Design and Implementation of an Intelligent based Remote Health Monitoring System using Wireless Sensor Network

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ABSTRACT
For the human population, health coverage is a critical requirement. With Internet of Things (IoT) becoming popular as technology advances medical resources have the chance to offer intelligent, reliable, and efficient medical services, either within or outside the medical facilities. As a result, the focus of this work is on the physiological data of patients. Patient's temperature and pulse rate are monitored using sensors, and the collected data is transmitted to the database using the WEMOS D1 module. An email is issued to the doctor when a patient's body vitals readings exceed the predetermined threshold. On the patients' smartphones, an Android application is installed, allowing them to report on their health state and set off an alarm in case of an emergency. This allows the doctor to find the patients' current location. The doctor can obtain the patient's physiological data and records remotely by seeing the patient's information on the web page. With the use of this technology, the number of unpredictable events that regularly put the lives of thousands of people in risk due to poor medical care would significantly decrease.

Keywords
Android application, Database, Internet of Things (IoT), Physiological data, Sensors

1. INTRODUCTION
Currently, the usage of technology being wireless is expanded to suit the requirement for telemetry systems. Health Monitoring is a software development methodology that collects and analyzes healthcare data in order to gain understanding on large-scale, complicated health concerns. A remote health monitoring system is a hospital medical system extension that allows a patient's vital bodily status to be monitored remotely. Embedded technology is used in a patient monitoring system to detect the body vitals. This technological development is critical since many hospitalized patients are dying from high fever, which is mostly caused by an increase in body temperature and heart disorders such as cardiovascular disease, cardiogenic shock, cardiac arrest, and heart defects. Fever is the body's method of saying that something is wrong by shortly raising the body temperature. Body temperature refers to the ability of the body to create and expel heat. Average body temperature differs from one individual to the next and varies during the day. The average body temperature is 37º Celsius (98.6º Fahrenheit). Temperatures low as 97° F (36.1° C) early in the day and high as 99° F (37.2° C) in the afternoon are considered normal [1].
The number of contractions and relaxations a heart makes in a given amount of time is referred to as the heart rate (usually per minute). The human heart beats to give oxygenated blood to the muscles while also transporting pollutants from the cells away from the tissues. The rate of the heartbeat can change depending on the need of the muscles to take oxygen and expel carbon dioxide, such as during exercise or sleep [2]. Specific age groups have different heart rates. A healthy resting heart rate for a human adult of 18 years or older is up to 72 beats per minute (bpm). When the patient is at rest, the heart's functioning is said to be efficient if it has a minimal heart rate. Babies have a considerably faster heart rate than adults, approximately 120bpm, while teenage youths have a pulse rate about 90bpm [3].
It is difficult for doctors to stay near to a patient's bedside to check their health state these days, which makes it critical that they have a management system that allows them to keep an eye on their patients even in their absence. Body vitals are important when it comes to keeping track of a patient. To guarantee that healthcare is always rendered on time, it is required to have a system that continually monitors a patient's vitals autonomously and then sends a notification when readings are out of range.

Understanding and testing the monitoring system is an important component of Mobile Health innovation. With the use of mobile phones and other communication devices, these systems are used to administer medication and healthcare to an extent. Patients Remote Health Monitoring System is a portable device that monitors the patient's body vitals anywhere. Sensors are used to measure the respective vitals, and data is transmitted via the internet using a Wi-Fi module. Patients' information is stored in a database for quick access and reference. Such system is designed so it can be used traditionally or/and remotely.

2. HEALTH MONITORING SYSTEM
Health monitoring systema have gained importance as a study area in recent years. Many institutions, including the military, homecare units, hospitals, sports training, and emergency monitoring systems, have conducted research on health monitoring. Health Monitoring offers software services for collecting and analyzing healthcare data in order to shed light on complicated, large-scale health challenges. Remote patient monitoring saves time for both patients and doctors by providing vital medical knowledge on an outpatient basis. Patient mobility is also becoming more popular. Remote patient monitoring devices use a secure connection to a wireless network to allow patients to leave the hospital sooner and avoid the need of unnecessary electrical cables.

2.1 IoT in Health Care System
The Internet of Things (IoT), often referred to as the internet of

Everything or the Industrial Internet, is a new technology concept that anticipates a universal network of connected devices and things. The Internet of Things (IoT) is widely recognized among the most essential areas for further research innovation, and it has gained the attention of a wide range of industries. Once coupled systems successfully communicate among each other, the effectiveness of IoT for businesses may be completely realized. Integrating IoT into the medical surveilling application has given us a significant edge in the implementation of contemporary medical solution [4]. Systems are becoming more important and effective. as a result of persistent internet access. Patients are monitored regularly via IoT-based health monitoring devices. The devices create essential signals by evaluating statistical data at any time when it is needed. Patients may be remotely monitored and appropriate actions taken in the event of an emergency since IoT-based systems are always linked to the internet. As a result, IoT-based devices may perform both detection and emergency response functions. The contrasts among traditional health monitoring applications and IoT-based health monitoring applications are considerable.

Gupta and Bisht [5] defines IoT as a catalyst for healthcare that plays a prominent role in a variety of applications A system is proposed in which a microcontroller serves as a communication gateway. This system offers a clever patient surveillance system that employs sensors to check patient's condition and relies on the internet to alert family members or concerned medics in the case of an attack. The controller is also linked to a buzzer, which alerts the caregiver to any changes in detector output. To track the patient's state, the sensors are attached to a microcontroller, which is then interfaced with an LCD display and a wireless local area network connection to issue alarms. If the system detects any changes in the patient's heart rate or blood pressure, it automatically sends an IoT warning to the doctor and displays patient data in real time through the cloud. An advanced sensing module is available, which uses a cordless connection module to relay the gathered vital signs to numerous computers [6]. Also, there is a technology with a graphical platform that enables a physician to examine several sick people in real time utilizing long-term surveillance information from various sensing devices, and it works with existing sensor data transmission protocols like IEEE 1451 and ISO IEEE 11073 [7].

2.2 Wireless Sensor Network (WSN) in Health Care System

Wireless sensor networks (WSNs) in particular play a critical part in monitoring system application, assisting in the early identification of irregular situations and the avoidance of significant repercussions.

The expansion of WSNs has been fueled by rapid advancements in sensor design, information technology, and wireless networks. A WSN comprises of a collection of wireless-capable sensing units that collaborate to accomplish a common purpose. Data is collected from all sensing devices in a WSN by one or more sinks (base stations). The interface via which the WSN communicates with the outside world is these sinks. The benefits of networked sensing over traditional sensing may be summed up as enhanced accessibility, reliability, and efficiency at a potentially reduced cost.

WSNs are made up of geographically dispersed sensor-enabled autonomy systems that monitor physical or environmental factors and could interact with RFID systems to track the status of items including their location, temperature, and motions [8]. WSN can handle a wide range of distributed systems including multi-hop interaction. Recent advances in low-power electronic components and mobile connectivity has aided progress of efficient, low-cost, low-power small devices for WSN technologies [9].

There are two parts to a typical wireless sensor network. Sensor Node and Network Architecture are the two terms used to describe these two concepts.

2.2.1 Sensor Node

In a WSN, a Sensor Node is made up of four fundamental components. Power Supply, Sensing Unit, Processing Unit, and Communication Unit are the components. The sensor gathers analog signals from the surrounding, which an ADC subsequently converts to electronic information. The main processing unit, which is commonly a microprocessor or a microcontroller, handles data processing and manipulation intelligently. The communication unit comprises of an information transmitting and retrieving radio system, that is generally a limited radio range. The entire structure is carried out in a single CR-2032 battery since all of the components are limited. A Sensor Node, despite its name, contains not just the sensing component but also other critical functions such as processing, communication, and storage. With all these qualities, elements, and improvements, a Sensor Node is accountable for objects data collection, networking, data matching, and integration of data from other instruments with its own data.

2.2.2 Network Architecture

The networking of these sensor nodes is similarly critical when a huge amount of sensor nodes is placed in a vast area to observe an external condition jointly. In a WSN, a sensor node employs wireless connectivity to communicate with other sensor nodes as well as a Base Station. The sensor nodes cooperate to execute the task after receiving directions from the base station. After obtaining the necessary data, the sensor nodes send it back to the station. Via online platform, a base station may link to other systems. A base station collects data from sensor nodes and does basic data analysis before providing the modified data to the user through the internet.

Wireless Medical sensor networks (WMSNs) are the name given to wireless sensor network that are built for medical purposes. The health care system has benefited greatly from wireless medical sensor networks. Wireless medical detectors are implanted on the body of a participant and could be utilized to track their physical health. These medical sensing devices track the patient's physical readings (temperature, heart rate, blood pressure, oxygen saturation, and so on) and send the information to a remote site in real time. These sensor readings can be interpreted by a clinician to determine a patient's health condition. As a result, after being discharged from the hospital, patients may benefit from long-term monitoring. Figure 1 shows what a WMSN comprises of and how it is been implemented.

Fig 1: Wireless medical (body) sensor network. (*Body Sensor*, n.d.)

A tele-health monitoring system was presented by Shallel and Anooz [10] which comprises of three major modules: a data sensor unit, a data processor unit, and a data communication unit. Changes in the vital signs are detected by the temperature sensor and the heartbeat sensor in the data sensor module. Following that, the data is transferred to the PIC controller of the data acquisition unit, where it is examined. Data is sent between a person and a piece of equipment through the communication device. This includes essential components like as message, sender, receiver, mediator, and protocol, which are used to convey messages to doctors via mobile phones.

Khalifeh et al. [11] created and developed a patient fall detection system based on a collection of sensing devices and an accurate controller that connects with the cloud via an Ethernet shield. This technology employs an accelerometer module to monitor patient movement and gives a warning if the patient falls. This is achieved through the use of a three-axes-based algorithm. The system uses a cloud-based clever algorithm to determine if the falling alarm is accurate or fake. In addition, the system uses cloud computing technologies to keep track of the patient in real time. This system makes advantage of cloud computing to provide a database as well as actual surveilling. Moreover, there are some drawbacks, such as the patient's limited mobility and the fact that the system does not send an alert to medical personnel in the event of an emergency.

Trivedi and Cheeran [12] suggested a smartphone controlled Arduino-based health indicator surveillance system All of the input collected by sensors is in raw format. The information is transmitted to the Arduino Microcontroller. The continuous readings obtained are transformed to discrete using an integrated analog to digital converter. Bluetooth is used to send the data values to a smartphone. The application relied on a Bluetooth module that only covered a small region. Mangu [13] developed a system that continually monitors the patient's vital signs and identifies anomalies by utilizing MQTT clients to transport data from sensors to a cloud platform, where the doctor or family members may monitor or follow the patient's health using Android applications.

On the basis of the Internet of Things, a smart patient heartbeat and body temperature monitoring system for safe health developed by Okubanjo et al [14] uses sensors to continuously monitor the patient's heart rate and body temperature, then sends the data to a cloud server for further analysis. Through a secure cloud-based data retrieval database administered by medical specialists, the suggested framework incorporates four-tier architectural elements to support data sensing, data processing, data transmission or communication, and output for further analysis of the patient's health state. The sensors, microcontroller, and wireless communication device were combined with a cloud-based server via an IoT platform in this study to improve patient-doctor contact and preserve real-time updates of patient information and medical specialist responses. In addition, the developed system's integration of IoT and embedded systems considerably improved speedy medical care for patients in rural places by removing long hospital lines and reducing manual patient record keeping. The technology is, however, confined to emergency circumstances and global positioning system location tracking.

3. DESIGN METHODOLOGY

The design and deployment of an intelligent remote monitoring system based on WSN proposed in this paper is achieved through the following:

1) Designing a real-time temperature and heart beat detecting device to display data to web server.
2) Designing an application of Internet of Things (IoT) using wireless sensor network for online data transmission.
3) Implementing a mobile app to enable emergency trigger using global positioning system (GPS) to track patient’s location.
4) Designing patient’s management system for data storage, analysis and referencing.

Figure 2 shows the overview of the remote monitoring system which includes the temperature sensor, the heart beat sensor, the wireless sensor module (communication gateway), the android app and the web database (cloud).

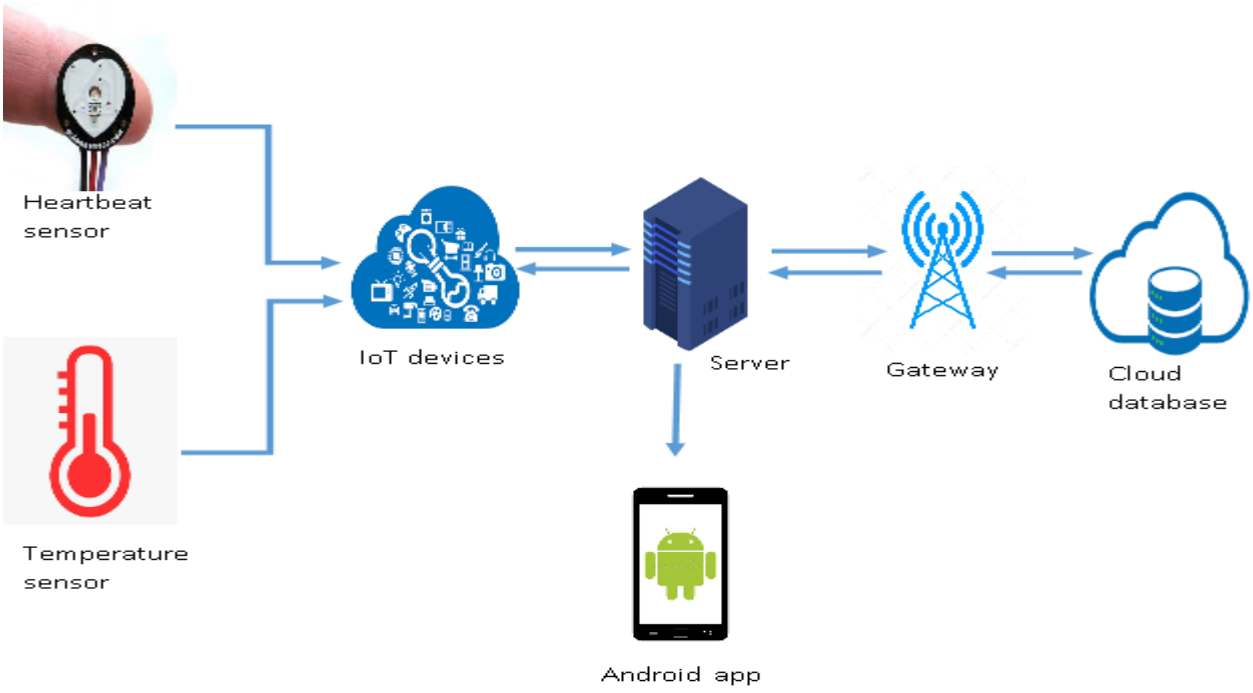

Fig 2: System design overview

The sensor captures the patients' vital signs and transfer them via the internet to a database via the communication gateway. The patient can report on health status and alert the doctor in the event of an emergency, as well as track the patient's whereabouts, using an Android application on his or her phone. The patient's data is saved in the cloud and accessible via a data network link on a web page, giving the doctor remote access to patient's physiological records and reports. The proposed system consists of the hardware and the software.

3.1 Hardware Devices

The hardware device consists of the WEMO DI WIFI module, the Heart beat sensor and the Temperature sensor LM35. The device starts by confirming the sensors are connected. The patient's personal physiological parameters are then taken and logged into the database on the web server. The information can then be viewed by authorized user from their devices. In a situation where the patient's personal physiological parameters go beyond a stipulated value, the system alerts the doctor by sending an email via the web server for immediate action. See Figure **3** for the flow diagram.

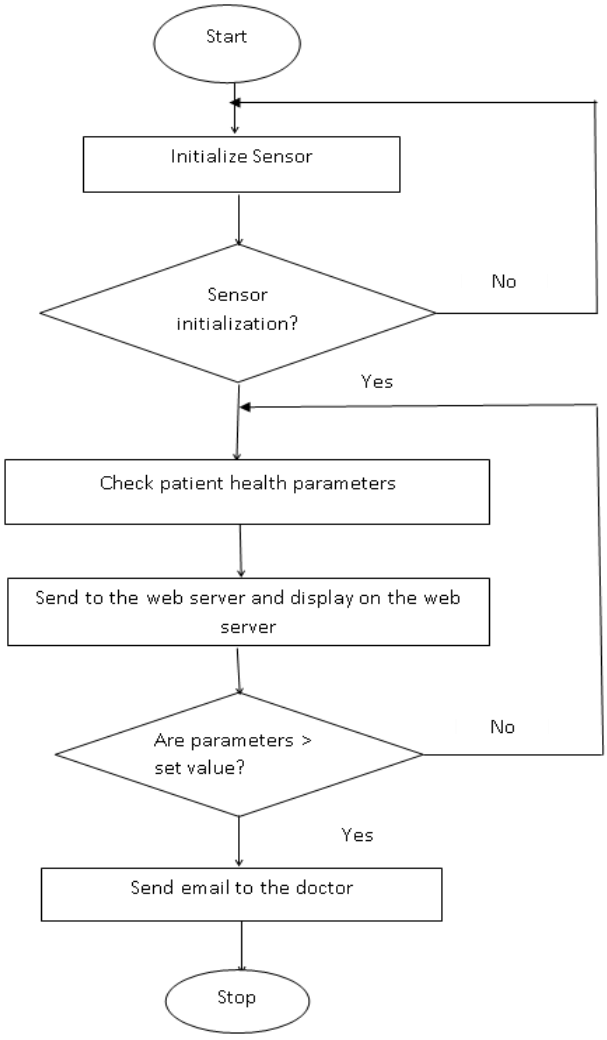

Fig 3: Hardware device flowchart diagram

3.2 Software Application

The software consists of the Android application and the web application.

3.2.1 Android Application

The Android application for this implementation requires that the patient is registered in the system database to be able to access the features of the Android App. The android packet kit (APK) file will be sent to the patient's smartphone to sign in with his or her medical registration number after installation. An OTP (One Time Password) will be forwarded to the patient's mobile number to verify the patient is in the system database to be able to logon to the Android App. The Android App is for patient to make a report about their health status and to initiate an emergency when needed, this information will be stored in the database and reflect on the web page for the doctor to be notified and take immediate action.

3.2.2 Web Application Development

The web application is an interactive computer program that uses web technologies to store and manipulate data, executing activities through the internet. This was created with the objective of collecting, conserving, and transmitting patients' physiological parameters report, which needed to be transferred among medical doctors and displayed. The web application has a unique web address for doctors to access its features through a web browser by logging in user ID. This application allows doctors remotely obtain a wealth of information on patients from anyplace, at any moment using peripheral devices like as laptops and mobile phones, allowing them to monitor and manage patients. The major web technologies used in this web application are HTML 5, CSS, PHP, JavaScript and Java.

3.3 System Configuration

The system is built on hardware and software as previously discussed. With the hardware connections, the physical pins are used to link the heartbeat sensor and the body temperature sensor to the WEMOS D1, as shown in Figure 4. The WEMOS D1 is a processing unit with an analog-to-digital converter (ADC) built in to convert sensor data to a digital signal. Both sensors' VCC and GND are connected to the WEMOS D1's VCC and GND pins. The signal pin (OUT pin) of the heartbeat sensor is connected to analog pin AO of the WEMOS D1, while the data pin of the LM35 is connected to analog pin A0 of another WEMOS D1. The data from the sensors is then analyzed and prepared for presentation on a compatible web page. To power the WEMOS D1 and other peripheral devices, an 8A constant voltage module steeps down the DC voltage of 19.5V power adapter to 5V constant voltage.

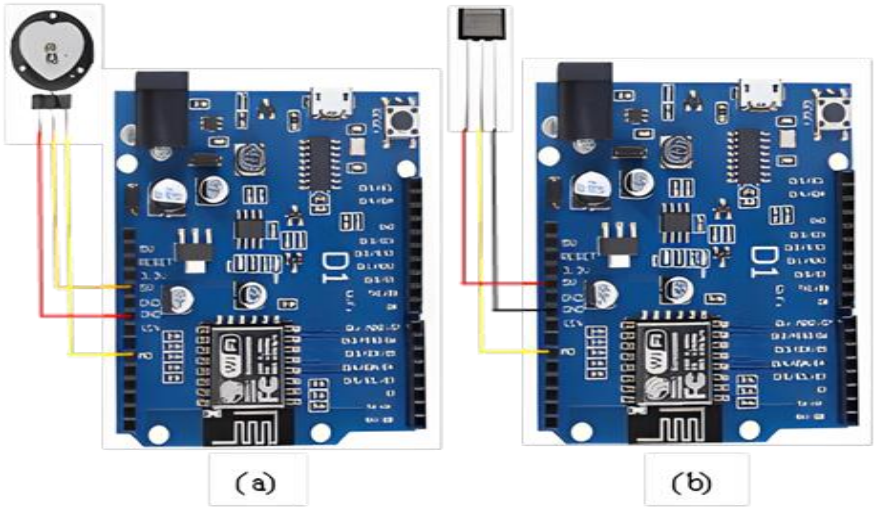

Fig 4: Circuit configuration of (a) Heartbeat sensor with WEMOS D1 (b) Temperature sensor with WEMOS D1

3.4 System Database

System database is a logically ordered set of data that may be accessed and stored electronically. This allows users to create, update, and handle database information and records, making it easy to create files and records, enter data, edit it, update it, and remark on it. It takes care of data protection, preservation, and alerting, as well as multi-access control and privacy.

The MySQL database was used to store all of the patient sensor data and diagnostics in this design. The database was deployed on a different server than the web application due to the volume of data that will be stored and requested from the system. This is done to ensure that the database is hosted on a cloud server with sufficient storage capacity and data security, as the information supplied to the database is vital. The web application's Backend facilitates the interaction between the web application and its database. The backend is the phase of web application development that deals with the application's performance and operation; it is where application's database connection is made.

4. RESULTS AND DISCUSSIONS

The system was built, having all applications been implemented and tested guarantying it achieves its objectives.

The hardware devices were tested and are working properly as intended, both in reading patient's body vitals and transmitting the readings to the online database.

The software testing of the system covers the functionality and graphical user interface of the Android app and the Web application. The Android app validates patient's ID before granting access to the application features which includes making a report and initialing an emergency to enable tracking their current location, see Figure 5.

The designed web application presents a user-friendly interactive graphical user interface for navigating through various pages, entering, modifying, deleting and viewing of patients' records and current location. This can be accessed on

smart phones and laptops through a web browser by providing logging on username and password to verify authorization. See Figure 6 for GPS patient location displayed on the web page.

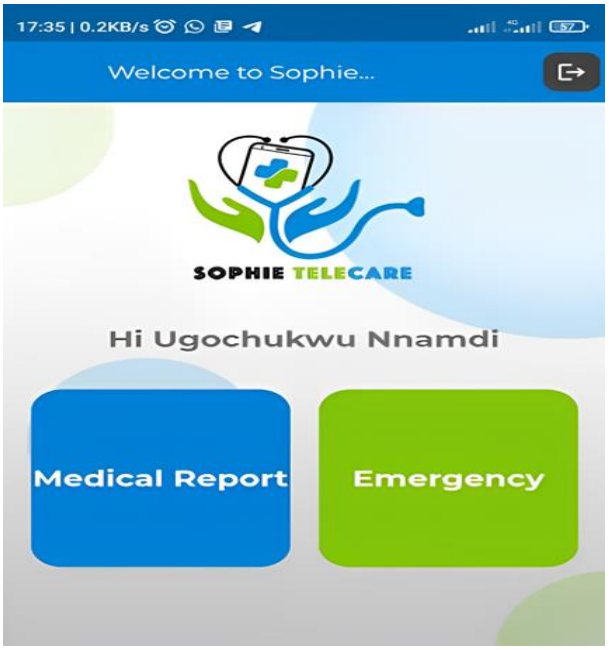

Fig. 5: Report/Emergency page of the Android App.

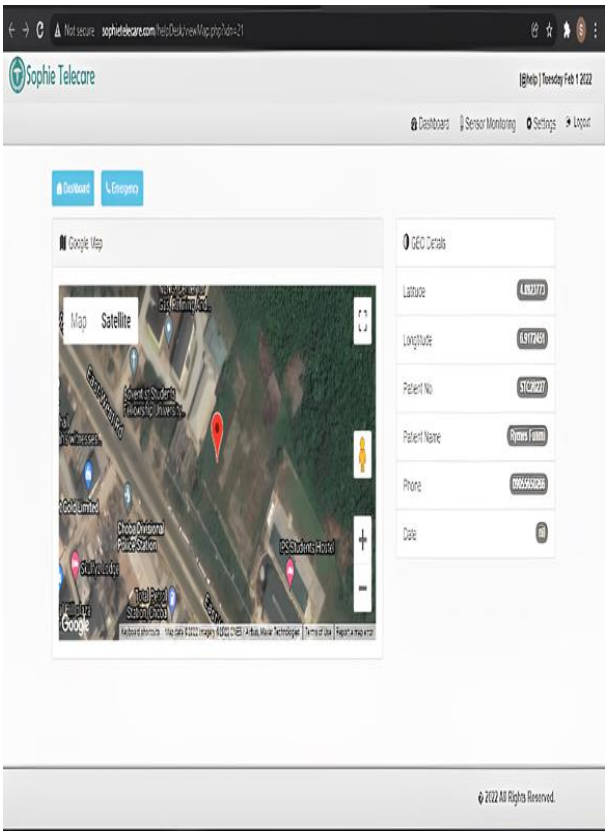

Fig. 6: The GPS location of patient.

To ensure compliance with certain requirements such as data entry, preconditions, expected results, and postconditions, test case scenarios are used to identify the system functionality, see Table 1.

Table 1. System Test Scenarios

PRECONDITIONS	ENTRY DATA	EXPECTED RESULTS	POST CONDITIONS (PASS/FAIL)
Patient wants to check vital signs	Confirm sensors are connected	Device detects and sends readings to the web server	Pass
Patient wants to access the Android app	Sign in with patient ID. Make a report or trigger an emergency	Display Home page. System sends report or trigger to the web server	Pass
Doctor wants to access the web application	Enter valid login details and click login	Display Home page	Pass
Doctor wants to track patient's location	Clicks on Location link on Emergency page	Directs to google map page	Pass
The user wants to view patient's reports	User clicks on patient report on home page	Directs to Patient report service page	Pass
Patient's vital exceeds above or below required condition	Vital values	System sends email alert immediately to doctor and indicates emergency events on the web page	Pass

5. CONCLUSION

Temperature and pulse rate for a vital sign monitoring system and wireless connection for data transmission have been described and assessed in this study. The experimental result demonstrates that the chosen sensors are appropriate for the proposed system. The body temperature and heartbeat of a patient's condition has been measured using the preferred sensors.

During this time, the wireless communication module (WEMOS D1) was put to the test by sending data from the sensor to a web server. The result demonstrates that the sensor can provide enough information for vital sign monitoring. Based on the results of the trial, the wireless communication module was designed to provide an automatic messaging capability via e-mail to send information on patient's physiological readings to the doctor when abnormality is been detected.

With the Android application patients makes report on health status and also alert doctor when help is needed by using the emergency feature which also indicates their current location. The built Android application allows the doctor to track a patient's current location via a web page if the patient's Android phone's GPS location is turned on.

The Web Application is built to ensure that the graphical user

interface is user-friendly and the page navigation is straightforward. Patients' records are stored in a database and displayed on the web application, allowing the doctor to obtain entry to the patient's physiological information and reports remotely and also view patient's location based on where the emergency feature was initiated.

6. CONTRIBUTION TO KNOWLEDGE

This system is beneficial in the healthcare sector since it allows wireless monitoring of a patient's heartbeat and body temperature, avoiding needless hospital visits. The contribution to knowledge is the Android app on the patient's Android phone, where patients can make complaints on their health status and also alert the doctor on current location by using the emergency feature when needed. The Android app grants the doctor access to track the patient's location of where the emergency feature was initiated when the need arises, provided the patient's Android phone Google map location is turned on.

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