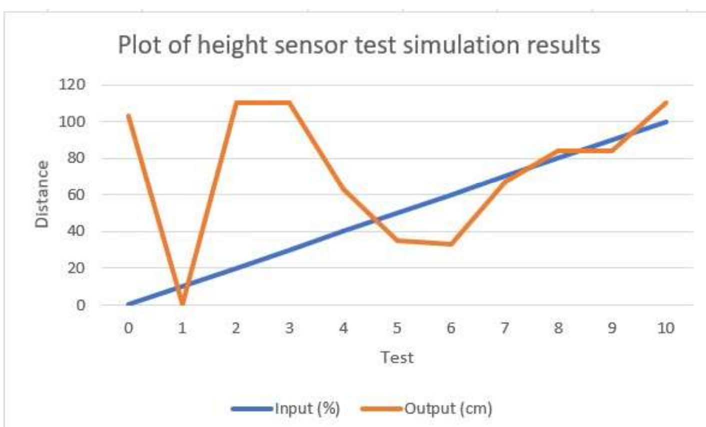


Figure 5.2: Plot of input and output height sensor values

Analysis

From the results shown in Table 3, the height sensor's values obtained from the simulation appear to be very random with no precision. The values obtained are also not consistent with the increasing input distance (in percentage). This can be observed in the graph shown in figure 5.2. The observed inconsistency could be as result of inaccurate measurement of sensor data or a defect in the Proteus ultrasonic sensor library used for the simulation.

5.2.3 Test on heart rate sensor.

Results

Table 4 shows the results obtained by simulating the heart rate sensor and recording its output values.

Table 4: Results from test on heart rate sensor

Test	**Input(%)**	**Output(BPM)**
1	10	80
2	20	127
3	30	111
4	40	140
5	50	99
6	60	146
7	70	128
8	80	143
9	90	95
10	100	84

The graph in figure 5.3 shows a plot of test results shown in table 4.

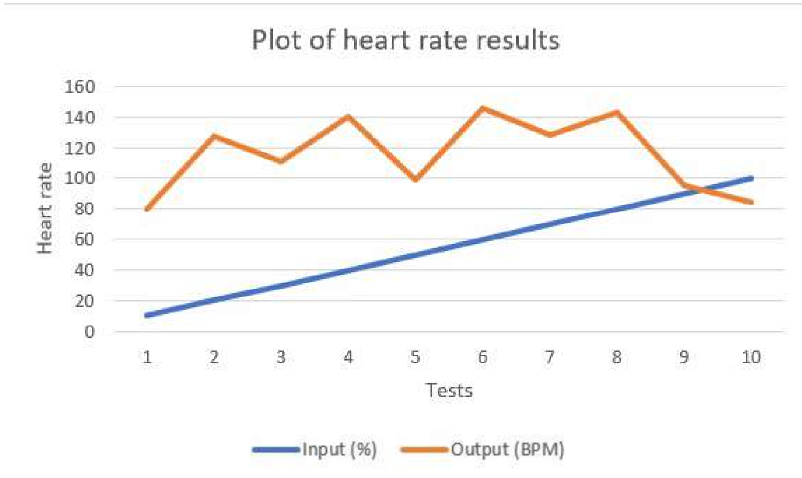


Figure 5.3: Plot of heart rate simulation data

Analysis

The test results shown in table 4 and the graph in figure 5.3 show that the output values are inconsistent with the input heart rate values. This can be attributed to an inaccurate reading of sensor values or certain faults in the heart rate sensor library used for the simulation.

Chapter 6: Conclusion

The work done so far on the IoT Health Kiosk establishes the basis for which IoT could be adopted to improve healthcare delivery in Ghana and the rest of Africa. By setting up the Health Kiosk in communities in the country, the government and private healthcare providers can significantly improve access to healthcare at an incredibly lower cost. This will also substantially reduce the burden on healthcare facilities making these social amenities last longer and incur lower running costs. Furthermore, the web application affords doctors the opportunity to track a patient's medical history. This aid doctors in making informed decisions during the diagnosis process. Also, with the health kiosk and its web application, individuals can now monitor and keep track of their health by carrying out more frequent vital sign checks. This way, people can quickly detect certain health conditions at early stages.

On the other hand, the current state of the system faces multiple challenges and limitations due to certain deliberate and some inadvertent factors. These limitations pose some level of hindrance and challenge to the effectiveness and sustainability of the project. However, these challenges present an opportunity for improvements to be made on the health kiosk to strengthen its efficiency, feasibility, and sustainability.

6.1 Project Limitations

The current design of the IoT health kiosk is marked by certain limitations and challenges which may hamper its successful implementation. Some of these limitations are outlined below.

1. Challenge in obtaining some proprietary sensors for the initial prototype. Many hospital-grade sensors (like the blood pressure and respiratory rate sensors) required for checking patients' vital signs are proprietary and hence present some difficulty in obtaining raw sensor values from the hardware. Therefore, such sensors could not be used for this project. The prototype had to use open-sourced sensors that have relatively lower accuracy than the hospital-grade sensors.

2. Access to smartphones and high illiteracy rate in the country. The current design of the health kiosk relies heavily on the fact that patients need to be educated enough to read and write and poses a smartphone. However, a good number of Ghana's population do not satisfy this criterion hence sidelining them from using the system. Also, the current system does not support usage by visually impaired patients.

3. Inadequate testing on the current prototype. For a hospital system like the health kiosk, there is a need to subject the system to rigorous testing and validation. These tests can sometimes require months to complete. However, due to the short time frame allocated for this project, extensive tests could not be carried out to iterate and test different designs adequately.

4. Feasibility with regards to physical examinations. Physical examination is an essential part of the medical diagnosis process. However, the current system does not provide doctors the opportunity to perform physical examinations during diagnosis. This is a considerable limitation since the majority of health conditions require a physical examination for effective diagnosis.

6.2 Future Works

The significance of the health kiosk and its limitations present a need for future works to be carried out to enhance the system. Not only should these future works attempt to mitigate the limitations outlined above, but they ought to bring improvements to the efficacy and robustness of the entire system. Some proposed future works that could be carried on the system are outlined below.

1. Introducing a means to perform physical examinations when required. Certain functionalities need to be put in place to ensure doctors can conduct physical examinations when the situation demands it.

2. Provision of assistance, support, and some functionalities to enable the uneducated and people without smartphones to use the system just like the educated smartphone users.

3. Making the system friendly to visually impaired patients.

4. Improving or changing the sensors implemented in the initial prototype to hospital-grade sensors with higher accuracy and efficiency.

5. Making the system contactless to reduce the risk of spreading contagious diseases like Covid-19.

6. Addition of more security features to the hardware and software systems. More cybersecurity preventive mechanisms need to be introduced into the system to prevent unauthorized access and data breaches.

7. Development of an admin interface to handle the addition of new doctors and kiosks for a hospital. Also, the admin can manage and keep track of patients who are attended to by the hospital's doctors.

8. Implementation of a Machine Learning model to aid doctors in the diagnosis of patient conditions.

9. Implementation of a Machine Learning model to assist patients in reporting their health conditions in a more detailed and comprehensive form.

Finally, the development of this health kiosk seeks to improve access to healthcare and reduce overcrowding in hospitals. This prototype serves as a blueprint for futures works and a proof of concept. Therefore, further research and works need to be carried out to ensure the development of a more effective and complete system to ameliorate the healthcare challenges in Ghana and Africa at large.

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Appendix

Appendix I : Interview Questionnaire for Oral Interviews

IoT Health Kiosk Oral Interview Questionnaire

Questions Administered to Prospective Patients.

1. Have you ever been to a hospital?
2. When was the last time you visited the hospital?
3. How often do you visit the hospital in a year?
4. How long does it take you to get to the hospital?
5. How many hospitals are in your community?
6. Do you find these hospitals to be overcrowded sometimes?
7. If you had a kiosk in your community and a mobile app that could help you could report your condition to a doctor will you use it?
8. How do you think that will be helpful to you?
9. What are some things you will expect the kiosk and app to help you do?

Questions Administered to Health Professionals.

1. Do you often find the hospital or clinic you work in to be overcrowded?
2. What do you think of a kiosk in communities where patients could go and get their vitals checked and sent to you for diagnosis?
3. If such a kiosk existed with a mobile app, what kind of services do you expect it to deliver to aid you in diagnosis?
4. Do you think your hospital will be willing to purchase a kiosk and set up in communities?