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Design of a Wearable Device to Track Heart Problems

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DECLARATION

I, **Hilarie NYIRANEZA**, declare that this dissertation entitled “**Design of a Wearable Device to Track Heart Problems**” is my original work based on research and a prototype and that no one have not submitted it for any other degree or professional qualification.

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CERTIFICATE

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ABSTRACT

This work reports on Design of a Wearable Device to Track Heart Problems. Heart-related illness, including cardiovascular disorders, remain a leading cause of death globally. The early identification and continuous monitoring of cardiac issues are critical to saving lives. However, several challenges make self-monitoring of heart health particularly difficult in Rwanda. Restricted access to healthcare services means that many individuals do not have the necessary medical support for regular heart check-ups. Budgetary constraints further exacerbate this issue, as advanced medical devices and regular consultations can be prohibitively expensive for many. Additionally, there is a general lack of understanding and awareness about heart health and the available monitoring technologies. To address these severe obstacles, a wearable device that tracks heart problems through heart rate monitoring can offer significant benefits. These include continuous monitoring of heart rhythm to detect arrhythmias, which can help ensure more efficient blood flow. By providing early warnings of potential issues, the device can alert users to seek medical advice or treatment promptly, supporting better oxygen delivery to tissues and reducing stress on the heart. The device is easy to use, allowing it to fit smoothly into daily life without causing any interruptions. This wearable device has temperature and heartbeat sensors that are capable of detecting and analyzing minute fluctuations in heart rate. Temperature sensor is essential for monitoring heart problems because it provide significant data on body temperature. High temperature can raise heart rate and metabolic requirement, posing a risk to those with cardiac problems. In contrast, a reduction in temperature can slow the heart rate and impact circulation. Heartbeat sensor provides a real-time heart rate and rhythm data. These sensors provide valuable insights into a person's cardiac autonomic function, with the data processed by a program stored in a microcontroller and ability to send the data to the cloud as well as a remedy generated by the system to help patient or health workers of the patient to know what they can do for first aid. The wearable device monitors heart rate and alerts patients directly with a red LED indicator if abnormalities are detected. Doctors receive notifications via GSM for calls and messages, and they can view the patient's heart health data on a dedicated website. This website is accessible to both doctors and caregivers, who can use the data to provide advice and guidance to the patient. The development process lasted six months and included repeated cycles of creating and testing versions. The device was tested in various environments to ensure its accuracy and reliability. It effectively detects even minor fluctuations in heart rate, including arrhythmias, facilitating early detection and timely medical intervention, which improves health outcomes. Future research will aim to validate the device's performance and integrate it into telemedicine. Upcoming features may include real-time communication, allowing doctors to give immediate feedback and instructions to patients, thereby improving heart health management, additional sensors may be added.

Key Words: Wearable device, Heart rate, LED (Light Emitting Diode), GSM (Global System for Mobile Communication)

LIST OF ACRONYMS

BPM: beats pulse per minute

CEBE: Regional Centre of Excellence in Biomedical Engineering and e-Health

CSS: Cascading Style Sheets

CVD: Cardiovascular diseases

ECG: Electrocardiogram

GaAs: gallium arsenide

Gann: gallium nitride

Gap: gallium phosphide

GSM: Global System for Mobile Communication

HRV: Heart Rate Variability

ICU: Intensive Care Unity

IDE: Integrated Development Environment

Iota: Internet of Things

IR: Infrared

LCD: Liquid Crystal Display

LED: Light Emitting Diode

MCU: Micro Controller Unit

Ndembu: Node Micro Controller Unit

OLED: Organic Light-Emitting Diode

PCB: Printed Circuit Board

PPG: photo plethysmography

SDK: Software Development Kit

SIM: Subscriber Identity Module

SMS: Short Message Service

WHO: World Health Organization

Wi-Fi: Wireless Fidelity

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CHAPTER 1. GENERAL INTRODUCTION

1.1 Introduction

In the present day, the great majority of heart-related disorders require ongoing monitoring over a long period. Heart rate monitoring is a vital aspect of maintaining heart health[1]

Cardiovascular diseases (CVD) encompass a range of conditions affecting the heart and blood vessels and stand as a powerful global health challenge. All racial and ethnic groups bear a heavy burden of mortality and morbidity from CVD, with men and women dying from it at about equal rates.

A total of 17.5 million people died from CVD in 2012, making up 31% of all deaths globally[2]. CVD has a significant economic impact on healthcare systems, including direct costs such as hospitalizations, rehabilitation services, physician visits, and drugs, as well as indirect costs related to mortality and morbidity, such as productivity losses and short- or long-term disability[3].

Notably, in China, in 2014, cardiovascular disease (CVD) remained the primary cause of mortality, accounting for 44.60% and 42.51% of all fatalities in rural and urban areas, respectively. These numbers were greater than those attributed to cancer or any other disease.[4] Similarly, in the United States, CVD ranks as the primary cause of death and represents a significant factor in hospitalization and disability among military personnel.[5]. In addition, according to the World Health Report 2002, cardiovascular diseases (CVD) will be the largest cause of death and disability in India by 2020. These statistics underscore the widespread impact of CVD on public health globally but despite these concerning numbers, the landscape of healthcare is evolving, with advancements in technology offering potential solutions. Specifically, wearable technology has become an effective tool in the field of healthcare, enabling ongoing health monitoring. The World Health Organization (WHO) emphasizes that many of CVD occurrences are preventable; stating that almost 80% of cases of premature CVD, strokes, and diabetes might be avoided with early detection and care. [6] Patients can obtain quick therapies and continuous monitoring for chronic illnesses through wearable sensors, mobile health applications, and tele monitoring equipment. It has been demonstrated that remote patient monitoring can improve patient outcomes, improve self-management, and decrease hospitalizations.

[7] As a result of a geographical condition that can be a barrier for a patient to be diagnosed at time needed, the provision of healthcare services has shifted from being clinic-centric to being patient-centric because of the integration of wearable sensors with mobile communication technologies.[8]

This work has to design a wearable device with heartbeat and temperature sensors to measure respectively the heartbeat and temperature of a concerned people as it is known that the two main indicators that doctors check on patients right away after they arrive are their body temperature and heartbeat. The device will record and analyze the heart rate which can serve as a foundation for determining the presence of CVD especially arrhythmias diseases. In addition, HRV is crucial for the management of arrhythmia, myocardial infarction, hypertension, and sudden cardiac death.

The identification and examination of HRV are extremely important for the detection and prevention of CVD [9] The term "heart rate" describes the number of times a heart beats (typically once per minute) and relaxes. Varied age groups have varied heart rates. An average adult's heart rate ranges from 60 to 100 beats per minute (bpm). The average heart rate of an athlete ranges from 40 to 60 bpm, depending on their level of fitness.[10]. This study focuses on one type of CVD known as arrhythmias disorders. An arrhythmia is an abnormal heart rhythm in which the heart beats too quickly, too slowly, or irregularly. Arrhythmias develop when the conduction system malfunctions, such as after a cardiac attack, heart failure, cardiomyopathy, or coronary heart disease. There are various types of arrhythmias, including Atrial Fibrillation (AFib), Atrial Flutter, Supraventricular Tachycardia (SVT), Ventricular Tachycardia (VT), Ventricular Fibrillation (VFib), Bradycardia.

The symptoms of arrhythmia includes palpitations, dizziness, feeling as if you may 'black out', breathlessness, chest discomfort and feeling tired [11].

Recognizing the pivotal role of early detection and intervention is crucial for mitigating the impact of cardiovascular diseases. Research suggests that early discovery of anomalies facilitates long-term restoration of human life. Also early detection of cardiac disease is essential for more effective treatment [12].

In this system, the microcontroller (Node MCU) will read heart rate data from the MAX30102 heart rate sensor and temperature sensor, display the output on an OLED display, notify the doctor via the GSM SIM800L, and send all data to the website via Wi-Fi. C programming will set the limit values for the heart rate. When the value displayed on the OLED is below and above the limit, the physician or the doctor will send a message advising the patients based on the results interpreted from the device's display. Wearable technology ensures that patients' important health information is constantly accessible, regardless of where they reside or how close a hospital is, which helps to bridge the gap between patients and healthcare experts. Consider a situation in which a person suffers from a heart arrhythmia while they are at a distance from a medical expert, Wearable technology like this device being developed for this research, can help by sending timely signals to healthcare personnel that could lead to life-saving steps. This kind of accessibility and proactive monitoring has the potential to improve healthcare delivery, making it more accessible and responsive to the needs of each patient. It intends to monitor hearts and save lives one beat at a time by giving continuous monitoring to all.

1.2 Problem statement

Cardiovascular illnesses, particularly arrhythmias, are a serious and growing health concern worldwide. In Rwanda, a lack of healthcare resources, awareness, and diagnostic and treatment facilities worsens the burden of arrhythmias. If left untreated, arrhythmias can cause major problems such as stroke, heart failure, and sudden cardiac arrest. Cardiovascular diseases are a primary cause of arrhythmias, and patients with CVD face several barriers to following their treatment plans. Heart diseases are prevalent in remote locations due to the difficulty of accessing doctors and hospitals. Furthermore, many people lack financial resources or knowledge about how

to maintain good health. People frequently reside in areas with a scarcity of good hospitals and doctors, making it difficult to obtain appropriate care. Furthermore, rural areas have limited access to cardiac doctors and other medical personnel. This means that people might not detect or treat heart problems in a timely manner. To solve this issue, it is vital to make healthcare and health education more accessible to those living in rural locations, as well as to guarantee that hospitals have all they need to assist patients with heart diseases. Furthermore, understanding what symptoms are "normal" for you and how to notice when they worsen is crucial. Because patients will continue to use the intended wearable device, they will be aware of the importance of an urgent medical visit.

To ensure accessible diagnosis for all citizens, Rwanda has implemented several measures: telemedicine allows remote consultations via mobile phones; mandatory health insurance helps eliminate financial barriers to diagnosis; and health posts and at-home healthcare professionals provide widespread access to care.

However, despite the Rwandan government's efforts, the problem of persons with heart disease continues to worsen, particularly in rural areas. It is "known" that people in rural areas tend to be poorer, sicker, and lead less healthful lifestyles [13]. Every nation struggles with communication and transportation, and they are all confronted with the issue of a scarcity of medical personnel, particularly physicians, in rural and isolated locations[14]. In Rwanda, a substantial percentage of hypertension illnesses go undetected due to a lack of regular physical checks and early detection of symptoms. Interventions to promote awareness about hypertension Regular physical checkups must also be encouraged [15]. A study in Rwanda found that rural individuals have a little greater prevalence of high CVD risk (8.0%) than urban ones (6.8%)[16]. Another study demonstrated that certain Rwandans living in rural and urban areas are aware of the factors that may increase their risk of CVD in their local communities; however, other people lack awareness of these factors due to a lack of information of CVD risk factors [17]. Cardiac arrhythmia, characterized by fast or slow heartbeats, causes tachycardia or bradycardia. Irregular heartbeats may not cause symptoms until they become acute, resulting in palpitations and chest pain. While some arrhythmias are minor, they can lead to catastrophic conditions like stroke, heart failure, and cardiac arrest[18]

To address these challenges, there is a need for innovative solutions in cardiovascular care. Integrating affordable and wearable technologies can offer continuous monitoring and communication with healthcare providers, empowering rural citizens to manage their health effectively. This approach leverages Rwanda's increasing access to technology to mitigate the burden of cardiovascular diseases in the population.

1.3 Research Questions (Hypotheses)

Here are more research questions for development of the outline:

1. What features (e.g., battery life, weight, material) are most important to users for ensuring they consistently use the device?

2. What are the most effective sensor technologies for monitoring heart conditions
3. Is the wearable device capable of detecting abnormal heart rhythms that indicate heart problems?
4. Will the alert and notification systems effectively inform users and healthcare providers of detected heart problems in a timely manner?

1.4 Objectives

1.4.1 General Objective

This project aims to design a wearable device capable of tracking heart problems through the interpretation of heart rate.

1.4.2 Specific Objectives

To achieve the general objective of this project, we use the following specific objectives as guiding points:

1. **Define Requirements and Develop Prototype:** identifying the essential technical, medical, and user needs for the heart rate monitor. Create and test an initial prototype to ensure it meets these needs. Refine the prototype based on feedback to improve performance and usability.
2. **Implement Notification System:** Develop a real-time alert system to notify doctors and patients of critical conditions.
3. **Enable Cloud Integration and Evaluate Performance:** Ensure the device can send data to the cloud for remote monitoring and assess its effectiveness in improving cardiovascular health through testing and evaluation.

1.5 Study Scope

The purpose of this project is to create a wearable gadget for monitoring heart rate in order to help prevent serious cardiac disorders. The device will detect abnormal heart rhythms by comparing real-time data to established normal values and will tell both the user and their doctor if there are any deviations. The system will have a dashboard where users may save recordings for future reference, and the device will be cloud-integrated to deliver advice and help manage heart health. This strategy seeks to provide prompt intervention and guidance to enhance cardiovascular health outcomes.

1.6 Significance of the Study

A wearable device for tracking heart-related problems that uses heart rate analysis would encourage preventative healthcare. Clearly, early detection of cardiac anomalies can lead to early interventions in one form or another, reducing the burden of CVDs and, eventually, improving health outcomes.

The wearable device detects irregular heart rhythms such as bradycardia and tachycardia, typically

before symptoms worsen. When the prototype detect an arrhythmia, it will send immediate warnings to the user and healthcare practitioners, allowing for timely medical action. This gadget is non-invasive and comfortable to wear, allowing the person to utilize it continuously without discomfort. The device provides a full perspective of cardiac rhythm health. This device will also help patients adhere to prescribed medications and lifestyle changes, improving overall management of arrhythmias. Wearable devices and continuous monitoring of arrhythmias play a critical role in detecting and managing the interrelated conditions such as coronary Artery Disease (CAD), Hypertension, heart failure, cardiomyopathy...

1.7 Organization

This paper begins by discussing cardiovascular diseases (CVD) and emphasizes the importance of early detection of arrhythmias using heart rate (HR) monitoring, explaining the benefits of early detection for better patient outcomes, and describing the proposed technology for continuous HR monitoring via a wearable device. The second chapter covers pertinent works from numerous papers, assessing alternative technologies and approaches to cardiovascular monitoring and emphasizing gaps and limits in existing research. The third chapter describes the design process for a wearable device, including the integration of heart rate and temperature sensors with a microcontroller and GSM module for real-time communication, as well as the hardware, software, and communication protocols needed to create prototypes. Chapter 4 discusses the practical application of wearable technology, including its components and functionalities. Finally, Chapter 5 summarizes the research methods and findings, providing insights and recommendations for future advances in cardiovascular health monitoring.

1.8 Summary

In this chapter, we learn about the global challenge of cardiovascular diseases and the importance of early detection using heart rate indicators. It introduces the idea of wearable technology for continuous health monitoring. By outlining the project's goals and significance, it sparks curiosity and encourages readers to explore further in the upcoming chapters

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

Wearable health monitoring devices have become increasingly popular due to their potential to provide continuous and non-invasive monitoring of vital signs. Among these vital signs, heart rate and body temperature are crucial indicators of an individual's health status. Integrating GSM and Wi-Fi capability technology into wearable devices enables real-time communication and remote monitoring with healthcare providers, facilitating timely intervention in case of abnormalities and remote. This literature review aims to explore existing research and developments in wearable devices capable of monitoring heart rate and temperature while providing GSM-based notifications for healthcare professionals, LED alerts for users, and able to send data to the website so that a user or doctor can log in and view all records of the patients.

2.2 Wearable Devices for Heart Rate Monitoring

A proposed system employs sensors to monitor a person's heart rate even while they are at home [19]. Despite these advantages, the patient must log into the system to check the data, which can take time.

To improve care and identify complications and disease development, wearable sensors can be used to promote healthier lifestyle, screen for incident disease, and offer discreet continuous monitoring to patients with chronic illnesses [20].

The electrocardiogram is a widely utilized and precise technique for determining heart rate. The electrocardiogram is a pricey instrument, and using it alone to assess heart rate is not cost-effective [21].

Prior research demonstrated the efficacy and safety of wireless and handheld ECG equipment for ongoing HR monitoring and arrhythmia detection. Patients should speak with their physician to examine their ECG recordings, nevertheless. Patients can email or print the ECG recording, and clinicians can view it on the manufacturer's website. Furthermore, when abnormal HR occurs, the systems do not offer a feature that alerts the patient or clinician [22].

Similarly, Even though a large number of ambulatory ECG monitoring devices have reached the market, a significant issue remains because patients or athletes engage in motion-related activities that produce undesired signal noise, which reduces the effectiveness of the monitoring. Figure 2 depicts a piece of work made employing a heartbeat and temperature measurement system for remote health monitoring over a wireless body area network [23]. Sensors detect data, which the microcontroller PIC16F73 processes before transmitting it to the doctor via the GSM module.

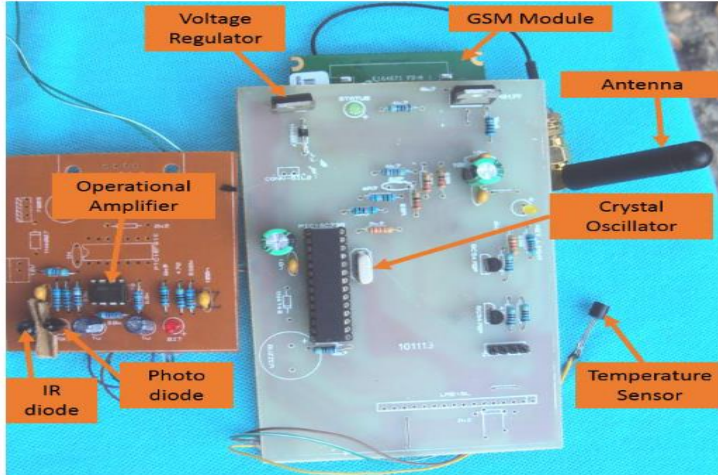


Figure 2.1: ECG monitoring devices with GSM modem.

During the design infrared light emitting diode (IR LED) and IR photodiode senses the pulse rate while temperature sensor of type LM35 is used to sense the body temperature. A device has been tested on many people, the results show that the device is able to detect the heart beat and temperature and send then to mobile telephone. The researchers claim the device to be miniaturized in the future to increase the comfort of the user and make it user friendly.

According to a different study, researchers fixed an ECG sensor with replaceable electrodes directly to the chest to monitor every heartbeat. The prototype's heartbeat sensor in this study is conveniently placed to the arm to monitor heartbeat [24]. Many connected devices, such as the Arduino UNO and Arduino Nano, pulse rate sensor, accelerometer sensor, Thing speak interface, and GSM technology, are used to periodically collect health-related data in order to detect heart attacks and save lives before they become dangerous, as mentioned in the paper [25], the architectural framework of the developed system is shown in Figure 2.2.

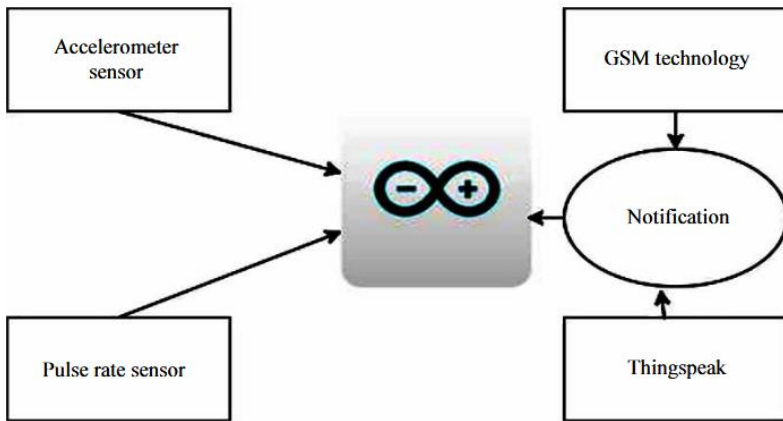


Figure 2.2: Block diagram of heart attacks detection system.

A device is composed of accelerometer sensor to detect the user position and pulse rate sensor to detect the heart beat therefore the data are processed by Arduino IDE, data are saved on

Thingspeak and the user get notification by using GSM technology. Figure 2 Shows the hardware parts used to develop a device.

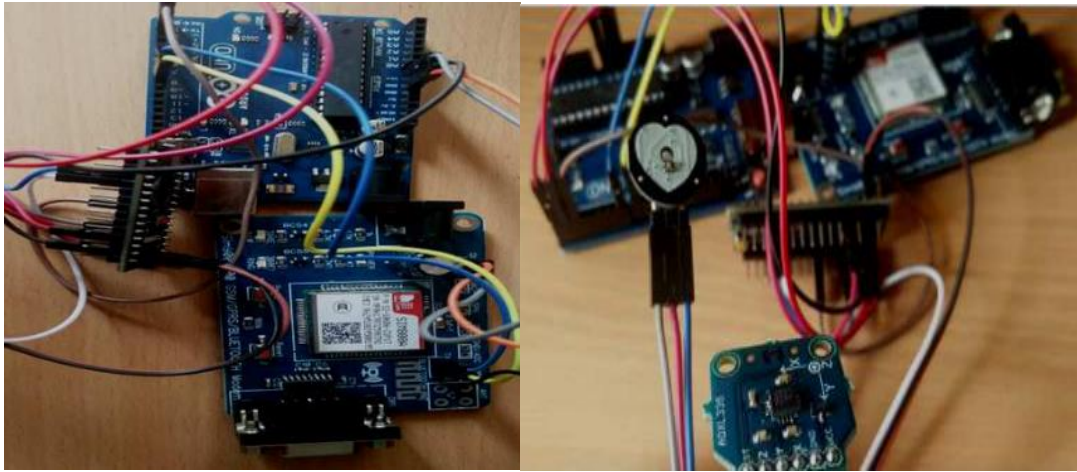


Figure 2.3: Hardware of Heart Attacks Detection System.

The system in this work will be helpful to everyone who needs to monitor the health of their heart, but it was more beneficial to older people, those with Frankenstein illness, and people who had a history of heart attacks due to genetic problems. It could be a regular individual who wants to know how their heart is doing or a patient who needs to see a doctor frequently since they have already been diagnosed with cardiac issues. This system will also be a result of financial and geographic barriers, since the patient can contact the doctor only in the event that the system indicates an emergency or a severe situation.

The research compares heart rate readings during physical exercise from a smartwatch, a fitness tracker, and a specialized sports gadget with a chest strap. Unintentional movements of the gadget in relation to the wrist make it difficult for fitness trackers and smart watches to detect abrupt changes in heart rate. Using the wearable's accelerometer, the user's wrist motions were recorded during the exercise[26].

Within an alternate method for checking or monitoring HR, the patient must wear a wearable HR sensor. Before monitoring heart rate (HR), connect the HR sensor to the smartphone via a Bluetooth link. If the system detects an abnormal heart rate, it will prompt the patient to grant permission to send an alert notification, including their location, to the caregiver in their contact list. If the patient agrees to send the alert notification or does not respond within 30 seconds, the caregiver will receive the alert notification via WhatsApp. Lastly, the results of the HR monitoring are saved in a cloud database[27]. To record heart rate, someone in the ICU awaiting a surgical operation must wear the gadget. If the device detects an abnormal heart rate and displays it on the OLED screen, the system should automatically send a notification to healthcare providers without requiring any additional action from the patient or wearer. Thus, even individuals who are unable to use the system can still benefit from it. Additionally, the patient may suffer if the caregiver is

too busy to notice the WhatsApp notification. When the patient receives an alert from this system, the LED will turn red, indicating that they should go to the health center right away.

2.3 Temperature Monitoring Wearable Devices

By monitoring both temperature and heart rate, the device provides a more complete picture of cardiovascular health, enhancing the accuracy of heart rate readings and allowing for early detection of disorders that may affect heart rhythm. Medical professionals generally use an ECG and a thermometer to take a patient's temperature and heart rate, although this manual equipment still require focus to produce accurate values [28]. An additional system, which includes an Arduino Uno control card, a temperature sensor, a heart rate sensor, and software for detecting changes in body temperature and heart rate, was constructed but no Wi Fi used[29]. Transferring the data to the computer via Wi-Fi allows for easy tracking of the information collected by the system's sensors. In this work, it seem like simple as there no need transfer data over Wi fi .Using a fingertip and temperature sensor, the design and creation of a microcontroller-based body temperature and heartbeat monitor is demonstrated. These sensors' readings are further analyzed before being transmitted to a remote site via a GSM module, where they are shown on a mobile device [30], Figure 2.5 shows the description of developed system that detect temperature and heart rate on fingertip.

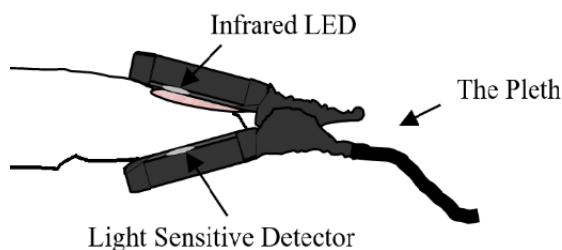


Figure 2.4: Fingertip Detection System

A piece of work by M. Rao et al [31]In their study, a consumer wearable device was created using a wireless sensor network and a microcontroller to continuously measure body temperature and send the data to a server for remote tracking from any location . When the body temperature threshold exceeded, the system activates an alert and provides the user with a reaction interface. Additionally, the integrated GSM-based IoT health-monitoring system measures several vital signs, including body temperature and heart rate. Additionally, users have the option to receive output via the GSM and LCD in the form of notifications.

The Arduino requests that we press the switch and insert our finger inside the sensor. Insert any finger into the sensor clip (except from the thumb) and press the switch (button). Using the IOT, Arduino uses the sensor data to determine the heart rate and shows the heartbeat on the smartphone. Sit back and unwind while the sensor gathers data; do not shake the wire, since this could lead to

inaccurate readings. Simply press the Arduino's reset button to restart the process if you'd like to run another test after the results are shown on your phone [33].

A smart health monitoring system designed for the elderly was proposed and implemented to track basic vital signs such as body temperature and heart rate, as well as indicators of the patient's condition like respiration rate. The developed system verifies the subject's vital signs and parameters before processing the data further through the use of a GSM wireless network system and an integration unit of sensors [34].

2.4 LED Alerts for User Notification

In addition to notifying healthcare providers, LED alerts provide visual cues to users regarding abnormal vital signs. Another paper designed a wearable device with integrated LED indicators for user feedback. When the system detects abnormal heart rate or temperature readings, the LEDs flash to alert the wearer, prompting them to contact a healthcare professional or seek medical attention. This feature enhances user awareness and empowers individuals to monitor their health proactively.[35]

Wearable devices capable of monitoring heart rate and temperature while providing GSM-based notifications and LED alerts offer significant potential for improving healthcare management. By leveraging advances in sensor technology, signal processing, and wireless communication, this device enables continuous monitoring of vital signs and facilitates timely intervention in case of abnormalities. It is affordable and low cost.

2.5 Systems that used Iot to monitor heart rate

A sensor was used to gather users' vital signs, and the data was then transferred over a wireless network to a remote service platform. The data center on the platform then performed a comparative analysis on the data, and in the meantime, the doctor provided medical treatment and health management to remote users based on the data indicators[36]. 2.5 shows the hardware setup of the developed system, which monitors the heart rate using a heartbeat sensor, Arduino Uno, display, and GSM modem.

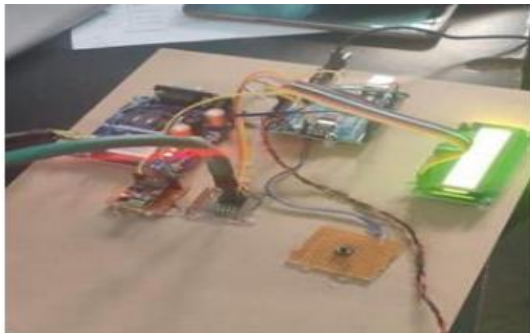


Figure 2.5: The Heart and Body Temperature Monitoring System.

The heart and body temperature are two of the most crucial aspects of health. The system uses IoT to obtain body temperature and heart rate data to monitor patients' health status. A mini-PC is used as a web server, and a pulse sensor measures body temperature and heart rate [37]. The goal of the IOT-developed Heart Rate Monitoring system is to track a patient's heartbeat in order to monitor

their risk of having a heart attack. The Heart Rate (HR) module uses a non-invasive method called photo plethysmography to measure the patients' heart rates. It then uses a Bluetooth module to transmit the data wirelessly to a computer or Android application [38]. For another paper, researchers designed and implemented a low-cost, internet-enabled health monitoring system using an Arduino Uno board. The device continually and non-invasively measures key human vitals using a mix of temperature, heart rate, and pulse oximeter sensors. In order to enable temperature measurement on the embedded system, a tiny digital DS18B20 thermometer is installed [39].

A piece of work described a developed wristband to monitor heartbeat and temperature using Internet of Things (IoT) system by using a temperature sensor (GY 906) to measure body and room temperature, and a second sensor (MAX30100) to monitor blood oxygen levels and heart rate frequency. Each sensor was connected to a microcontroller individually and serially[40]. This work uses the ESP8266 to transfer data to the server for monitoring and future use with a single microcontroller module.

2.6 Heart rate measuring in monitoring cardiac arrhythmias

Cardiac arrhythmias are irregular heart rhythms characterized by unusually fast or slow rates (tachycardia and bradycardia, respectively)[41]. From article [42] , the ECG was used to be connected to the smart phone via Bluetooth in which the ECG signal is automatically analyzed to detect abnormal heart rate and 13 other forms of arrhythmia and alert the physicians accordingly. The distance covered by the Bluetooth may be a barrier of this device in a long distance. There are many types of arrhythmias diseases but some of them like VT can be serious, especially in people with heart disease, and may be associated with more symptoms than other types of arrhythmia[43]

2.7 Summary

The literature analysis highlights significant progress in wearable health monitoring devices for tracking heart rate and body temperature. Research has explored technologies like photo plethysmography (PPG) and electrocardiogram (ECG), integrated with GSM and Wi-Fi for real-time data and remote monitoring. These devices can enhance patient care by providing continuous monitoring and timely notifications. However, a notable gap exists in developing systems that automatically alert healthcare providers without requiring user action. Current solutions often require patient login for result analysis and face challenges such as signal noise during physical activity and the high cost of precise ECG equipment

CHAPTER 3. RESEARCH METHODOLOGY

This study used a quantitative approach to gather data. This includes detailing the steps taken to complete the study, the system design methodology, the tools used for data collection, and the prototyping of the proposed solution.

3.1 Research Process

The first step in the research process for “The Design of Wearable device to track heart problems” is thorough a literature review to determine what technologies and information are already available for wearable health monitoring, with an emphasis on heart rate (HR) analysis in particular. The purpose of this survey is to identify the weaknesses and gaps in the current wearable device-based cardiac monitoring methods. The next was developing a problem statement that fills in the identified gaps. Getting input from possible users regarding the acceptability and usability of the suggested system is also the crucial step taken. The data collection on the user’s perspective done by conducting focus surveys to find out what people think about the proposed wearable technology and to find out about their preferences and concerns. We used online forms (questionnaires) to conduct the survey and chose sample size groups of thirty individuals, including men, women, youth, and seniors.

I. USER REQUIREMENTS

The technical components required to design a prototype are gathered and assembled to ensure real-time heart rate monitoring, data encryption, quick alerting of users when an abnormal heart rate is detected, daily data recording, and compatibility with widely used wearable devices. Both the doctor and the patient's caregivers can view advice on preventing cardiovascular problems caused by low or fast heartbeats, with a graph assisting in data analysis.

II. USER’S PERSPECTIVES

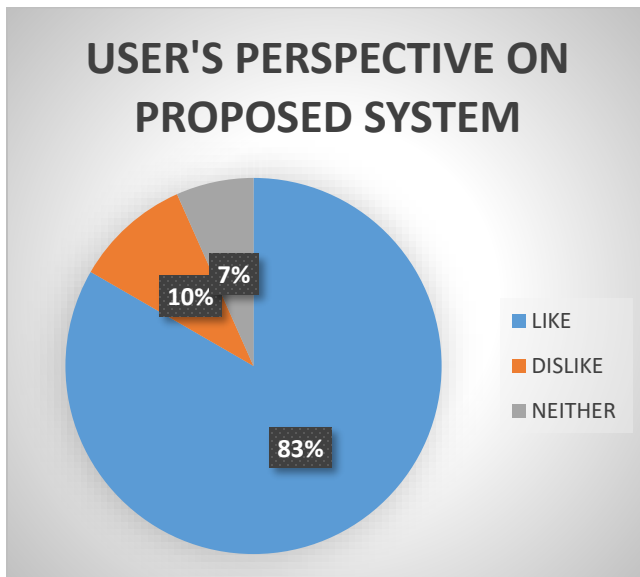


Figure 3.1: Collected Data Analysis.

The survey findings, shown in Figure 8, show that a considerable proportion of the participants were pleased with the suggested system. This good feedback demonstrates the system's ability to meet user needs effectively.

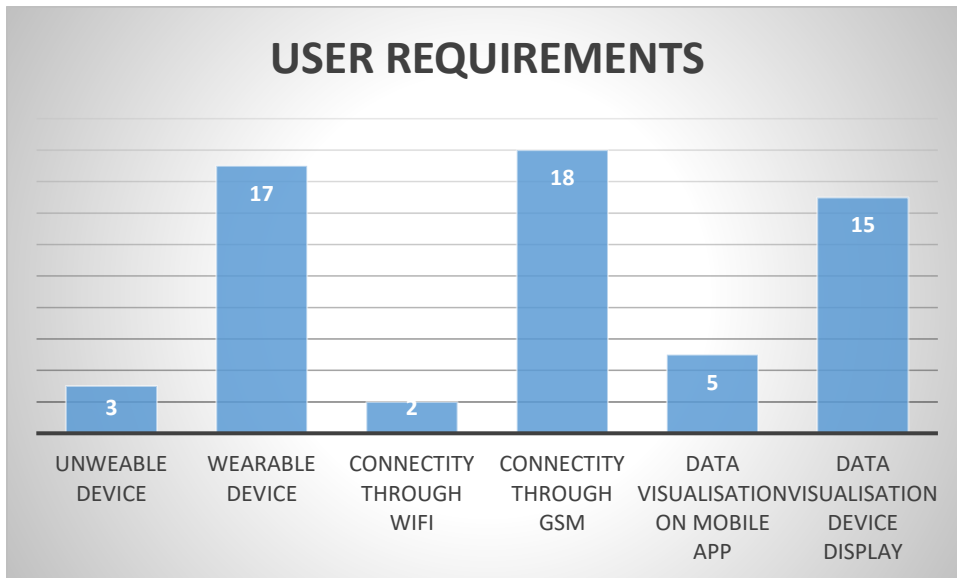


Figure 3.2 user requirements data

3.2 Research Design Method

This section explains the technological aspects involved in designing a wearable gadget that uses heart rate variability to track cardiac issues. Fritzing software designs the device, using components such as temperature and heartbeat sensors, a microcontroller, a GSM module, an OLED display, and a power supply for powering the system during its use.

- **Key requirements of the developed device.**

Design the wearable device like a finger wear on the individual's body to provide a convenient platform for displaying heart rate data. Set a microcontroller to receive electrical signals from the biosensor and convert them into heart rate measurements. The microcontroller will be programmed using C language to ensure efficient signal processing and data management, enabling it to send the data from the sensor to the database. The device will use heartbeat and temperature to detect cardiovascular signals, such as heart rate, from the individual's body and transmit these signals to the microcontroller for analysis and interpretation. Additionally, the wearable device will include GSM capabilities to enable communication between the user and healthcare professionals, facilitating the transmission of HR data and alerts to clinicians for remote monitoring and intervention.

3.2.1 Tools and Technologies

The device uses sensors to detect the patient's heartbeat and body temperature, and a central unit controls it. The values from these sensors are further processed and transferred via GSM module and send it to the server through wireless.

3.2.1.1. Pulse Oximeters (heart beat sensor)

Pulse oximeters are low-cost, non-invasive medical sensors that continuously measure the oxygen saturation (SpO₂) of hemoglobin in the blood. It displays the percentage of blood that is loaded with oxygen.

The MAX30100 pulse oximeter and heart rate sensor is an I2C-based low-power plug-and-play biometric sensor.

MAX30100 Module Hardware Overview

The module features the MAX30100 – a modern, integrated pulse oximeter and heart rate sensor IC, from Analog Devices. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry (SpO₂) and heart rate (HR) signals.

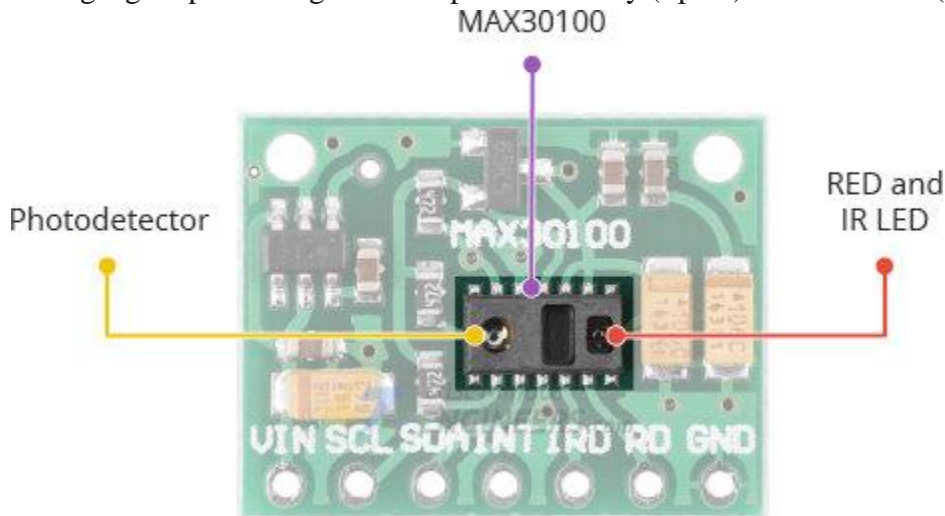


Figure 3.3: The MAX30100 pulse oximeter

On the right, the MAX30100 has two LEDs – a RED and an IR LED. In addition, on the left is a very sensitive photodetector. The idea is that you shine a single LED at a time, detecting the amount of light shining back at the detector, and, based on the signature, you can measure blood oxygen level and heart rate.

The device has two LEDs: one emits red light and the other emits infrared light. The device uses only infrared light to measure the pulse rate, while both red light and infrared light measure the oxygen levels in the blood. When the heart pumps blood, there is an increase in oxygenated blood because of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the pulse rate is determined.

Oxygenated blood absorbs more infrared light and passes more red light while deoxygenated blood absorbs red light and passes more infrared light. This is the main function of the MAX30100 is to read the absorption levels for both light sources and stores them in a buffer that can be read via I2C communication protocol.

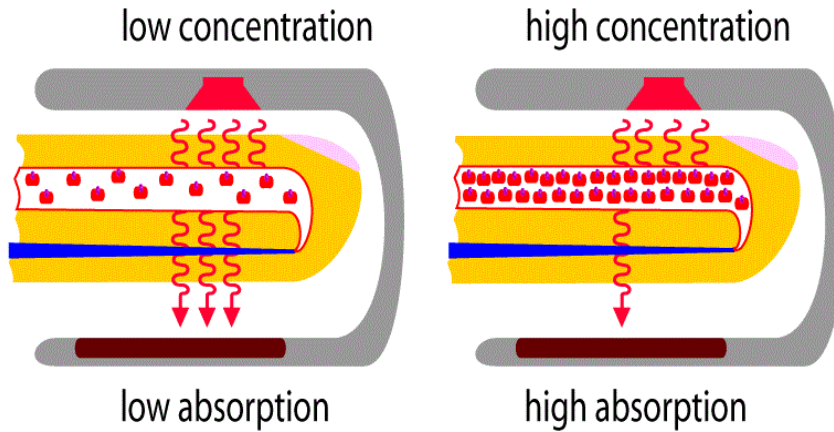


Figure 3.4: deoxygenated blood VS Oxygenated blood

3.2.1.2. OLED DISPLAYS

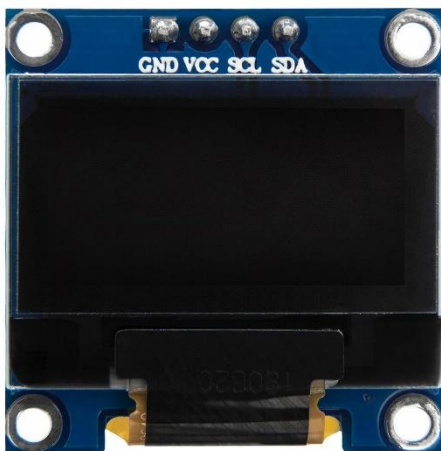


Figure 3.5: OLED DISPLAY

'OLED stands for Organic Light-Emitting Diode, a technology that uses organic molecules to produce light through LEDs. OLED materials fabricate thin films placed between two conductors. When an electrical current passes through, these films emit bright light. Each pixel in an OLED display emits its own light, resulting in superior picture quality with deeper blacks, better contrast ratios, and wider viewing angles. OLED is more energy-efficient and flexible.

In contrast, LCD relies on a backlight to illuminate liquid crystals. While it offers high peak brightness and a longer lifespan, it generally has poorer contrast ratios and viewing angles. LCD is more resistant to burn-in but less energy-efficient compared to OLED.

Table 3.1: Technical Specification of OLED

SN	Item	Specification
1	Resolution	128*64
2	Display area: 29.42 x 14.7mm	1.16"*0.58"
3	Driving voltage	3.3-5V
4	Operating temperature	-40 ° to 70 °
5	Interface type	IIC interface

3.2.1.3. DHT11 TEMPERATURE AND HUMIDITY SENSOR

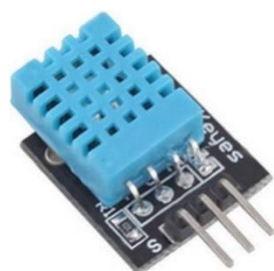


Figure 3.6: DHT11 TEMPERATURE AND HUMIDITY SENSOR

DHT11 sensor consists of a capacitive humidity-sensing element and a thermistor for sensing temperature.

The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature

This sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To achieve a larger resistance value even with the smallest change in temperature, manufacturers typically use semiconductor ceramics or polymers to make this sensor.

Technical details

Table 3.2: Technical Specification of DHT11 Sensor

SN	Item	Specification
1	Humidity range	20 to 80% with 5% accuracy
2	Temperature range	0 to 50 degree Celsius with a 2-degree accuracy.
3	Max Current	2.5mA
4	Power	3 to 5 volts

The DHT11 provides digital output signals that a microcontroller or digital interface like Arduino can read. The data is transmitted in a serial format which includes both temperature and humidity readings.

3.2.1.4. MICRO CONTROLLER

A microcontroller is a small computer embedded on a single integrated circuit. It includes a processor core, memory, and various input/output peripherals. Engineers use microcontrollers in a wide range of embedded systems for tasks such as controlling devices, gathering data from sensors, and managing communication between different components. Programmers use them to execute specific tasks, making them essential components in many electronic devices and systems.



Figure 3.7: Node Mcu

The Node MCU (Node Microcontroller Unit) is an open-source software and hardware development platform used to create Internet of Things (IoT) devices. It consists of a small board with a Wi-Fi chip called ESP8266 and supports programming with the Lua language or the Arduino IDE.

The platform makes it easy to connect everyday objects to the internet, enabling remote communication and control. Its user-friendly design and built-in Wi-Fi capabilities have made it a popular choice for home automation and prototyping projects.

The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds.

It enables devices to connect to and handle via the Internet, making it a practical and cost-effective solution for a wide range of wireless applications and projects, including the Internet of Things (IoT).

Technical specifications of Arduino Uno

Table 3.3: Technical Specification of Node MCU

Specifications
Model: ESP8266-12E
Wireless Standard: 802.11 b/g/n
Frequency range: 2.4 GHz - 2.5 GHz (2400M-2483.5M)
Wi-Fi mode: Station / SoftAP / SoftAP+station
Stack: Integrated TCP/IP
Output power: 19.5dBm in 802.11b mode
Data interface: UART / HSPI / I2C / I2S / Ir
Remote Control GPIO / PWM
Supports protection mode: WPA / WPA2
Encryption: WEP / TKIP / AES
Power supply: from 4.5 VDC to 9 VDC (VIN) or via micro USB connector
Consumption: with continuous Wi-Fi transmission about 70 mA (200 mA MAX) - in standby < 200μA
Operating temperature: from -40°C to +125°C
Dimensions (mm): 58×31.20×13
Weight: 10 grams

3.2.1.5. GSM SIM 800L

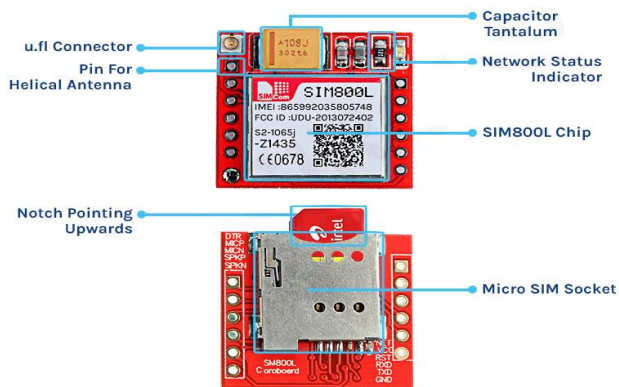


Figure 3.8: GSM SIM 800L

The GSM SIM800L is a small and versatile GSM (Global System for Mobile Communications) module that enable communication over GSM networks. The GSM SIM800L is a compact module used for GSM communication. It supports quad-band GSM/GPRS frequencies and enables functionalities like making calls, sending SMS, and connecting to the internet over GSM networks. It frequently serves in projects such as remote monitoring, vehicle tracking, and Internet of Things applications. It connects with other devices over Universal Asynchronous Receiver-Transmitter (UART) and fits well into various projects due to its small form factor and low power consumption. Global System for Mobile Communications (GSM) technology enables mobile devices to send and receive messages and make calls by connecting to nearby cell towers. When a call is placed, the device connects to the tower, which then routes the call through the cellular network to the recipient. Users compose text messages on the device and send them through the network to the recipient's device. GSM relies on protocols defined by the GSM standard, and users need a Subscriber Identity Module (SIM) card for network access and authentication.

Technical Specification SIM800L

Table 3.4: Technical Specification of SIM00L

SN	ITEM	SPECIFICATION
1	Power Voltage	2.8V-5.0V
2	Lower power consumption	1milliampres
3	Quad-band	850/900/1800/1900MHz
4	Size	23mm x 35mm x 5.6mm
5	GPRS multi-slot class12 connectivity	Max. 85.6kbps (down-load/up-load)
6	Recommended Current	1 – 2 Amps
7	Recommended voltage	3.4 – 4.4 Volts
8	Recommended Watts	5 Watts

3.2.1.6. LED (LIGHT EMITTING DIODE).



Figure 3.9: LED (Light Emitting Diode)

LEDs (Light-Emitting Diodes) are semiconductor devices that emit light when an electric current passes through them. They are energy-efficient, long lasting, durable, and used in various

applications such as lighting, displays, indicator lights, automotive lighting, and decorative lighting.

LEDs operate based on electroluminescence, a phenomenon where light results from the movement of electrons in a semiconductor material. When current flows through the semiconductor diode, electrons combine with electron holes within the device, releasing energy in the form of photons, which manifests as light.

An LED typically consists of a semiconductor chip placed within a reflective cup, encapsulated in a transparent lens. The semiconductor chip is made of materials like gallium arsenide (GaAs), gallium phosphide (GaP), or gallium nitride (GaN), doped with impurities to create regions of negative and positive charge.

3.2.2 System Design Flowchart

The following flowchart illustrates the system design roadmap for the development of the wearable device:

This flowchart provides a visual representation of the sequential steps involved in the research design method, guiding the progression from conceptualization to conclusion. Each step builds upon the preceding ones, culminating in the evaluation and interpretation of research findings.

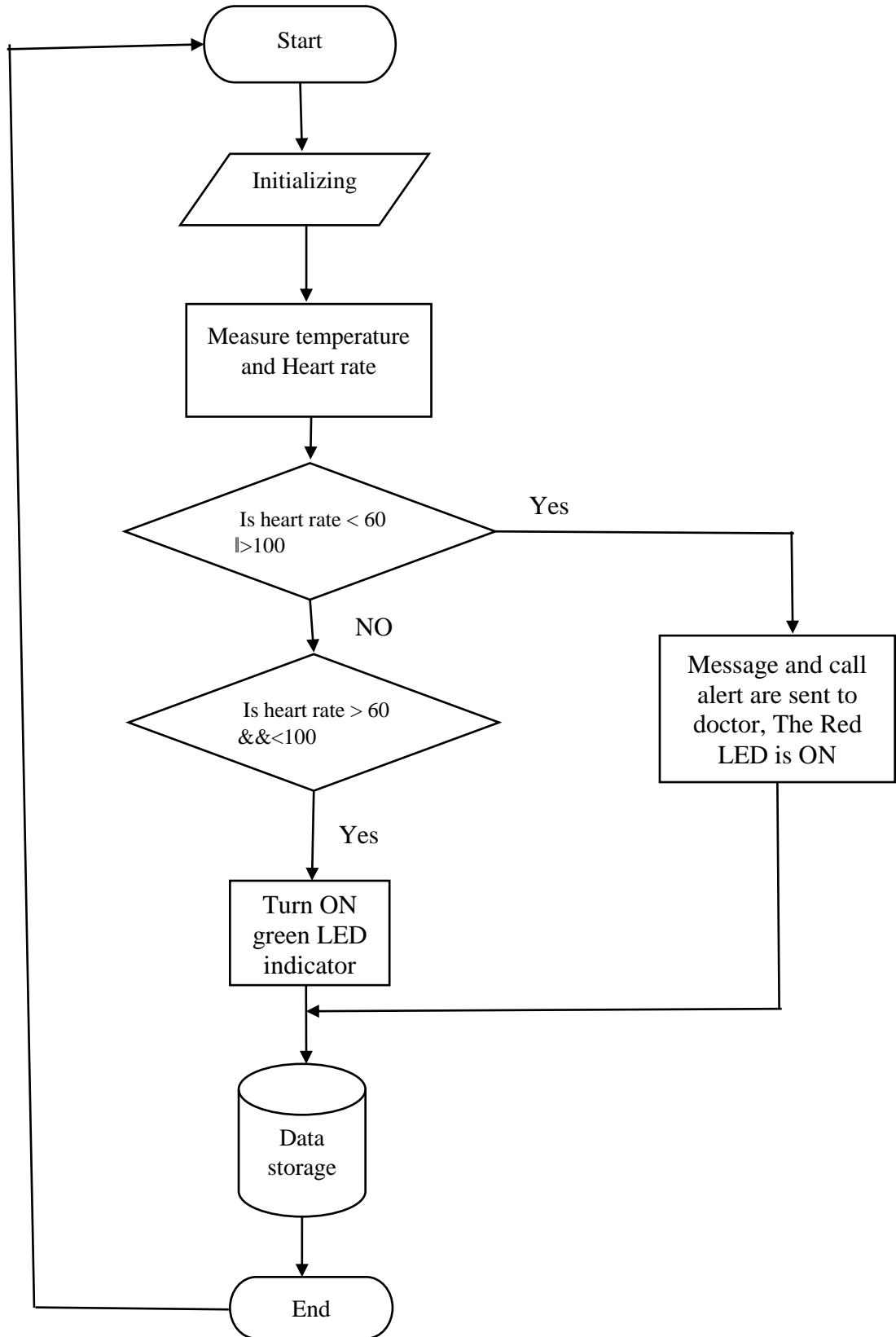


Figure 3.10: System Design Flowchart

3.2.3 Block diagram of proposed system

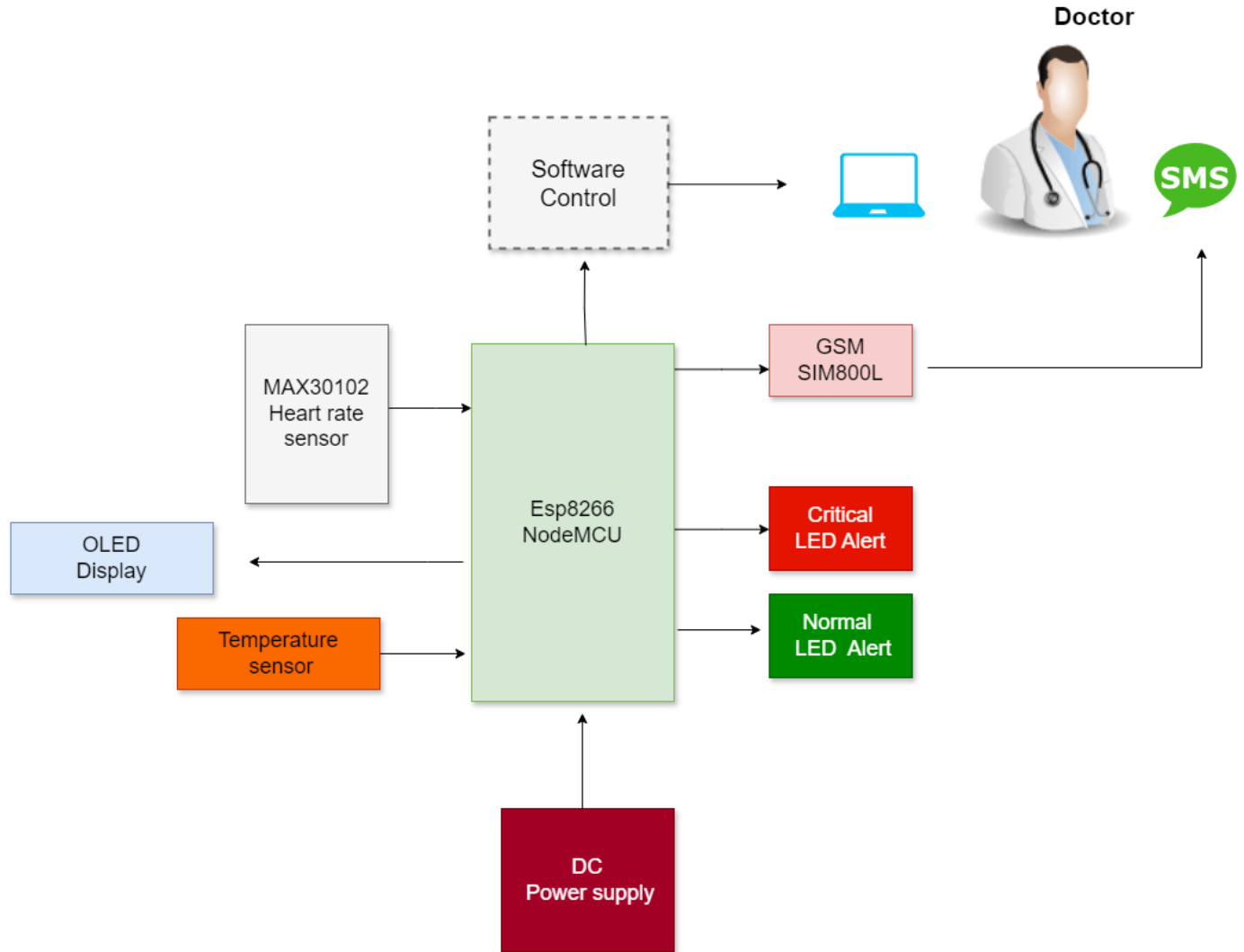


Figure 3.11: Block diagram of proposed system

The functioning principle of the system that tracks cardiac disorders through the interpretation of heart rate requires several critical components to work together:

The microcontroller (MCU) serves as the system's brain, coordinating the actions of all other components. It takes data from sensors, processes it, and operates the display and communication modules. This Node MCU has an esp8266 Wi-Fi module, making it appropriate for data transmission to the server. The Heartbeat Sensor detects the user's heart rate by monitoring changes in blood volume or pulse. It commonly uses photo plethysmography (PPG) to detect variations in blood flow.

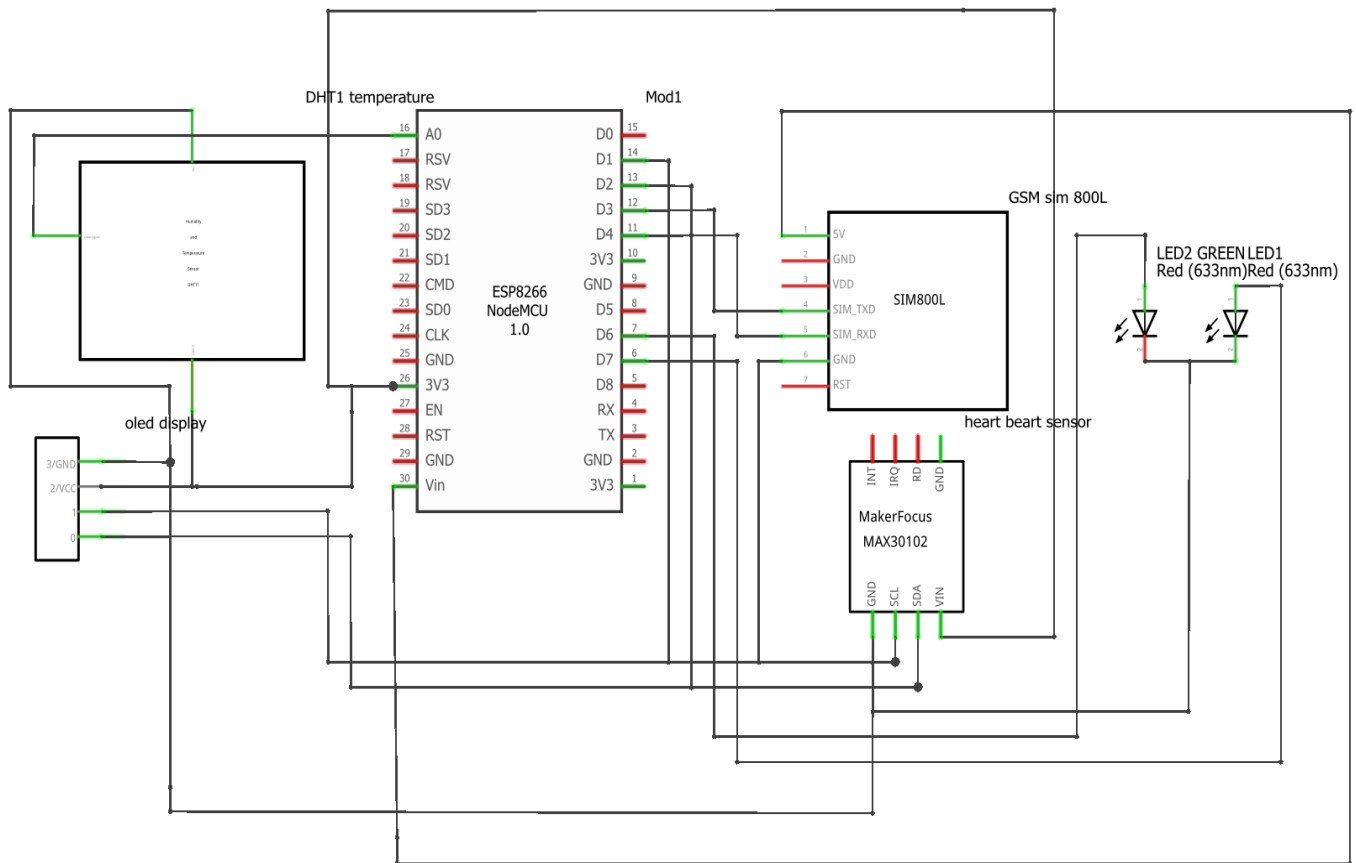
Temperature Sensor measures the user's body temperature. It can help detect fever and track variations in temperature, which may indicate health issues.

A reliable power source is required for the system to function properly. It supplies power to all components, assuring continuous operation.

The GSM module allows connectivity with cellular networks. It can send health data, such as heart rate and temperature, to a remote server or a mobile app via SMS, GPRS, or other communication protocols. The OLED display gives the user real-time feedback by displaying health statistics like heart rate and temperature. It provides a straightforward and easy-to-read interface for tracking health status.

Together, these components enable the system to monitor the user's health parameters continuously. The MCU takes data from the heartbeat and temperature sensors, processes it, and presents the results on the OLED display in real time. Furthermore, the GSM module enables remote monitoring and transmission of health data to caregivers or healthcare experts for further analysis or intervention, as needed.

3.2.4 Circuit diagram of the system



fritzing

Figure 3.12: Circuit diagram

Working principle of the circuit

A power source is required for microcontroller operation. The microcontroller receives the voltage and current it needs from the power supply to operate properly.

In brief, the integrated system consists of an Esp8266 Node MCU that sends data from the microcontroller to a website. In order to establish communication, the Node MCU must connect to your Wi-Fi network and then transfer the data via HTTP requests. The ESP8266 Node MCU must connect to Wi-Fi using the network name and password. Then it is set up to deliver data to a specified web address using the GET or POST methods. This allows the Node MCU to communicate with the server and send the required data. Ensure that the server is ready to receive and process the data you are providing.

The heartbeat sensor, temperature sensor, GSM module, OLED display, and LED indicators offer an effective solution for continuous monitoring of the user's health data. By identifying anomalies in heart rate and temperature, the system immediately warns the user and sends notifications to the chosen doctor via SMS and phone call via the GSM module, as well as transmitting the data to the cloud for remote monitoring. The doctor may remotely view all data received by the microcontroller by simply logging into the system; with this information, he can make an accurate assessment of the severity of the issue and interpret several factors that may be causing the irregularities.

On the device, an LED will alert the patient to the seriousness of the problem. A red LED indicates that medical attention is required immediately, whilst a green LED indicates that the situation is stable. Furthermore, in emergency instances where no doctor responds, the red LED acts as a reminder to the user to seek quick medical attention. This system enables users to manage their health actively by facilitating timely intervention, guidance from healthcare professionals, and data storage. This data aids in decision-making, tracking changes, and analyzing the root cause of the heart rate problem that has led to a critical condition. It improves healthcare accessibility and responsiveness, resulting in better health outcomes and peace of mind for both users and caregivers.

3.2.5 Software Design

Software algorithms implemented all temperature and heartbeat sensing, SMS alert production, and LED control functionality. Arduino programming principles produced efficient, well-structured code with error handling mechanisms and optimized resource consumption, ensuring a smooth interface between the software and hardware. The code seamlessly integrated sensor interfacing, GSM connection, and LED control modules to ensure the gadget runs smoothly.

To make it simple for users to engage with the system, developers created a dashboard. The system entered and stored the heart rate information gathered from the sensors into the database. By connecting to a Wi-Fi network, the Node MCU can establish an internet connection and communicate with the server. It uses the associated sensor to read heart rate data. At regular intervals, the Node MCU uses HTTP GET requests to relay the gathered heart rate data to a server. This guarantees ongoing observation and data recording.

The Node MCU sends the heart rate data to the PHP script running on the server. The script extracts the heart rate value from the incoming HTTP request and then inserts the retrieved data into a MySQL database. This process ensures that all heart rate measurements are saved for future analysis and observation.

MySQL runs the database, chosen for its user-friendliness and dependability. The database stores all the heart rate information from the Node MCU, and each entry includes a time record that shows the exact moment when the system received the data.

3.2.6 Testing and Validation

A number of tests were carried out to see how effectively the device functions in various scenarios. Typical use, anomalous sensor readings, and issues with network connectivity were also tested. The objective was to observe the device's behavior and confirm that it worked reliably in different situations.

3.3 Budget of the prototype

Table 3.5: components cost

Component	Description	Cost (USD)	Quantity
Temperature Sensor	Digital temperature(DHT11)	\$2.00	1
Heart Rate Sensor	Optical heart rate sensor (MAX30100)	\$5.00	1
OLED Display	OLED display	\$3.00	1
LEDs	Indicator LEDs (Red, Green)	\$1.00	2
Power Backup	Rechargeable battery with charging circuit	\$10.00	1
Microcontroller	Microcontroller (with ESP8266)	\$8.00	1
PCB and Connectors	Custom PCB and connectors	\$10.00	1
GSM Module	GSM module with SIM card slot (e.g., SIM800L)	\$10.00	1
SIM Card	Prepaid SIM card for data connectivity	\$2.00	1

The Total Cost of the components is \$51. When the Miscellaneous Costs and Development Costs are added, this prototype is about \$100.00. The device will be cheaper than prototype like about the cost of \$60.

3.4 Summary

This chapter outlines the methodology for designing a wearable device to monitor heart health via HR analysis by focusing on arrhythmias diseases. It covers system design, tools and technologies, data collection methods, research process, research design, and a system design flowchart. Key elements include smart device interface, microcontroller integration, biosensor technology, GSM communication, esp8266 Wi-Fi module and validation studies. The chapter emphasizes a systematic approach to develop a comprehensive solution for continuous cardiovascular health monitoring.

CHAPTER 4. THE PROJECT RESULTS FROM IMPLEMENTATION.

4.1 Overview of the Wearable Device

The wearable device continuously monitors heart rate and body temperature, providing real-time data to patients and healthcare providers. If it features an alert system with a red LED that lights up to signal abnormal heart rates, alerts caregivers, and sends an SMS to a doctor via a GSM module in critical situations. An OLED screen displays the real-time data, while Wi-Fi capability supports remote monitoring and data storage, ensuring secure access through an online dashboard.

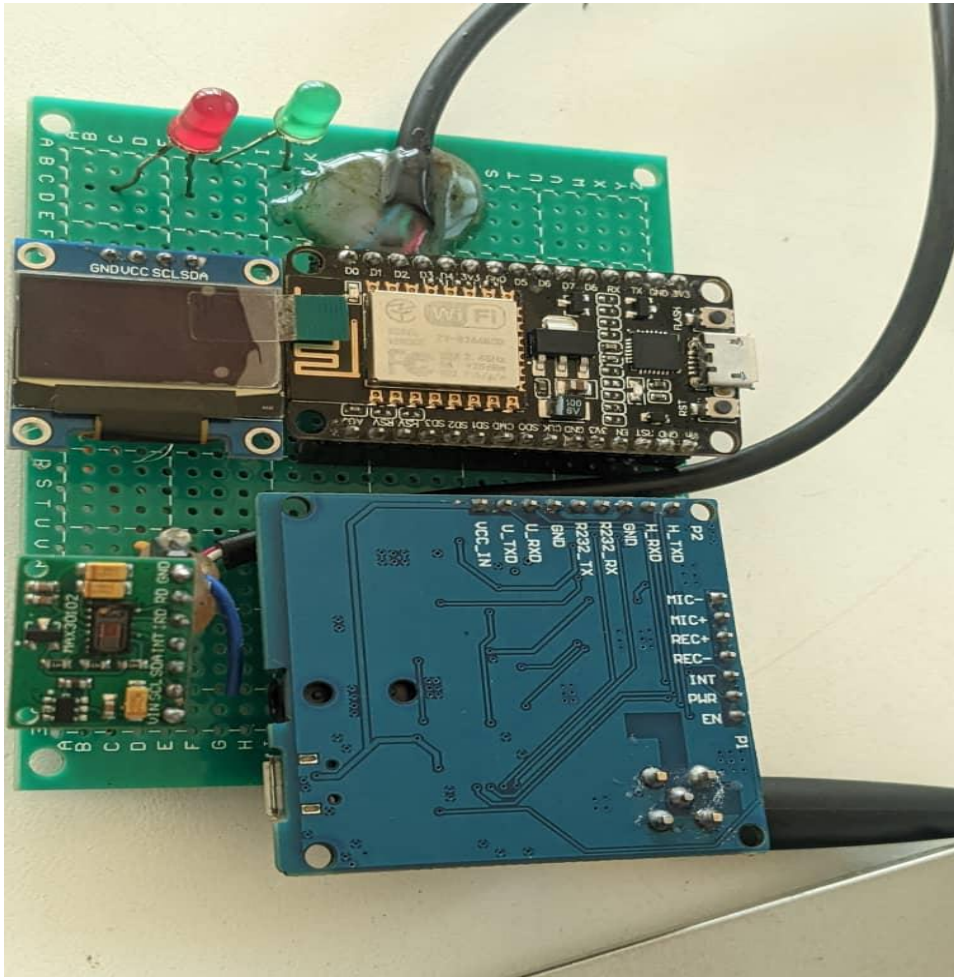


Figure 4.1: system with the interconnected components

4.2 Prototype Testing and Results

Table 4.1: prototype testing and results

Testing ID	Heart Rate (bpm)
P1	52
P2	67
P3	73
P4	75
P5	80
P6	86
P7	59
P8	62
P9	78
P10	85

A prototype was tested on ten individuals of different ages to evaluate its performance. The heart rate readings recorded by the device are summarized in 4.2

None of the readings fall into the tachycardia category, which is above 100 bpm, while P1 and P7 are noted as bradycardia, given they are below the normal heart rate threshold of 60 bpm. The rest of the readings are within the normal range which is between 60 and 100 bpm.

4.3 Calibration and Accuracy

Testing the prototype's accuracy is critical for validating its performance and ensuring dependable heart rate readings. Accurate data is critical for detecting issues such as arrhythmias and ensuring that the device's warning and notification capabilities function properly. High accuracy improves user trust, satisfies regulatory requirements and assures that the prototype functions similarly to existing devices. Accurate measurements also help to refine the device's functionality and keep it clinically relevant. The below table is showing data found while testing accuracy.

Table 4.2: Accuracy testing

Testing ID	Heart Rate (bpm)	Smartwatch (bpm)
P1	52	53
P2	67	68
P3	73	73
P4	75	76
P5	80	80
P6	86	87
P7	59	59
P8	62	63
P9	78	78

In order to calibrate the device and ensure of its accuracy, the comparison of the data taken by the prototype with data sent by smart watch. The data taken by smart watch at the same time and person during taking data by using a developed device are listed in 4.3, and then the results are compared to identify the accuracy of the developed device. This consistency across various individuals reinforces the reliability of the device.

Table 4.3: A chart showing the prototype's accuracy

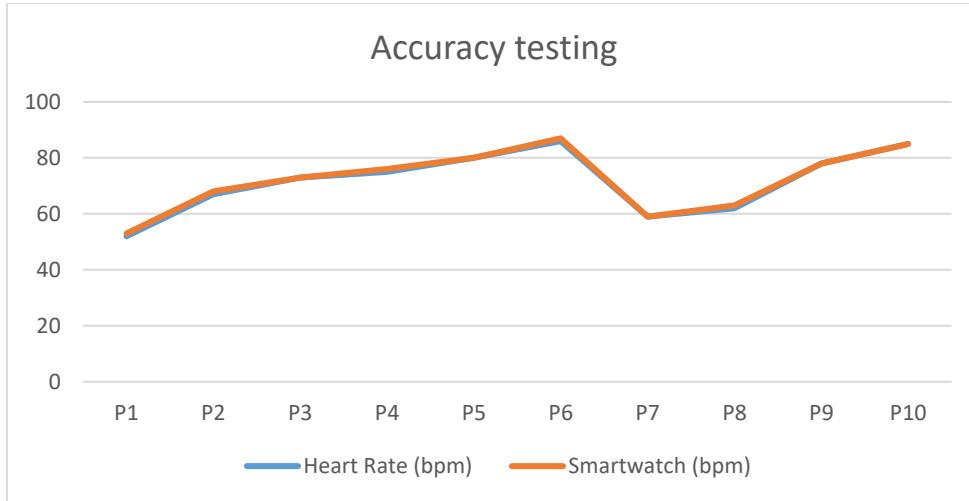


Figure 4.2: measurement of heartrate by using smart watch vs prototype

The data taken by smart watch (left image) showed 69 Bpm. After testing the same person using the prototype, the same value is found as it can be seen from the right side

4.4 Alert notification when the Heart rate is abnormal

The device effectively alerted patients to abnormal heart rates via an LED indicator and sent immediate SMS notifications to doctors or caregivers through the GSM module. For example, when the heart rate of 55 bpm was detected, the LED illuminated, and an SMS was sent to the registered medical professional, enabling timely intervention. As we see in the below figure



the heart rate is abnormal we need to check for bradycardia: 55 BPM

Figure 4.3: Abnormal heart rate (Left image) and notifying message (right image)

4.5 Monitoring system

Heart rate depends on many aspects such as age, physical condition and life style. Table 7 shows the measure heartbeat of different people taken in order to test the prototype. These values are taken using smart watch and developed device at the same time. Physical conditions may influence the Heart rate as there are seen below.

Table 4.4: Heart rate depend on many aspects such as age, physical condition and life style

Participants	Age(years)	Physical condition	Heart rate(prototype)	Heart rate(Smart watch)	Accuracy
P1	25	Healthy, regular exercise	82 bpm	81 bpm	98%
P2	45	Moderate fitness level	107 bpm	107 bpm	100%
P3	60	Sedentary lifestyle	99 bpm	98 bpm	98%
P4	35	Athlete, high fitness level	82 bpm	82 bpm	100%
P5	50	Occasional exerciser	80 bpm	79 bpm	98%
P6	28	Regular exerciser	86 bpm	86 bpm	100%
P7	65	Active lifestyle	67 bpm	67 bpm	100%

Here is the user interface built with PHP, HTML, CSS and MYSQL database.

In order to emphasize the security of information of patient only doctor or patient have access to the system by login to the system with right credential

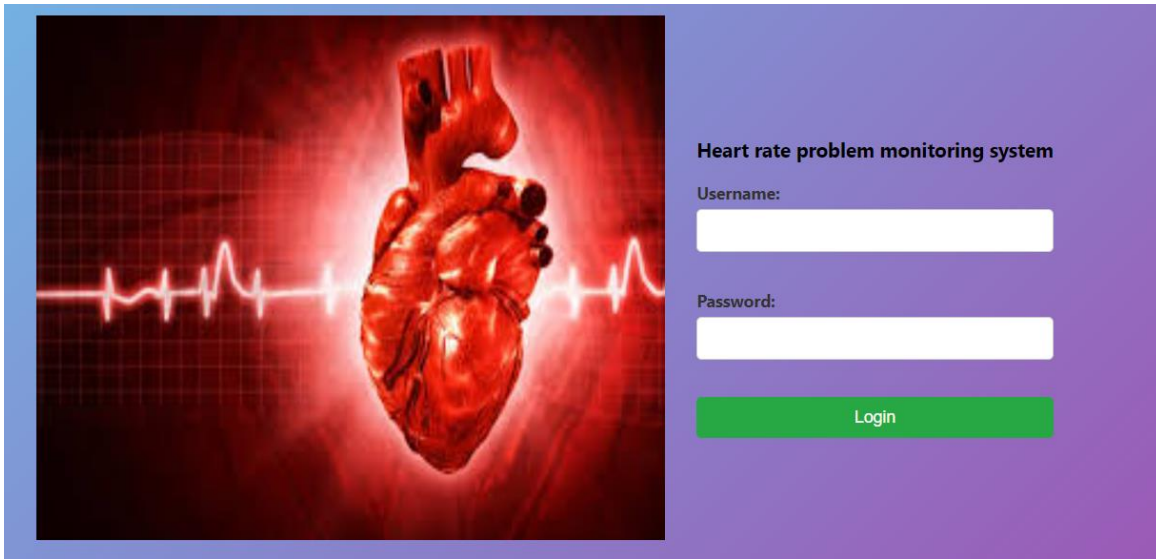


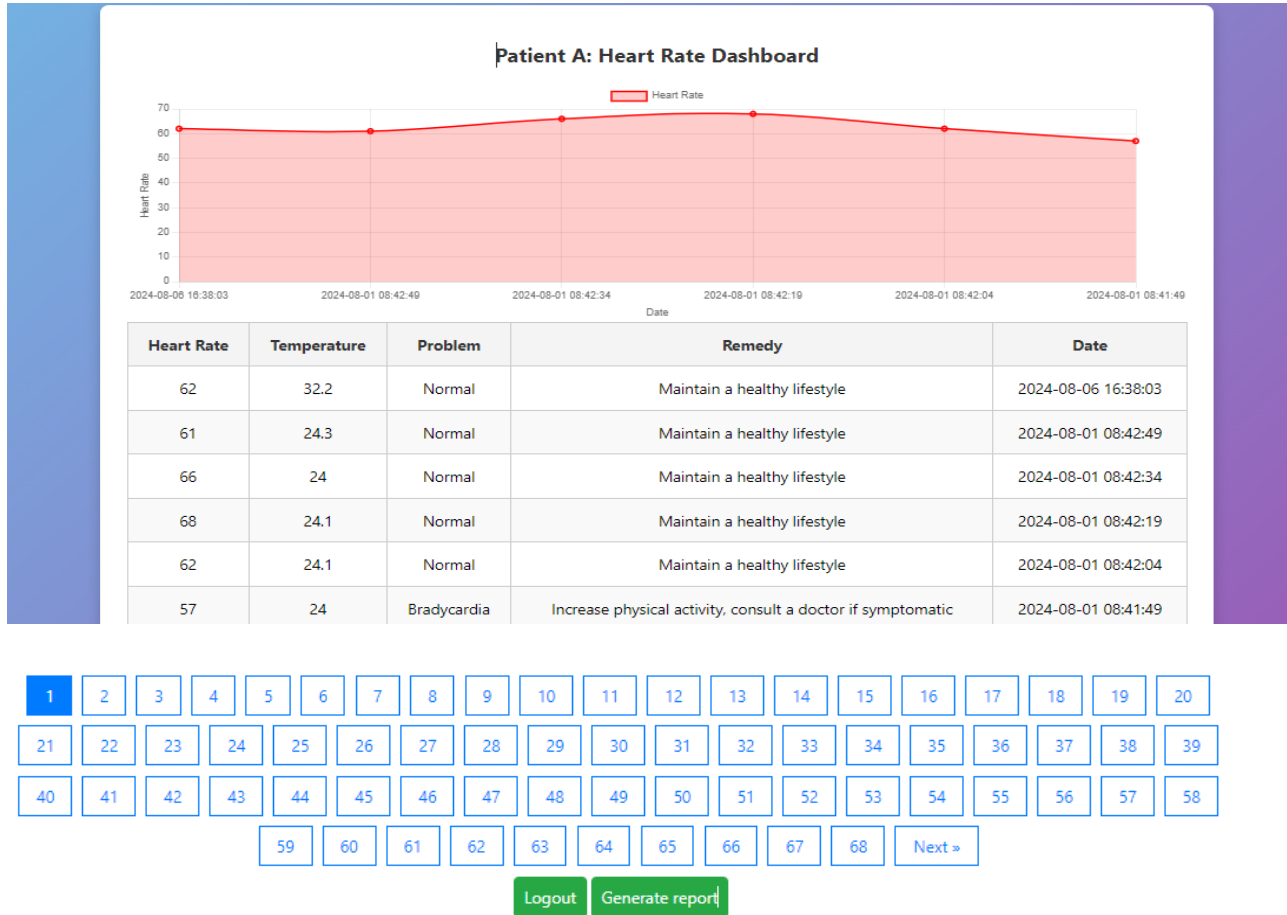
Figure 4.4: dashboard login interface

Users log into the system by entering their username and password and then clicking the login button. The system employs robust security measures to verify these inputs, ensuring that only authorized individuals can access sensitive health information. This involves checking the credentials against a secure database, utilizing encryption to protect data during transmission, and implementing additional security protocols such as multi-factor authentication. These measures are essential to prevent unauthorized access, protect personal and health data from cyber threats, and ensure patient confidentiality. Once the inputs are verified and deemed correct, the user is granted access to the dashboard, ensuring that all personal and health data remains protected and confidential.

Implementation Workflow overview for the system

The Node MCU establishes a Wi-Fi connection, reads sensor-derived heart rate data, and periodically transmits this data to a server. A PHP script called `receive_data.php` manages incoming GET requests from the Node MCU on the server side. The configured MySQL database includes a table called `heart_rate_data` with columns for heart rate, temperature, problem, remedy and date. To display the heart rate data obtained from the database, deploy an HTML file and the `display_data.php` script on a website.

Table 4.5: heart rate dashboard



The information gathered from wearable health monitoring devices can significantly enhance analysis and decision-making processes in healthcare. For instance, continuous heart rate monitoring can help identify patterns and triggers that may not be evident in sporadic check-ups. If a patient's heart rate spikes critically due to stress, the system can log this event, allowing both the patient and healthcare providers to review the data later. By identifying potential stressors or activities that lead to abnormal heart rates, patients can take preventive measures to avoid similar situations in the future. This proactive approach not only aids in managing current health conditions but also helps in predicting and preventing potential health issues.

Moreover, an integrated dashboard that includes real-time data and historical records can provide immediate insights and first aid remedies. When the system detects an abnormal heart rate, the dashboard offers systematic guidance on initial actions to take before professional medical help arrives. This feature is crucial in emergencies, providing users with practical instructions to stabilize their condition. Combining real-time monitoring, historical data analysis, and immediate remedial actions empowers patients to manage their health more effectively and supports healthcare providers in delivering timely and accurate care. This complete approach can ultimately

improve health outcomes and enhance patient safety. The website also includes a feature to download all data from the table and print it for in-depth analysis.

4.6 Results discussion

The prototype's heart rate measurements closely matched those from a conventional heart rate monitor, indicating high accuracy. This accuracy is particularly important in detecting arrhythmias, which can be a sign of underlying cardiovascular diseases. The device's ability to reliably detect bradycardia (as seen in P1 and P7) is crucial for identifying potential arrhythmias that may require medical attention.

A raised body temperature frequently causes the heart to beat faster as the body tries to regulate the heat. A more accurate diagnosis is obtained when a temperature and heart rate sensor are combined, even if conditions like stress or dehydration can cause elevated heart rate without a corresponding rise in body temperature. By using an integrated approach, medical professionals can make more accurate and knowledgeable decisions by being able to determine if a higher heart rate is caused by a fever, arrhythmias or by another condition.

P1 and P7 are said to have bradycardia after being sure that there is no fever caused by another health issue.

This real-time alert system, combined with precise location tracking, marks a significant improvement over existing solutions, which may lack clarity or cause delays in responding to critical health events. Timely alerts are especially important in managing arrhythmias, where early intervention can prevent the progression of CVD.

The dashboard page include the table, which display all the data from database, because every time the device send the data to the database the system is displaying only six recent data on first page with its graph. Next button is used to view following page as shown in this part 4.5

Summary

Project Implementation focused on the implementation of the wearable technology for tracking heart problems using HR analysis. The chapter provided a circuit diagram illustrating the key components and their connections, serving as a visual representation of the hardware architecture of the wearable device. This chapter marked a significant milestone in the research project, as it transformed the conceptual design into a physical prototype ready for testing and validation.

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this study developed and implemented wearable technology for tracking heart problems using heart rate (HR) analysis. The aim was to address the need for non-invasive, continuous monitoring solutions for cardiovascular diseases. The project resulted in a circuit diagram for the device's hardware architecture and a physical prototype ready for testing using heartbeat sensor, temperature sensor, microcontroller GSM to send SMS to the doctor and LED to alert the patient in case of critical condition as well as send data to the cloud for remote monitoring. This technology has the potential for significant improvement in early detection and management of heart problems, thereby enhancing individual health outcomes.

5.2 Recommendations

Future research will aim to validate the device's performance and integrate it into telemedicine. Upcoming features may include real-time communication, allowing doctors to give immediate feedback and instructions to patients, thereby improving heart health management, additional sensors may be added.

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APPENDICES

APPENDIX 1: DATA COLLECTION

1. Personal Information

Age:

Gender:

2. Medical History:

Do you have any medical condition of heart disease?

Yes / No.

3. Did ever use any Health Monitoring System?

Yes/No.

4. If (3) is yes, what are the type of system did you use?

Answer

.....

5. If (3) is yes, what are the features will you recommend to improve?

Answer

.....

6. Would you like to use wearable technology that will be helpful in monitoring the way your heart beat in order to know if you have a bradycardia or tachycardia?

- i. Like
- ii. Dislike
- iii. Neutral

7. What are the measures you may take in order to live with CVD without getting in emergency condition

.....

8. Are you aware of common risk factors of Cardiovascular diseases

.....

...

APPENDIX 1: CODES USED

```
#include <Wire.h>
#include <DHT.h>
#include <SoftwareSerial.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>
#include "MAX30105.h"
#include "heartRate.h"
#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_RESET -1
Adafruit_SSD1306 display (SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

#define DHTPIN D7 // Pin where the DHT11 is connected on NodeMCU (GPIO2)
#define DHTTYPE DHT11 // DHT sensor type
MAX30105 particleSensor;
SoftwareSerial mySerial (D3, D4); // GSM Tx & Rx is connected to Arduino D3 & D4
const byte RATE_SIZE = 4;
byte rates [RATE_SIZE];
byte rateSpot = 0;
long lastBeat = 0;
float beatsPerMinute;
int beatAvg;
float temperature;
float vref = 3.3;
float resolution = vref / 1023;

#define RED_LED_PIN D5
#define GREEN_LED_PIN D6

const char* ssid = "wifiSSID"; // Replace with your WiFi SSID
const char* password = "WIFIPASSWORD"; // Replace with your WiFi password
const char* serverIP = "192.168.8.150"; // Replace with your XAMPP server's IP or IP of your
computer

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  Serial.begin(115200);
  mySerial.begin(115200); // Initialize SoftwareSerial for GSM module
  connectWiFi();

  Serial.println("DHT11 Test");
  dht.begin();
```

```

if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) { // Address 0x3C for 128x64
  Serial.println(F("SSD1306 allocation failed"));
  for(;;);
}
display.display();
delay(2000);
display.clearDisplay();
display.setTextSize(1);
display.setTextColor(SSD1306_WHITE);

Serial.println("Initializing...");
if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) {
  display.clearDisplay();
  display.setCursor(0, 0);
  display.print("Heart Beat Sensor");
  display.setCursor(0, 10);
  display.print("Initialization Failed");
  display.display();
  Serial.println("Heart Beat sensor not found");
  while (1);
}

Serial.println("Place your index finger on the sensor.");
particleSensor.setup();
particleSensor.setPulseAmplitudeRed(0x0A);
particleSensor.setPulseAmplitudeGreen(0);
display.clearDisplay();
display.setCursor(0, 0);
display.print("Place Finger");
display.setCursor(0, 10);
display.print("on the sensor");
display.display();
delay(6000);

pinMode(RED_LED_PIN, OUTPUT);
pinMode(GREEN_LED_PIN, OUTPUT);
}

void loop() {
  float temperature = dht.readTemperature();

  for (int i = 0; i < 500; i++)
    Heart_Beat();

  if (particleSensor.getIR() < 50000) {
    display.clearDisplay();

```

```

display.setCursor(0, 0);
display.print("Please place");
display.setCursor(0, 10);
display.print("finger on sensor");
display.display();

digitalWrite(RED_LED_PIN, LOW);
digitalWrite(GREEN_LED_PIN, LOW);
} else if (beatsPerMinute == 0 && beatAvg == 0) {
display.clearDisplay();
display.setCursor(0, 0);
display.print("Taking");
display.setCursor(0, 10);
display.print("measurement...");
display.display();

digitalWrite(RED_LED_PIN, LOW);
digitalWrite(GREEN_LED_PIN, LOW);
} else {
Serial.print("BPM=");
Serial.print(beatsPerMinute);
Serial.print(", Avg BPM=");
Serial.print(beatAvg);
Serial.println();

display.clearDisplay();
display.setCursor(0, 0);
display.print("BPM: ");
display.print(beatAvg);
display.setCursor(0, 20);
display.print("Temp: ");
display.print(temperature);
display.print((char)223); // Degree symbol
display.print("C");

display.display();

sendDataToServer(beatAvg, temperature);// send data to dashboard

// Control LEDs based on heart rate
if (beatAvg > 100) {
digitalWrite(RED_LED_PIN, HIGH);
digitalWrite(GREEN_LED_PIN, LOW);
call();
sendSMS1(beatAvg);
delay(1000);
}

```

```

    }
    else if(beatAvg < 50){
        digitalWrite(RED_LED_PIN, HIGH);
        digitalWrite(GREEN_LED_PIN, LOW);
        call();
        sendSMS(beatAvg);
        delay(1000);
    }
    else {
        digitalWrite(RED_LED_PIN, LOW);
        digitalWrite(GREEN_LED_PIN, HIGH);
    }
}

delay(5000);
}

void Heart_Beat() {
    long irValue = particleSensor.getIR();
    if (checkForBeat(irValue) == true) {
        long delta = millis() - lastBeat;
        lastBeat = millis();
        beatsPerMinute = 60 / (delta / 1000.0);
        if (beatsPerMinute < 255 && beatsPerMinute > 20) {
            rates[rateSpot++] = (byte)beatsPerMinute;
            rateSpot %= RATE_SIZE;
            beatAvg = 0;
            for (byte x = 0 ; x < RATE_SIZE ; x++)
                beatAvg += rates[x];
            beatAvg /= RATE_SIZE;
        }
    }

    if (irValue < 50000) {
        beatsPerMinute = 0;
        beatAvg = 0;
    }
}

void updateSerial() {
    delay(500);
    while (Serial.available()) {
        mySerial.write(Serial.read()); // Forward what Serial received to Software Serial Port
    }
    while (mySerial.available()) {

```

```

    Serial.write(mySerial.read()); // Forward what Software Serial received to Serial Port
  }
}

void sendSMS(unsigned long beatAvg) {
  Serial.println("Sending SMS...");
  mySerial.println("AT"); // Once the handshake test is successful, it will back to OK
  delay(1000);
  mySerial.println("AT+CMGF=1"); // Configuring TEXT mode
  delay(1000);
  mySerial.println("AT+CMGS=\"+250785152100\""); // Replace with your recipient's phone
number
  delay(1000);
  mySerial.print("the heart rate is abnormal we need to check for bradycardia: ");
  mySerial.print(beatAvg);
  mySerial.println(" BPM "); // Include the stance phase duration in the SMS content
  mySerial.println((char)26); // End AT command with Ctrl+Z
  delay(1000);
}

void sendSMS1(unsigned long beatAvg) {
  Serial.println("Sending SMS...");
  mySerial.println("AT"); // Once the handshake test is successful, it will back to OK
  delay(1000);
  mySerial.println("AT+CMGF=1"); // Configuring TEXT mode
  delay(1000);
  mySerial.println("AT+CMGS=\"+250785152100\""); // Replace with your recipient's phone
number
  delay(1000);
  mySerial.print("the heart rate is abnormal we need to check for tachycardia ");
  mySerial.print(beatAvg);
  mySerial.println(" BPM "); // Include the stance phase duration in the SMS content
  mySerial.println((char)26); // End AT command with Ctrl+Z
  delay(1000);
}

void call() {
  Serial.println("Making call to Doctor...");
  mySerial.println("AT"); // Once the handshake test is successful, it will back to OK
  updateSerial();
  mySerial.println("ATD+250785152100;"); // Change with correct phone number
  updateSerial();
  delay(20000); // wait for 20 seconds...
  mySerial.println("ATH"); // Hang up
  updateSerial();
}

```

```

}
void connectWiFi() {
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("WiFi connected");
  Serial.print("IP Address: ");
  Serial.println(WiFi.localIP());
}
void sendDataToServer(float beatAvg, float temperature) {
  HTTPClient http;
  String url = "http://" + String(serverIP) + "/heart/new.php";
  http.begin(url);
  http.addHeader("Content-Type", "application/x-www-form-urlencoded");
  String postData = "beatAvg=" + String(beatAvg) + "&temperature=" + String(temperature);
  int httpResponseCode = http.POST(postData);
  if (httpResponseCode > 0) {
    Serial.print("HTTP Response code: ");
    Serial.println(httpResponseCode);
  } else {
    Serial.print("Error in HTTP request. HTTP Response code: ");
    Serial.println(httpResponseCode);
  }
  http.end();
}

```

NEW.PHP CODES

```

<?php
// Database configuration
$servername = "localhost"; // Change to your MySQL server name
$username = "root"; // Change to your MySQL username
$password = ""; // Change to your MySQL password
$dbname = "heart"; // Change to your MySQL database name

// Create a connection to the database
$conn = new mysqli($servername, $username, $password, $dbname);

// Check connection

```

```

if ($conn->connect_error) {
    die("Connection failed: " . $conn->connect_error);
}

// Check if the POST data is set
if (isset($_POST["beatAvg"]) && isset($_POST["temperature"])) {
    $beatAvg = $_POST["beatAvg"];
    $temperature = $_POST["temperature"];

    $date_time = date('Y-m-d H:i:s'); // Get current date and time

    // Insert the data into the database
    $sql = "INSERT INTO sensor_data (beatAvg, temperature, date_time) VALUES ($beatAvg,
$temperature, '$date_time')";

    if ($conn->query($sql) === TRUE) {
        echo "Data inserted successfully";
    } else {
        echo "Error: " . $sql . "<br>" . $conn->error;
    }
} else {
    echo "beatAvg, temperature not set.";
}

// Close the database connection
$conn->close();
?>

```