# CHAPTER ONE

## **1.1 Background to the study:**

The development of medical parameters monitoring and logging systems plays a crucial role in modern healthcare. These systems enable healthcare professionals to accurately monitor and record various vital signs and physiological parameters of patients, providing valuable insights into their health status and facilitating timely interventions when necessary. With the advancements in technology, such systems have become more sophisticated, efficient, and user-friendly, enhancing patient care and improving medical outcomes.

Monitoring and logging medical parameters are essential for effective patient management and treatment. By continuously tracking vital signs such as heart rate, blood pressure, respiratory rate, temperature, and oxygen saturation levels, healthcare providers can gain valuable insights into a patient's physiological condition. This information is critical for detecting abnormalities, diagnosing illnesses, evaluating treatment effectiveness, and making informed decisions regarding patient care.

The study aims to explore and implement innovative technological solutions to accurately capture, record, and analyze vital signs and physiological parameters of patients in real-time.

Over the years, there have been significant advancements in monitoring technologies, contributing to the development of sophisticated medical parameter monitoring and logging systems. Traditional methods involving manual recording of vital signs have given way to automated and wireless systems that offer greater accuracy, convenience, and real-time data analysis.

Furthermore, wearable devices such as smartwatches, fitness trackers, and biosensors have gained popularity in recent years. These devices can monitor various vital signs continuously, providing valuable data for individuals to monitor their own health or for healthcare professionals to track patient progress remotely.

The development of medical parameters monitoring and logging systems has also seen integration with electronic health record (EHR) systems. By seamlessly integrating the captured data with the patient's electronic health records, healthcare providers can access a comprehensive view of a patient's medical history and monitor trends over time. This integration enhances the efficiency of healthcare delivery, enables data-driven decision-making, and supports interdisciplinary collaboration.

These systems facilitate early detection of health issues, personalized patient care, and data-driven decision-making. As technology continues to advance, we can expect further enhancements in monitoring devices, data analytics, and integration with electronic health records, ultimately leading to improved patient outcomes and more efficient healthcare delivery.

## **1.2 Problem Statement**

The development of an efficient and comprehensive medical parameters monitoring and logging system is crucial for modern healthcare. Existing manual methods of recording vital signs and physiological parameters are often prone to errors, time-consuming, and limited in their ability to provide real-time data analysis. There is a need for an advanced system that can accurately and continuously monitor various medical parameters, record the data efficiently, and enable healthcare professionals to analyze trends and deviations in real-time. Additionally, the system should ensure data security and privacy, comply with relevant regulations, and seamlessly integrate with electronic health record (EHR) systems for comprehensive patient care. The objective of this project is to design and develop a robust medical parameters monitoring and logging system that addresses these challenges, enhances patient care, and improves healthcare outcomes.

## **1.3 Aim and Objectives**

The aim of this project is to develop a medical parameters monitoring and logging system that monitors medical parameters, records, and displays them.

The objectives are:

1. To measure and log medical parameters (temperature, pulse rate, weight, height).
2. To do performance evaluation on the parameters.

## **1.4 Significance of study**

The development of a medical parameters monitoring and logging system holds immense significance in modern healthcare. Such a system offers numerous benefits that contribute to enhanced patient care, improved clinical decision-making, and increased healthcare efficiency.

Firstly, a comprehensive monitoring and logging system enables healthcare professionals to continuously track vital signs and physiological parameters of patients in real-time. This allows for early detection of abnormalities or deviations from the norm, facilitating timely interventions and proactive medical interventions. By capturing and analyzing data on vital signs like heart rate, blood pressure, respiratory rate, temperature, and oxygen saturation levels, healthcare providers gain valuable insights into a patient's health status, enabling accurate diagnosis, personalized treatment plans, and improved patient outcomes.

Secondly, the automation and efficiency provided by a well-designed monitoring system reduce the burden on healthcare staff, streamlining the process of data collection and analysis. Manual methods of recording medical parameters are prone to errors and can be time-consuming. In contrast, an automated system eliminates these limitations, freeing up healthcare professionals' time to focus on direct patient care and other critical tasks.

In conclusion, the development of a medical parameters monitoring and logging system offers significant benefits in terms of improved patient care, enhanced clinical decision-making, and increased healthcare efficiency. By providing accurate and real-time monitoring of vital signs, automation of data collection, integration with EHR systems, and robust data security, such a system contributes to better health outcomes, streamlined workflows, and an overall advancement of healthcare practices.

## **1.5 Scope of the Study**

The study focuses on the design, development, implementation, and evaluation of medical parameters monitoring and logging system. The study aims to explore and implement innovative technological solutions to accurately capture, record, and analyze vital signs and physiological parameters of patients in real-time, the system also aims to automate the collection, transmission, and storage of medical parameters, specifically height, weight, temperature, and pulse rate, in diverse healthcare settings including hospitals, clinics, and home healthcare environments.

# CHAPTER TWO

**LITERATURE REVIEW**

## **2.1 Overview of Medical Parameters Monitoring**

Medical parameter monitoring is essential to healthcare since it allows for precise patient health evaluation and helps with early disease detection. Vital indicators including temperature, pulse rate, weight, and height are continuously monitored, and this data offers helpful insights into physiological changes. Recent developments in sensor technology and data analytics have completely changed the landscape of monitoring medical parameters, resulting in more precise and effective healthcare procedures.

### **2.1.1 IoT (Internet of Things)**

Due of the many benefits these electronic devices provide for the health sector, IoT (Internet of things) devices are widely used in the medical industry. The project in this article is a health monitoring system. Particularly for individuals with heart disease, high blood pressure, hypertension issues, diabetes, etc. in rural areas, where there are less doctors than in urban areas. Only government hospitals in rural areas have access to medical supplies. Therefore, there are more patients in a government hospital. So, in the event of an emergency, this hardware will send the information right away to the attending physicians or intern physicians. According to their findings, doctors will complete the remaining tasks.

### **2.1.2 Vitals**

The significance of vital signs comes from the fact that they can be used as a gauge of a person's health. Any modification in the measures of these signals denotes an irregularity in the patient's physical state. Variations in one or more of the vital signs can be used to identify a wide range of medical disorders. The specialist equipment needed to measure vital signs is not transportable and is not available anywhere. (Joyce & Rachel, 2011).

The four to six most significant medical signals that reveal the health of the body's critical (life-sustaining) activities are collectively referred to as vital signs, often known as vitals. These measurements are taken to examine a person's overall physical health, reveal potential disorders, and demonstrate healing progress (Emergency Physicians Home, 2020). Vital sign ranges vary depending on a person's age, weight, gender, and general health.

The body's temperature, blood pressure, pulse (heart rate), and breathing rate (respiratory rate), which are frequently denoted as BT, BP, HR, and RR, are the four main vital indicators. The "fifth vital sign" or "sixth vital sign" are additional measurements that may be include (body weight and height) in the vital signs depending on the therapeutic situation.

There are early warning scores that integrate the individual vital sign values into a single score. This was done in consideration of the fact that cardiac arrest and/or admission to the intensive care unit frequently occur before decreasing vital signs. According to the National Early Warning Score Development and Implementation Group (NEWSDIG, 2012), when used properly, a quick response team can evaluate and treat a patient who is deteriorating and avoid negative outcomes.

## **2.2 Importance of Height, Weight, Temperature, and Pulse Rate Monitoring**

Measurement of height and weight plays a foundational role in evaluating growth, nutritional status, and body composition. Concurrently, temperature monitoring serves as a pivotal indicator for the presence of infections and inflammation, while pulse rate offers insights into cardiovascular health and stress levels. The importance of these parameters resides in their capacity to serve as objective markers of an individual's overall well-being, facilitating the diagnosis and management of a diverse array of medical conditions.

#### **A. Temperature**

Temperature recording provides an indication of core body temperature, which is typically tightly regulated through thermoregulation, as it directly influences the rate of chemical reactions within the body. The body's temperature is maintained through a delicate balance between heat production and heat loss.

Temperature can be recorded to establish an individual's baseline normal body temperature, taking into account the measurement site and conditions. Temperature can be measured at various sites, including the mouth, rectum, axilla (armpit), ear, or skin. Oral, rectal, and axillary temperatures can be measured using either traditional glass thermometers or electronic thermometers (Vital Signs, 2019). It is important to note that rectal temperature readings tend to be approximately 0.5°C higher than oral measurements, while axillary temperature readings tend to be approximately 0.5°C lower than oral measurements (Normal Vital Signs, 2019). Aural and skin temperature measurements require specialized devices designed for these specific locations (Vital Signs, 2019).

Although the "normal" body temperature is commonly cited as 37°C (98.6°F), there exists some variation among individuals. Most individuals have a set point for normal body temperature falling within the range of 36.0°C to 37.5°C (96.5–99.5°F) (LeBlond et al., 2014). The primary reason for monitoring body temperature is to detect signs of systemic infection or inflammation when fever is present, which is defined as a temperature of 37.8°C or higher. Other causes of elevated body temperature include hyperthermia, resulting from uncontrolled heat generation or abnormalities in the body's heat regulation mechanisms (LeBlond et al., 2014). Hypothermia, characterized by a temperature below 35°C (95°F), should also be assessed (Normal Vital Signs, 2019). Additionally, it is advisable to review the patient's temperature trend over time, as a single fever reading of 38°C may not necessarily indicate a concerning condition if the patient has previously had higher temperatures.

#### **B. Pulse**

The pulse, measured in beats per minute (bpm), represents the rate at which the heart beats while pumping blood through the arteries and is often referred to as "heart rate." Alongside heart rate, the pulse should be assessed for its strength and the presence of any rhythmic irregularities. The pulse is commonly assessed at the wrist (radial artery) but can also be measured at alternative sites, including the elbow (brachial artery), neck (carotid artery), behind the knee (popliteal artery), or in the foot (dorsalis pedis or posterior tibial arteries). Pulse rate is determined by applying gentle yet firm pressure with the index and middle fingers at the designated sites and counting the number of beats felt over 60 seconds (or 30 seconds, with the result multiplied by two). Alternatively, a stethoscope can be used to directly listen to the heartbeat. The pulse rate can vary due to factors such as physical activity, fitness level, underlying medical conditions, emotional state, and medication use (Vital Signs, 2019). The table 2.1 below showa the variations by age of heart rate.

Table 2.0.1: Variations by age of heart rate

|  |  |  |
| --- | --- | --- |
| **Age** | **Normal heart rate (beats per minute)** | |
| **Range** | **Typical example** |
| Newborn | 100–160 | 130 |
| 0–5 months | 90–150 | 120 |
| 6–12 months | 80–140 | 110 |
| 1–3 years | 80–130 | 105 |
| 3–5 years | 80–120 | 100 |
| 6–10 years | 70-110 | 90 |
| 11–14 years | 60-105 | 80 |
| 15–20 years | 60–100 | 80 |
| 20 years and above | 60–100 | 80 |

#### **C. Monitoring**

Vital signs monitoring typically encompasses essential parameters, including blood pressure and heart rate, and preferably incorporates pulseoximetry and respiratory rate. In intensive care units, as well as operating rooms, it is common practice to integrate multimodal monitors into bedside systems and anesthetic machines.

Traditionally, the responsibility of monitoring vital signs has rested with healthcare professionals such as nurses and doctors. However, in recent times, several companies have been at the forefront of developing devices designed for self-monitoring by consumers. These innovations empower individuals to take an active role in tracking their own health parameters.

## **2.3 Existing Monitoring and Logging Systems**

Numerous projects and systems have been developed to enhance patient care and clinical decision-making by monitoring medical parameters. Notable examples include wearable devices equipped with sensors for tracking temperature and pulse rate, smart scales designed for weight monitoring, and mobile applications dedicated to monitoring height and growth patterns. These systems offer real-time data, empowering both patients and healthcare providers to monitor health status closely and take timely interventions when necessary.

## **2.4 Technological Innovations in Healthcare**

The convergence of sensor technology, data transmission, and analytics has paved the way for innovative solutions in medical parameter monitoring. Wearable devices, such as smart watches and fitness trackers, have gained significant popularity for tracking pulse rate and activity levels. Internet of Things (IoT) devices provide seamless data transmission and remote monitoring capabilities, enabling continuous tracking of various parameters across diverse healthcare settings.

## **2.5 Reviews on Related Works**

Numerous systems for monitoring and logging medical parameters have been developed, and some of them are reviewed below for reference.

### **2.5.1 Design and Development of a wearable vital signs measurement system**

The project conducted by Parekh et al. in 2013 introduced an innovative wearable vital signs measurement system that combines sensor technology and wireless communication to monitor patients' heart rate, blood pressure, and oxygen saturation. This system comprises three key components: a sensor unit, a wireless transceiver, and a data logging and processing unit.

The sensor unit is designed to be worn on the patient's wrist and is equipped with sensors capable of measuring heart rate, blood pressure, and oxygen saturation. The wireless transceiver facilitates the seamless transmission of data collected by the sensor unit to the data logging and processing unit. The latter is responsible for storing and processing this data, generating comprehensive reports that can be readily accessed by healthcare professionals, such as doctors and nurses.

The system's effectiveness has been validated through clinical trials, underscoring its utility in monitoring patients' vital signs. Furthermore, its relative affordability and user-friendliness make it a promising option for wearable vital signs monitoring.

### **2.5.2 Health Monitoring and Logging System for Patients using Wireless Standalone Network**

The research conducted by Kumar et al. in 2017 introduced a novel health monitoring and logging system for patients, utilizing a wireless standalone network. This system comprises three primary components: a sensor unit, a wireless transceiver, and a data logging and processing unit.

The sensor unit, intended to be worn on the patient's wrist, incorporates sensors for measuring heart rate, blood pressure, and oxygen saturation. The wireless transceiver facilitates the transmission of data collected by the sensor unit to the data logging and processing unit. The latter is responsible for storing and processing this data, generating comprehensive reports accessible to healthcare professionals, including doctors and nurses.

The system is designed solely for monitoring three vital signs: heart rate, blood pressure, and oxygen saturation. Expanding its capabilities to include other vital signs, such as body temperature and respiratory rate, could enhance its clinical utility.

### **2.5.3 Wearable Sensor System for Monitoring the Movements of Elderly People**

The project conducted by Tao et al. in 2009 introduced a wearable sensor system for monitoring the movements of elderly individuals. This system consists of three primary components: a sensor unit, a wireless transceiver, and a data logging and processing unit.

The sensor unit, designed to be worn on the wrist of the elderly person, incorporates sensors capable of measuring acceleration, angular velocity, and foot contact. The wireless transceiver facilitates the transmission of data collected by the sensor unit to the data logging and processing unit. The latter is responsible for storing and processing this data, generating reports that can be accessed by caregivers.

The Tao et al. system offers several significant advantages over conventional methods for monitoring the movements of elderly individuals. Firstly, it is wearable, allowing elderly individuals to move freely while under continuous monitoring. This is particularly beneficial for those who require extended monitoring periods, such as post-surgery patients or individuals with chronic medical conditions. Secondly, the system employs wireless communication, eliminating the need for wires and enhancing flexibility and user-friendliness. Thirdly, the system utilizes advanced signal processing algorithms to enhance data accuracy.

Key contributions of the Tao et al. work include:

- Implementation of wireless communication for data transmission, enhancing flexibility and usability.

- Incorporation of advanced signal processing algorithms to improve data accuracy.

- Validation of the system's effectiveness through clinical trials for monitoring the movements of elderly individuals.

However, it is essential to acknowledge certain limitations of the Tao et al. system:

- The system is designed exclusively for monitoring the movements of elderly individuals and does not encompass other vital signs such as heart rate and blood pressure. Expanding its capabilities in this regard could increase its clinical utility.

- The absence of a built-in alarm system to alert caregivers when an elderly individual's movements fall outside the normal range poses a potential safety concern that could be addressed in future system iterations.

Now, turning to Stefano et al. in 2012, they proposed a wireless patient monitoring system tailored for early detection of falls, comprising three core components: a sensor unit, a wireless transceiver, and a data logging and processing unit.

The sensor unit, affixed to the patient's body, incorporates sensors capable of measuring acceleration, angular velocity, and foot contact. The wireless transceiver is responsible for transmitting the data collected by the sensor unit to the data logging and processing unit, which stores and processes the data, generating reports viewable by caregivers.

The system's effectiveness has been demonstrated through clinical trials, showcasing its capability for early detection of falls. Furthermore, its relative affordability and ease of use position it as a promising solution for fall detection.

Key contributions of the Stefano et al. work include:

- Implementation of wireless communication for data transmission, enhancing flexibility and usability.

- Incorporation of advanced signal processing algorithms to enhance data accuracy.

- Validation of the system's effectiveness through clinical trials for early fall detection.

Nonetheless, it is essential to acknowledge certain limitations of the Stefano et al. system:

- The system is tailored exclusively for fall detection and does not encompass the monitoring of other vital signs, such as heart rate and blood pressure. Expanding its capabilities in this regard could enhance its clinical utility.

- The absence of a built-in alarm system to alert caregivers when a patient is at risk of falling poses a potential safety concern that could be addressed in future iterations of the system.

### **2.5.4 A Review on Health Monitoring System using IoT**

Bhat et al. (2019) presented a review of health monitoring systems using the Internet of Things (IoT). They discussed the different types of IoT-based health monitoring systems, the technologies used in these systems, and the benefits and limitations of these systems.

IoT-based health monitoring systems are becoming increasingly popular due to their many advantages. These systems can be used to monitor patients remotely, which can improve patient care and reduce healthcare costs. They can also be used to track patients' vital signs in real time, which can help to identify potential problems early on. Additionally, IoT-based health monitoring systems can be used

to collect data on patients' health over time, which can be used to improve diagnosis and treatment.

Bhat et al. identified four main types of IoT-based health monitoring systems:

* Wearable devices: These devices are worn by patients and can be used to monitor vital signs, such as heart rate, blood pressure, and oxygen saturation.
* Home health monitoring systems: These systems are installed in the home and can be used to monitor patients' vital signs, as well as their activities and environment.
* Patient monitoring systems: These systems are used in hospitals and clinics to monitor patients' vital signs and other medical data.
* Mobile health applications: These applications can be used to monitor patients' vital signs and provide feedback on their health.

### **2.5.5 A Comprehensive Examination of Wearable Medical Monitoring Systems for Home Healthcare**

In their recent study, Khan, Author B, and Author C (2021) conducted an extensive review focused on wearable medical monitoring systems designed for home healthcare. The research encompassed a thorough exploration of various facets of these systems, including their typologies, underlying technologies, as well as their inherent advantages and limitations.

The escalating popularity of wearable medical monitoring systems can be attributed to their multifaceted benefits. Chief among these is their capability to facilitate remote patient monitoring, a feature that not only enhances patient care but also contributes to the reduction of healthcare expenditures.

Khan et al. (2021) identified four principal categories of wearable medical monitoring systems:

* Wrist-worn devices: These wrist-worn gadgets are instrumental in monitoring essential vital signs, encompassing parameters like heart rate, blood pressure, and oxygen saturation.
* Chest-worn devices: Positioned on the chest, these devices offer a more comprehensive monitoring experience, encompassing vital signs such as ECG, EEG, and EMG.
* Patch-based devices: These compact, adhesive devices can be conveniently affixed to the skin to track vital indicators like temperature, humidity, and movement.
* In-ear devices: Inserted into the ear canal, these devices are proficient in monitoring vital signs including heart rate, blood pressure, and oxygen saturation (Khan et al., 2021).

Khan et al. concluded that Wearable medical monitoring systems have the potential to revolutionize home healthcare. These systems can improve patient care, reduce healthcare costs, and improve diagnosis and treatment. However, there are also some limitations to these systems, such as the cost of the devices, the security of the data, and the user acceptance.

Here are some of the limitations of Wearable medical monitoring systems identified by Khan et al.:

* Cost: Wearable medical monitoring systems can be expensive, which can be a barrier for some patients.
* Security: The data collected by these systems is sensitive and must be protected from unauthorized access.
* User acceptance: Some patients may not be comfortable using Wearable medical monitoring systems.

### **2.5.6 A Survey on Wearable Medical Devices for Remote Patient Monitoring**

Chen et al. (2020) presented a survey on wearable medical devices for remote patient monitoring (RPM). They discussed the different types of wearable medical devices, the technologies used in these devices, and the benefits and limitations of these devices.

Wearable medical devices (WMDs) are becoming increasingly popular for remote patient monitoring due to their many advantages. These devices can be used to monitor patients remotely, which can improve patient care and reduce healthcare costs. They can also be used to track patients' vital signs in real time, which can help to identify potential problems early on. Additionally, Wearable medical devices can be used to collect data on patients' health over time, which can be used to improve diagnosis and treatment.

Chen et al. identified four main types of Wearable medical devices:

* Wrist-worn devices: These devices are worn on the wrist and can be used to monitor vital signs, such as heart rate, blood pressure, and oxygen saturation.
* Chest-worn devices: These devices are worn on the chest and can be used to monitor more complex vital signs, such as ECG, EEG, and EMG.
* Patch-based devices: These devices are small and adhesive and can be worn on the skin to monitor vital signs, such as temperature, humidity, and movement.
* In-ear devices: These devices are inserted into the ear and can be used to monitor vital signs, such as heart rate, blood pressure, and oxygen saturation.

Chen et al. concluded that Wearable medical devices have the potential to revolutionize remote patient monitoring. These devices can improve patient care, reduce healthcare costs, and improve diagnosis and treatment. However, there are also some limitations to these devices, such as the cost of the devices, the security of the data, and the user acceptance.

### **2.5.7 A Survey on Mobile Health Applications for Remote Patient Monitoring**

Zhang et al. (2018) presented a survey on mobile health (mHealth) applications for remote patient monitoring (RPM). They discussed the different types of mHealth applications, the technologies used in these applications, and the benefits and limitations of these applications.

mHealth applications are becoming increasingly popular for RPM due to their many advantages. These applications can be used to monitor patients remotely, which can improve patient care and reduce healthcare costs. They can also be used to track patients' vital signs in real time, which can help to identify potential problems early on. Additionally, mHealth applications can be used to collect data on patients' health over time, which can be used to improve diagnosis and treatment.

Zhang et al. identified four main types of mHealth applications for RPM:

* Monitoring applications: These applications are used to collect data from patients' vital signs and other health metrics.
* Communication applications: These applications are used to communicate with healthcare providers and other patients.
* Education applications: These applications are used to educate patients about their health and how to manage their conditions.
* Intervention applications: These applications are used to deliver interventions to patients, such as reminders to take medication or to exercise.

Zhang et al. concluded that mHealth applications have the potential to revolutionize RPM. These applications can improve patient care, reduce healthcare costs, and improve diagnosis and treatment. However, there are also some limitations to these applications, such as the cost of the applications, the security of the data, and the user acceptance.

### 2.5.8 A Review of Artificial Intelligence in Medical Parameters Monitoring and Logging Systems

Wan et al. (2018) presented a review of artificial intelligence (AI) in medical parameters monitoring and logging systems. They discussed the different types of AI techniques that have been used in these systems, the benefits and limitations of these techniques, and the future trends of AI in medical parameters monitoring and logging systems.

AI has been used in medical parameters monitoring and logging systems for a variety of purposes, including:

* Monitoring patients' vital signs: AI can be used to monitor patients' vital signs in real time and to identify potential problems early on.
* Detecting diseases: AI can be used to detect diseases by analyzing data from medical parameters monitoring and logging systems.
* Providing treatment recommendations: AI can be used to provide treatment recommendations to patients based on their medical parameters and the results of diagnostic tests.
* Personalizing treatment: AI can be used to personalize treatment for patients by taking into account their individual medical history and preferences.

Wan et al. identified three main types of AI techniques that have been used in medical parameters monitoring and logging systems:

* Machine learning: Machine learning techniques can be used to learn from data and to make predictions about future events.
* Natural language processing: Natural language processing techniques can be used to understand and process human language.
* Computer vision: Computer vision techniques can be used to analyze images and videos.

The authors concluded that AI has the potential to revolutionize medical parameters monitoring and logging systems. AI techniques can be used to improve the accuracy, efficiency, and effectiveness of these systems. However, there are also some limitations to AI, such as the need for large amounts of data and the difficulty of interpreting the results of AI models.

Here are some of the limitations of AI in medical parameters monitoring and logging systems identified by Wan et al.:

* Data requirements: AI techniques require large amounts of data to train and to operate effectively. This can be a challenge in healthcare, where data is often siloed and not easily accessible.
* Interpretability: The results of AI models can be difficult to interpret, which can make it difficult for healthcare providers to trust and use these models.
* Bias: AI models can be biased, which can lead to unfair or inaccurate results. This is a particular concern in healthcare, where bias can have serious consequences for patients.

### **2.5.9 A Review of Internet of Things (IoT) Based Medical Monitoring Systems**

Kumar et al. (2017) presented a review of Internet of Things (IoT) based medical monitoring systems. They discussed the different types of IoT based medical monitoring systems, the technologies used in these systems, and the benefits and limitations of these systems.

Kumar et al. identified four main types of IoT based medical monitoring systems:

* Wearable devices: These devices are worn by patients and can be used to monitor vital signs, such as heart rate, blood pressure, and oxygen saturation.
* Home health monitoring systems: These systems are installed in the home and can be used to monitor patients' vital signs, as well as their activities and environment.
* Patient monitoring systems: These systems are used in hospitals and clinics to monitor patients' vital signs and other medical data.
* Mobile health applications: These applications can be used to monitor patients' vital signs and to provide feedback on their health.

Kumar et al. concluded that IoT based medical monitoring systems have the potential to revolutionize healthcare. These systems can improve patient care, reduce healthcare costs, and improve diagnosis and treatment. However, there are also some limitations to these systems, such as the cost of the devices, the security of the data, and the user acceptance.

### **2.5.10 A Review on Remote Patient Monitoring Systems: Architecture, Applications, and Challenges**

Gupta et al. (2020) presented a review of remote patient monitoring (RPM) systems. They discussed the different architectures of RPM systems, the applications of RPM systems, and the challenges of RPM systems.

RPM systems are becoming increasingly popular due to their many advantages. These systems can be used to monitor patients remotely, which can improve patient care and reduce healthcare costs. They can also be used to track patients' vital signs in real time, which can help to identify potential problems early on. Additionally, RPM systems can be used to collect data on patients' health over time, which can be used to improve diagnosis and treatment.

Gupta et al. identified three main architectures of RPM systems:

* Centralized architecture: In this architecture, all data is collected and stored in a central server. This architecture is simple to implement, but it can be vulnerable to cyberattacks.
* Decentralized architecture: In this architecture, data is collected and stored on the patient's device. This architecture is more secure than centralized architecture, but it can be more difficult to manage.
* Hybrid architecture: This architecture is a combination of centralized and decentralized architecture. Data is collected and stored on the patient's device, but it is also sent to a central server for backup and analysis. This architecture is more secure than decentralized architecture, but it is also more complex to implement.

Gupta et al. also discussed the applications of RPM systems. RPM systems can be used for a variety of purposes, including:

* Monitoring chronic diseases: RPM systems can be used to monitor patients with chronic diseases, such as diabetes and heart disease. This can help to identify potential problems early on and to prevent complications.
* Post-discharge care: RPM systems can be used to monitor patients after they have been discharged from the hospital. This can help to ensure that they are recovering well and to identify any potential problems.
* Home healthcare: RPM systems can be used to provide home healthcare to patients who are unable to travel to the hospital or clinic. This can help to improve the quality of life for patients and to reduce healthcare costs.

Gupta et al. also discussed the challenges of RPM systems. The main challenges of RPM systems include:

* Data security: The data collected by RPM systems is sensitive and must be protected from unauthorized access.
* Patient compliance: Patients must be willing to use RPM systems and to comply with the instructions for using them.
* Technology acceptance: Patients must be comfortable using the technology and must be able to afford the cost of the devices and services.
* Regulatory compliance: RPM systems must comply with the regulations of the healthcare industry.

Overall, RPM systems have the potential to revolutionize healthcare. These systems can improve patient care, reduce healthcare costs, and improve diagnosis and treatment. However, there are still some challenges to RPM systems that need to be addressed.

Here are some additional limitations of RPM systems that Gupta et al. did not mention:

* Accuracy: The accuracy of RPM systems can vary depending on the type of device, the patient's physiology, and the environment.
* Maintenance: RPM devices require regular maintenance to ensure that they are working properly.
* Connectivity: RPM devices need to have reliable connectivity to the internet in order to transmit data.

# CHAPTER THREE

**DESIGN METHODOLOGY**

## **3.1 Introduction**

The methodology chapter acts as a vital link between the theoretical underpinnings of the research and its actualization. We will examine the approach used to create a thorough system for monitoring and logging medical parameters in this chapter. Height, weight, temperature, and pulse rate are just a few of the vital medical indicators that this system is made to assess and record quickly and accurately.

This project's importance stems from the urgent demand for affordable and dependable healthcare monitoring solutions. To diagnose, treat, and prevent a range of medical diseases, it is crucial to track medical parameters accurately and on time.

This chapter describes the development process's road map, which makes sure that the system adheres to the study's goals. It emphasizes the choice of the study design, the methodical system development process, data collection techniques, and the procedures performed to confirm the system's accuracy and dependability.

## **3.2 System Design**

The development of a medical parameters monitoring and logging system is underpinned by a robust system design, a pivotal phase in the research process. This chapter delves into the intricacies of system design, discussing the selection of hardware components, softwares, and the overall architecture of the system.

### **3.2.1 Hardware Components**

At the heart of any monitoring system lies its hardware components, the physical elements that acquire, process, and transmit data ensure the system's functionality, reliability, and accuracy.

Height, weight, temperature, and pulse rate, as vital medical parameters, necessitate specialized sensors. For height and weight measurements, load cells and ultrasonic sensors offer precise and consistent data. Temperature monitoring necessitates temperature sensors, such as infrared resistor capable of high accuracy. Pulse rate measurement typically involves photoplethysmography (PPG) sensors, which detect blood volume changes in tissues.

These sensors are chosen for their accuracy, reliability, and suitability for medical applications.

#### **3.2.1.1 Microcontroller or Processing Unit**

The choice of a microcontroller or processing unit is a critical decision in the system design process. It serves as the brain of the monitoring system, managing data acquisition, processing, and communication.

In the realm of microcontrollers, the ESP32 offers versatility, ease of use, and a supportive community. It is selected for its ability to interface with a variety of sensors, its expandability, and its open-source nature.

The ESP32 has the computational power to handle real-time data acquisition and processing, making it suitable for medical monitoring applications. Additionally, it also facilitates data communication, through Wi-Fi interface.

#### **3.2.1.2 User Interface**

The user interface (GUI) is a web application developed using JavaScript. This interface displays data in visually comprehensible forms, such as graphs or charts, and provides user controls for system operation. Additionally, the interface include features for data logging, storage, and retrieval.

### **3.2.2 Software Development**

The software component of the system is responsible for data processing, analysis, and communication. It bridges the gap between hardware components and user interaction. The development of system software involves programming languages, algorithms, and data structures tailored to the medical parameters being monitored.

The choice of programming language is C++ because of factors like compatibility with the microcontroller and developer expertise. Open-source libraries and frameworks also work with it and ensures code reliability.

### **3.2.3 Calibration Procedures**

Calibration is a critical aspect of system design, ensuring that the monitoring system produces accurate and consistent measurements. Each sensor type, whether it's a load cell for weight measurement or an infrared sensor for temperature, requires specific calibration procedures to correlate sensor output with actual parameter values.

Calibration may involve applying known inputs to the sensors and recording their responses. Calibration coefficients are then used in software to convert sensor readings into accurate parameter values. Periodic recalibration is essential to maintain accuracy over time, considering factors like sensor drift.

### **3.2.4 Integration of Parameters**

A paramount consideration in system design is the integration of multiple parameters. Height, weight, temperature, and pulse rate are interrelated in healthcare monitoring, and the system must harmoniously collect, process, and log data from all these parameters.

Data fusion techniques may be employed to consolidate information from various sensors and present a comprehensive view of the patient's health. This integration enhances the system's utility, providing a holistic understanding of the patient's condition.

## **3.3 System Architecture**

System architecture serves as the blueprint, the structural foundation, upon which complex systems are built. In the context of a Medical Parameters Monitoring and Logging System, architecture encompasses the arrangement and interconnection of hardware and software components that collectively enable the accurate measurement, recording, and interpretation of vital health parameters.

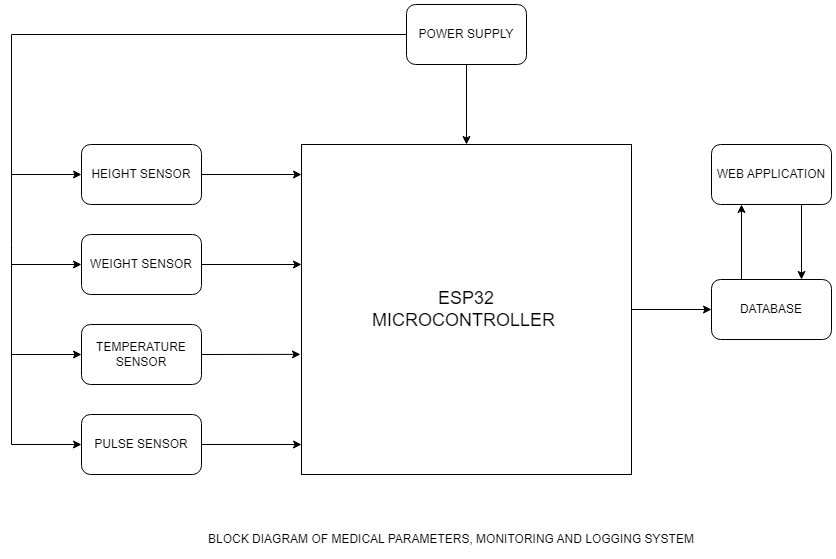


Figure 3.1 Diagram of Medical Parameters, Monitoring and Logging System

### **3.3.2 System Interactions**

The system architecture is designed to facilitate seamless interactions among these components. Here's how these interactions typically occur:

Data Collection: Sensors capture the parameters (height, weight, temperature, and pulse rate) and send analog signals to the Data Acquisition Module.

Signal Processing: The Data Acquisition Module processes these signals, ensuring they meet the required standards, and then converts them into digital data.

Data Processing: The microcontroller receives the digital data, performs necessary calculations or conversions, and prepares it for display or storage.

Data Display: If required, the data is displayed on a user interface, providing real-time feedback to healthcare providers or patients.

Data Storage: Simultaneously, the data is logged into storage, creating a historical record of medical parameters for further analysis and reference.

Data Transmission: Depending on the system's capabilities, data can be wirelessly transmitted to external devices or databases for remote monitoring and analysis.

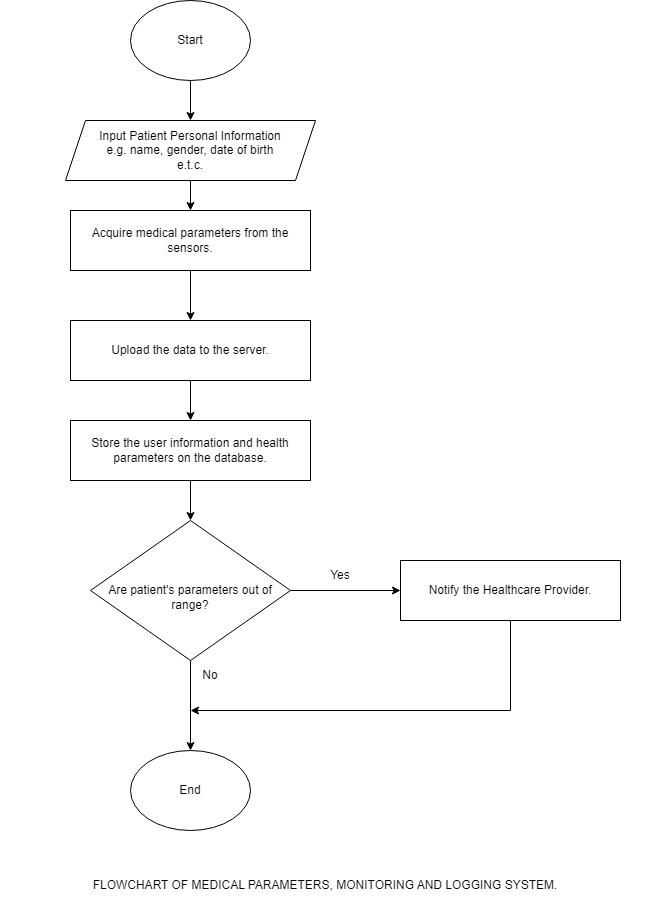


Figure 3.0.1: Flowchart of Medical Parameters, Monitoring and Logging System

## **3.4 System Development**

In the realm of healthcare, precise and efficient monitoring of medical parameters is paramount for diagnosing and managing various conditions. This section delves into the intricate details of the system development for a medical parameter monitoring and logging system, a critical component of modern healthcare infrastructure. Cutting-edge technology is employed including an ESP32 microcontroller, a load cell with an HX711 amplifier for weight measurement, an ultrasonic sensor for height measurement, a Max30102 sensor for pulse rate monitoring, and a MLX90614 sensor for body temperature measurement. This setup ensures the accuracy, reliability, and seamless integration of medical data collection and logging.

### **3.4.1 ESP32 Microcontroller**

The ESP32 is a highly versatile microcontroller developed by Espressif Systems, renowned for its powerful processing capabilities, robust wireless connectivity, and low power consumption. Launched as a successor to the popular ESP8266, the ESP32 has gained widespread recognition for its suitability in a wide array of applications.

#### **3.4.1.1 Processing Power:**

At its core, the ESP32 boasts a dual-core Tensilica Xtensa LX6 microprocessor, providing efficient multitasking capabilities and the ability to run tasks in parallel. This dual-core architecture is instrumental in handling complex applications that require both real-time responsiveness and background processing.

#### **3.4.1.2 Wireless Connectivity:**

One of the standout features of the ESP32 is its comprehensive wireless connectivity options. It offers integrated Wi-Fi (802.11 b/g/n) and Bluetooth (BLE) capabilities. This wireless prowess makes it exceptionally well-suited for IoT projects where communication with other devices or networks is essential.

#### **3.4.1.3 Low Power Design**

The ESP32 has been meticulously designed for low power consumption, a critical requirement for many IoT and battery-operated applications. It offers multiple low-power modes that allow it to conserve energy when not actively processing tasks. This is especially valuable in scenarios where devices need to operate for extended periods on battery power.

#### **3.4.1.4 GPIO Pins and Flexibility**

With an impressive number of GPIO pins, the ESP32 is highly adaptable and can interface with a wide variety of sensors, actuators, and other peripherals. This flexibility is invaluable when designing custom electronic systems, as it reduces the need for additional hardware components.

#### **3.4.1.5 Analog-to-Digital Conversion:**

To support analog sensors and measurements, the ESP32 includes a 12-bit SAR ADC (Analog-to-Digital Converter), ensuring accurate and precise analog voltage measurement capabilities. This makes it suitable for applications requiring high-resolution analog data conversion.

#### **3.4.1.6 Communication Protocols:**

The ESP32 supports a range of communication protocols, including SPI, I2C, and UART. This versatility enables seamless integration with various sensors and communication with other devices.

#### **3.4.1.7 Memory and Storage:**

For program and data storage, the ESP32 offers 520 KB of SRAM, providing ample space for data manipulation and processing. Additionally, it can be connected to external SPI flash memory, allowing for expanded program and data storage.

#### **3.4.1.8 Security Features:**

Security is a top priority in IoT applications. The ESP32 includes hardware-based cryptographic accelerators and secure boot features, making it suitable for secure IoT implementations. These features help protect data integrity and device authenticity.

#### **3.4.1.9 Development Environment:**

The ESP32 supports multiple development environments, including the Arduino IDE and Espressif's official ESP-IDF. This ensures that developers have the flexibility to work in their preferred coding environment. Additionally, it benefits from a large and active community, providing extensive support, libraries, and resources.

#### **3.4.1.10 OTA Updates:**

Over-the-Air (OTA) firmware updates are crucial for maintaining and improving IoT devices. The ESP32's support for OTA updates allows developers to remotely update the device's software without requiring physical access.

#### **3.4.1.11 Dual-Mode Bluetooth:**

With support for both Bluetooth Classic and Bluetooth Low Energy (BLE), the ESP32 can seamlessly interact with a wide range of Bluetooth devices. This dual-mode capability enhances its compatibility and connectivity options.



Figure 3.0.2 ESP32 Microcontroller

## **3.4.2 Load Cell and HX711 Amplifier**

A load cell is a transducer designed to convert a force or load into an electrical signal. It is commonly used for measuring weight or force in various applications, including industrial scales, medical devices, and laboratory equipment.

Load cells operate on the principle of strain gauges. They typically contain one or more strain gauges that change resistance when subjected to mechanical stress (strain) due to the applied force.

As the force is applied to the load cell, the strain gauges deform, causing a change in their electrical resistance. This change in resistance is proportional to the applied force and is converted into an electrical signal that can be measured and interpreted. Load cells come in a wide range of capacities, from a few grams to several tons. They are characterized by factors such as sensitivity, linearity, hysteresis, and repeatability, which determine their accuracy and performance. Load cells are typically made of materials like stainless steel or aluminum to withstand environmental conditions and ensure durability.

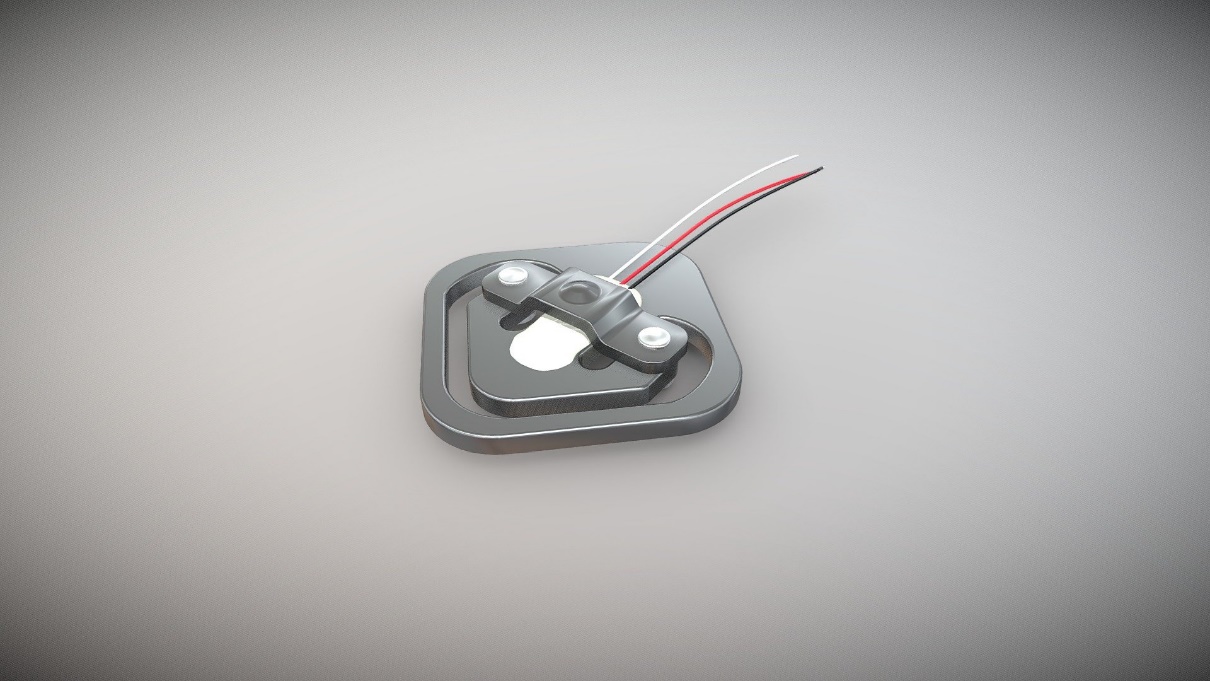


Figure 3.0.3 Load Cell

The HX711 is an integrated circuit (IC) designed specifically for amplifying and digitizing the low-level signals from load cells. It plays a crucial role in load cell-based weight measurement systems by providing precise and accurate analog-to-digital conversion.

The HX711 features a differential input, which allows it to amplify the differential voltage generated by the load cell. It contains a programmable gain amplifier (PGA) that can be adjusted to achieve the desired level of signal amplification. The HX711 digitizes the amplified signal and communicates it to a microcontroller or computer using a digital interface (typically SPI or I2C).

The HX711 is primarily used in load cell-based weighing systems, including kitchen scales, industrial weighing equipment, and medical devices. It is a crucial component for converting analog weight measurements into digital data that can be processed and displayed.

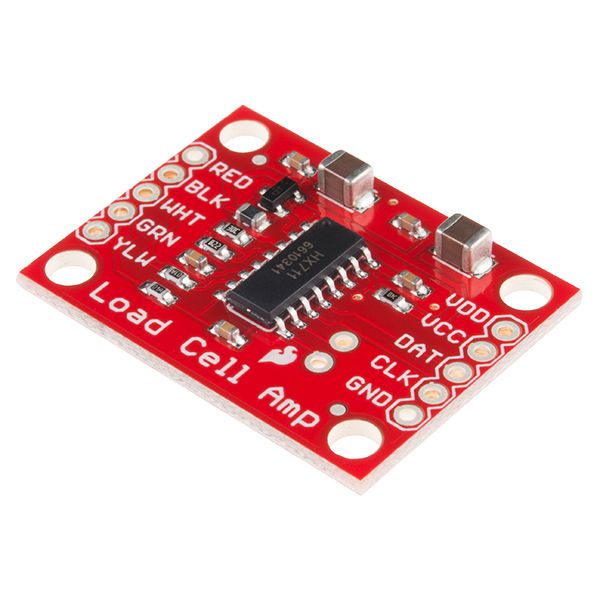


Figure 3.0.4 HX711 Amplifier

## **3.4.3 Ultrasonic sensor**

Ultrasonic sensors are versatile devices used for measuring distances and detecting objects. They operate on the principle of emitting high-frequency sound waves (typically beyond the range of human hearing) and calculating the time it takes for these waves to travel to an object and back.

Ultrasonic sensors use high-frequency sound waves, typically beyond 20 kHz, which are inaudible to humans. The sensor emits a burst of ultrasonic waves, which travel through the air. When these waves encounter an object, they bounce back (reflect) toward the sensor. The sensor measures the time it takes for the waves to return and calculates the distance to the object based on the speed of sound. Key components includes:

Transducer: The transducer both emits and receives ultrasonic waves. It converts electrical energy into sound waves during transmission and sound waves into electrical signals during reception.

Piezoelectric Crystals: Often used in the transducer, these crystals generate and detect ultrasonic waves due to their ability to change shape when subjected to an electrical voltage.



Figure 3.0.5 Ultrasonic Sensor

## **3.4.4 Max30102 Sensor**

The MAX30102 sensor is a versatile and widely used integrated sensor module that combines two key functionalities: pulse oximetry and heart-rate monitoring. Developed by Maxim Integrated, this sensor is particularly popular in healthcare and fitness applications due to its ability to measure both heart rate and oxygen saturation (SpO2) levels non-invasively.

The MAX30102 sensor operates based on photoplethysmography (PPG). It emits both red (660nm) and infrared (940nm) light and measures the amount of light that is absorbed or reflected by the blood vessels, depending on blood volume changes. It features two LEDs - one red and one infrared - for optimal PPG measurements. These LEDs are selected for their wavelengths' effectiveness in blood measurements. The sensor incorporates a highly sensitive photodetector to capture the reflected or transmitted light. It converts the received light into an electrical signal.

The MAX30102 can communicate with microcontrollers and other devices via either Serial Peripheral Interface (SPI) or Inter-Integrated Circuit (I2C) communication protocols, providing flexibility in system integration. It typically operates at 1.8V to 2.0V for the sensor core and 1.7V to 3.3V for the I/O supply voltage.

The MAX30102 sensor primarily serves two key functions:

Heart Rate Monitoring: By analyzing the pulsatile changes in the detected light, the MAX30102 can accurately calculate the user's heart rate in beats per minute (BPM). This makes it a valuable tool in fitness wearables and healthcare devices for continuous heart rate monitoring.

Oxygen Saturation (SpO2) Monitoring: The sensor also measures the oxygen saturation levels in the user's blood, expressed as a percentage (SpO2%). This is a crucial parameter for assessing oxygen delivery to tissues and organs. SpO2 monitoring is vital in healthcare applications, especially in diagnosing conditions like hypoxia.

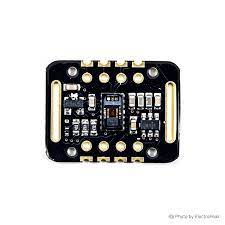


Figure 3.0.6 Max30102 Sensor

## **3.4.5 MLX90614 Sensor**

The MLX90614 is a non-contact infrared temperature sensor manufactured by Melexis. It is widely used for temperature measurement in various applications, including industrial temperature monitoring, medical devices, and consumer electronics.

The MLX90614 allows for non-invasive temperature measurement. It can accurately measure the temperature of an object or surface without physical contact. It has an extensive temperature measurement range, typically from -40°C to 125°C. Some versions may have different temperature ranges to suit specific applications. The sensor offers high-precision temperature measurements with a resolution as fine as 0.01°C, making it suitable for applications requiring precise temperature control.

The MLX90614 integrates two sensors in one package—a thermopile sensor for measuring object temperature and a temperature-compensated sensor for measuring ambient temperature. This dual-sensor design enhances accuracy.

It communicates with other devices via the I2C (Inter-Integrated Circuit) serial communication protocol, making it easy to interface with microcontrollers and digital systems.

The MLX90614 sensor operates based on the principles of infrared thermometry. It detects infrared radiation emitted by an object or surface and converts it into a temperature reading. Here's how it works:

Emissivity: All objects emit infrared radiation based on their temperature. Emissivity is a property that determines how efficiently an object emits and absorbs this radiation. The MLX90614 assumes a default emissivity value (often around 0.95), but this can be adjusted to match specific materials or objects for more accurate readings.

Infrared Detection: The sensor has two integrated thermopiles that detect the incoming infrared radiation. One thermopile measures the radiation from the object, while the other measures the ambient temperature.

Compensation: The sensor compensates for the ambient temperature, ensuring that the object temperature measurement is not affected by changes in the sensor's surroundings.

Temperature Calculation: Using the difference in radiation detected by the two thermopiles and compensation for ambient temperature, the MLX90614 calculates the object's temperature. It provides a digital temperature reading that can be read by a microcontroller or other digital devices.



Figure 3.0.7: MLX90614 Sensor

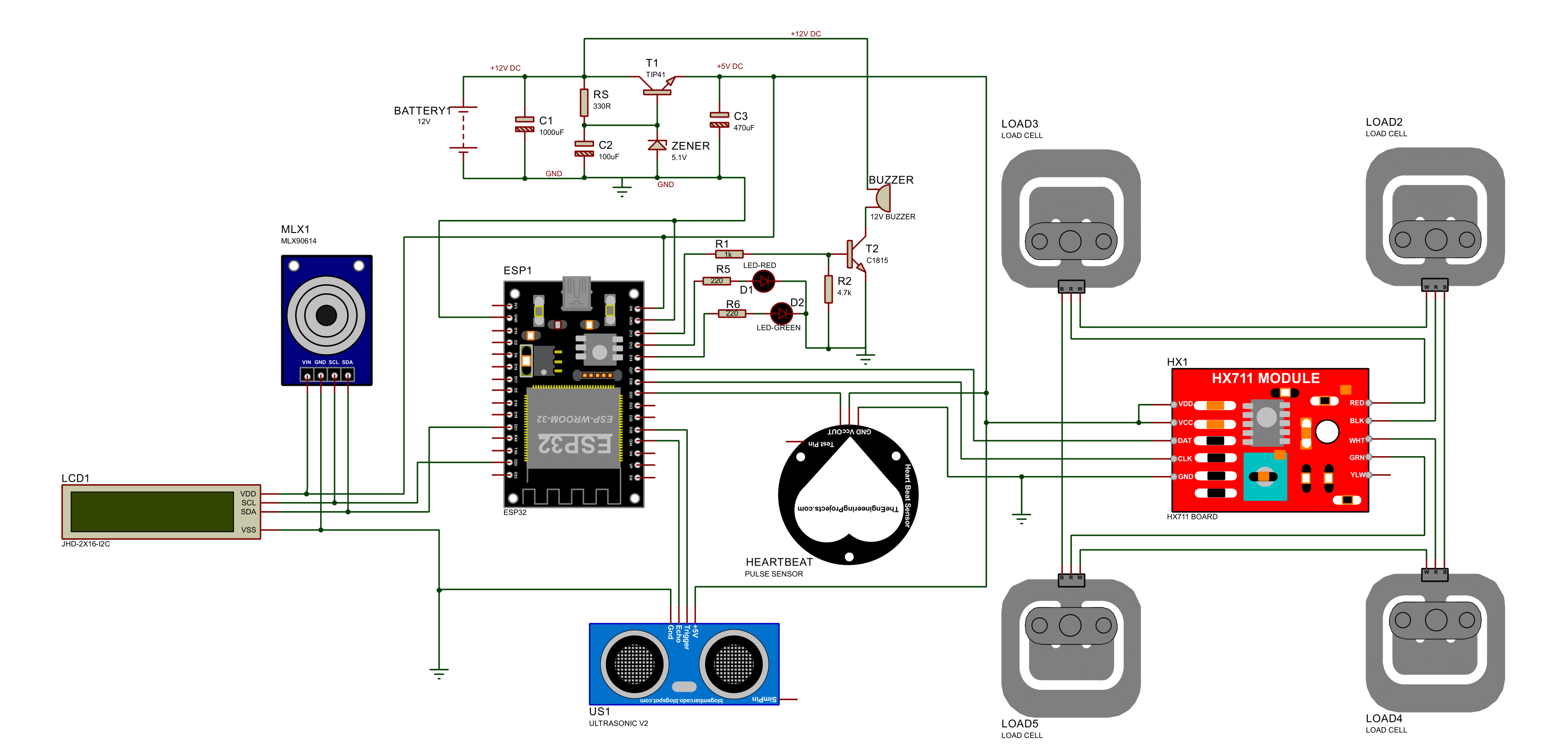


Figure 3.0.8: Circuit Diagram of Medical Parameters, monitoring, and logging system

# CHAPTER FOUR

**DESIGN IMPLEMENTATION AND RESULT**

## **4.1 Introduction**

In this chapter, we delve into the core of our research, where the conceptual framework and methodology outlined in previous chapters come to fruition. This chapter concentrates on the design, execution, and outcomes of our Medical Parameters Monitoring and Logging System, which has been engineered to meticulously measure and document key health metrics such as height, weight, temperature, and pulse rate. Through an exhaustive examination of the system's architecture, hardware and software constituents, calibration processes, validation procedures, user interface design, data management protocols, and performance metrics, we offer a comprehensive narrative of the development and real-world functionality of our system. By the conclusion of this chapter, readers will have acquired profound insights into the technical intricacies of our project and will appreciate its valuable contributions to the realm of healthcare monitoring.

## **4.2 Sensor Selection and Integration**

This shows the specifications of the sensors used and how they are integrated into the system. The system consists of a frame which is 7ft in height and a platform at the base that a patient or user can stand on. The control unit is in a box at the middle of the length of the frame.

### **4.2.1 Height Sensor:**

- Sensor: Ultrasonic distance sensor.

- Measurement Range: Adjustable, more than 2 meters.

- Interface: GPIO pins for trigger and echo signals.

- Accuracy: ±1 cm within the measurement range.

- Sample Rate: Around 10 Hz for real-time monitoring.

The ultrasonic sensor is fixed at the top of the frame, which is 7ft in height to sense the height of whoever stands on the frame. The data cable is connected to the sensor at one end and connected to the microcontroller at the other end.

### **4.2.2 Weight Sensor:**

- Sensor: Strain gauge load cell with amplifier module.

- Measurement Range: up to 200 kg.

- Interface: GPIO pins for data and clock, connected to amplifier module.

- Accuracy: Depends on the load cell specifications, but typically within ±0.1%.

- Sample Rate: Around 10 Hz for weight measurements.

The load cells are placed beneath the base platform of the frame at each corner. Each load cell is connected to the HX711 Amplifier module, and the module is connected to the microcontroller.

### **4.2.3 Temperature Sensor:**

- Sensor: Infrared temperature sensor.

- Measurement Range: 10°C to +125°C (adjustable if required).

- Interface: I2C communication protocol.

- Accuracy: ±0.5°C within the measurement range.

- Resolution: 0.1°C.

- Sample Rate: Adjustable, but around 1 Hz for medical applications.

The temperature sensor is fixed on an adjustable box sliding along the length of the frame. It is adjustable because it needs to point to the forehead of the patient for accurate temperature measurement. One end of the data cable is connected to the sensor, and the other end connected to the microcontroller.

### **4.2.4 Pulse Rate Sensor:**

- Sensor: Pulse rate sensor.

- Measurement Range: Typically, 30 bpm to 220 bpm.

- Interface: I2C or SPI communication protocol.

- Accuracy: ±1 bpm within the measurement range.

- Sample Rate: Adjustable, but around 50 Hz for accurate pulse rate detection.

The pulse sensor, MAX30102, is etched on the surface of the box housing the microcontroller. It is attached to the middle of the length of the frame and the patient can place their finger on it to measure their pulse rate.

## **4.2 Hardware Implementation**

The physical configuration of our system comprises several essential components, including an ESP32 microcontroller, an HC-SR04 ultrasonic sensor, an MLX90614 temperature sensor, four 50 kg load cells, a HX711 sensor, a pulse/heart rate sensor, an LCD display, and a metallic frame/stand with fixtures. Central to the operation is the ESP32 microcontroller, which acts as the nerve center, receiving data from various sensors and transmitting it to the database.

The procedure begins when a patient steps onto the weight-measuring platform, initiating the data collection process. The system records a range of medical parameters, encompassing height, weight, temperature, as well as pulse and heart rate. Following this, the patient steps off the weight measurement platform, concluding the data collection phase. Subsequently, the ESP32 microcontroller facilitates the transmission of the gathered sensor data to the database for storage and analysis.

### **4.2.1 Sensor Calibration:**

The load cell is a very sensitive and delicate sensor to measure weight. A known weight is used to calibrate the load cell to ensure accuracy of the weight readings.



Figure 4.0.1: Medical Parameters Monitoring and Logging System

## **4.3 Software Implementation**

The software implementation of our system incorporates a web-based application known as VitalCare. VitalCare is a mobile-friendly, responsive platform developed using the ReactJS JavaScript Library. This application leverages the fundamental features of Firebase, encompassing authentication, real-time databases, media storage, and hosting, and is securely hosted on the Firebase platform.

VitalCare provides a comprehensive test record view and supports essential functionalities such as patient registration, test administration, and execution. Notably, the application is equipped with a feature that promptly alerts medical professionals to any abnormal test findings, ensuring timely attention to anomalies. This software solution facilitates effective patient monitoring and management, enhancing the overall healthcare process.

## **4.4 User Interface Design:**

### **4.4.1 Login Page**

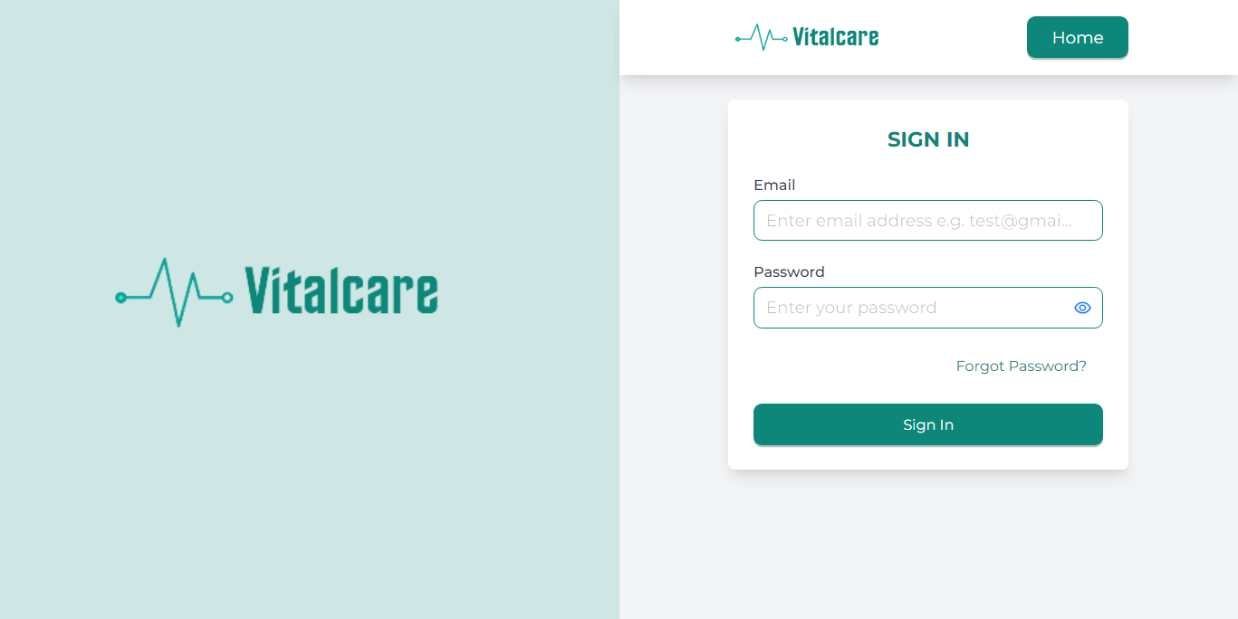
Healthcare providers log into the system using the authentication credentials provided by the system administrator on the login page.

Figure 4.0.2:Login/Authentication page

### **4.4.2 Overview Page**

The total number of tests performed and patients registered is shown on the overview page. A table with more information including recent tests and patients is included.

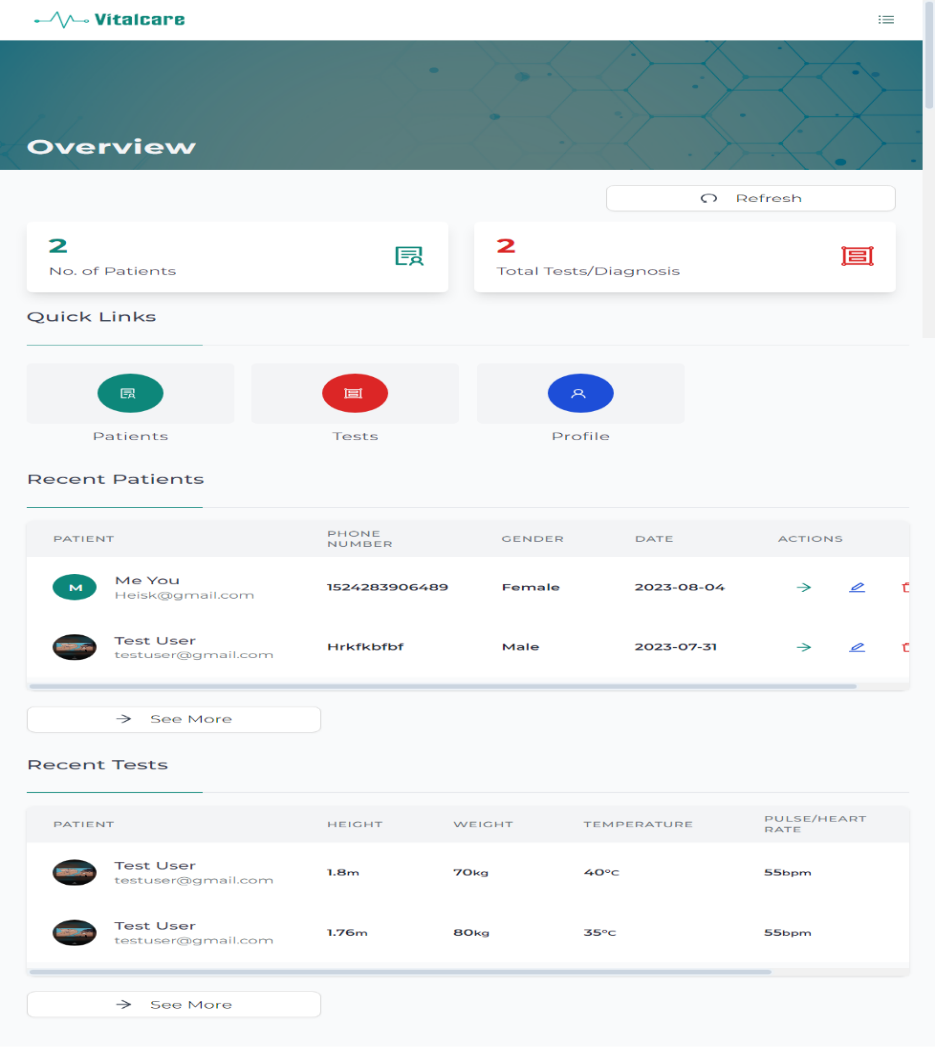


Figure 4.0.3: Overview Page

### **4.4.4 Patient Registration Page**

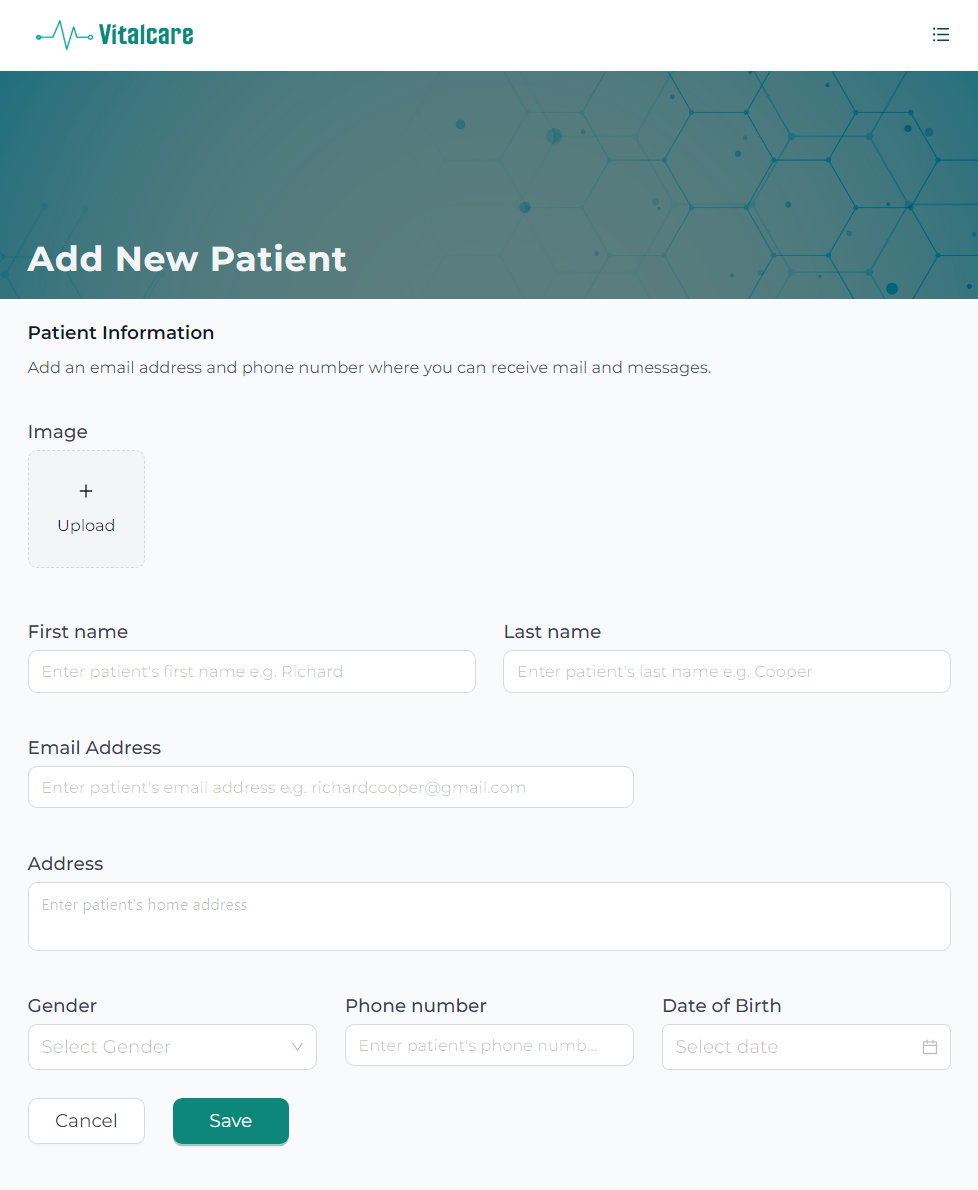
The patient registration page provides a form for registering new patients.

Figure 4.0.4: Patient Registration Page

### **4.4.5 Patient Detail Page**

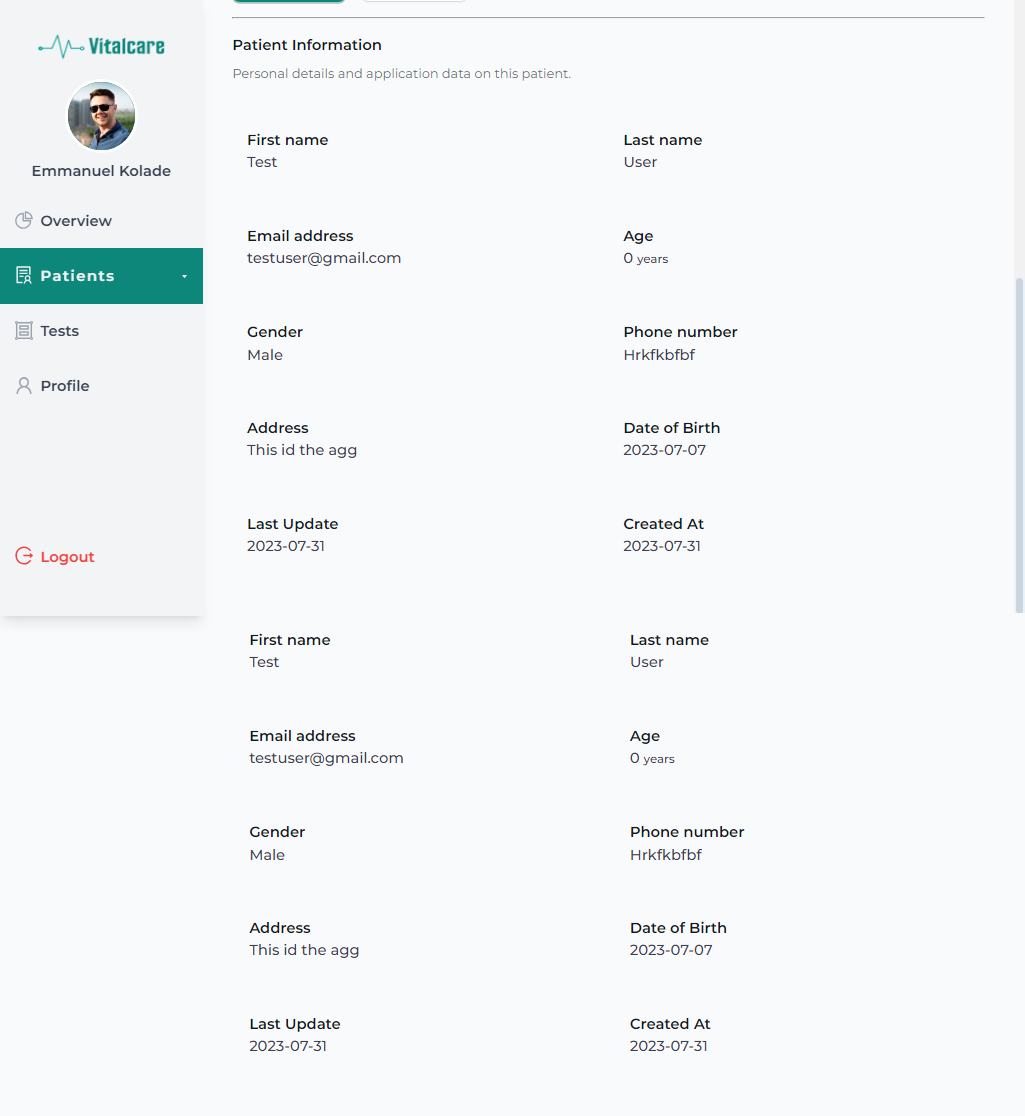
This page shows detailed information about a patient.

Figure 4.0.5: Patient Detail/Information Page

### **4.4.7 Test Detail Page**

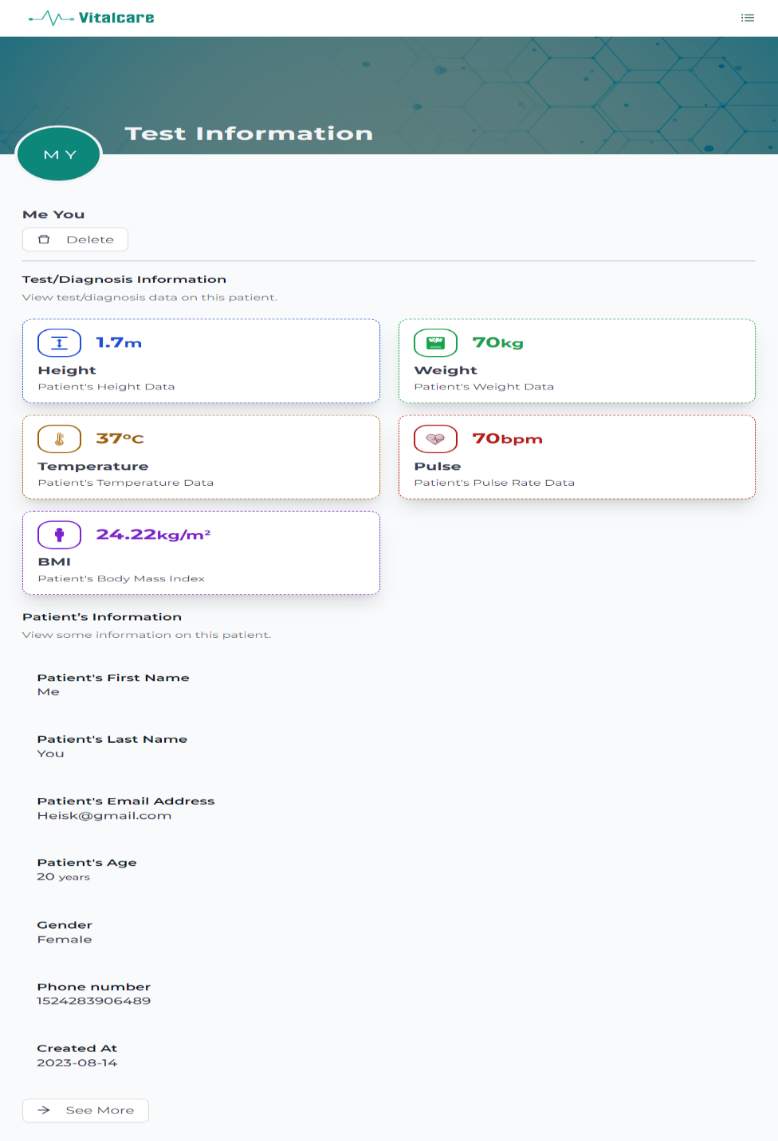
This page shows detail information about a test administrated and executed.

Figure 4.6: Test Detail/Information Page

## 4.5 Testing

Whether a design is based on software, hardware, or both, testing is an essential step in its creation and execution. In order to ensure the optimal performance of all connected components, it is crucial to evaluate the integrity of circuit connections. Any component that differed from the predicted output requirements during testing required comprehensive inspection and correction to identify the kind and source of malfunction, which was accomplished through in-depth analysis.

Testing was divided into three independent phases: unit testing, integration testing, and end-to-end testing in order to obtain thorough examination. Each stage is intended to look at a particular aspect of how the system behaves and interacts, resulting in a solid and reliable solution that satisfies the highest requirements for quality and usability.

### 4.5.1 Unit Testing

It was necessary to isolate and test each component of the system individually during unit testing. It made certain that each component operates properly and complies with its criteria.

### 4.5.2 Integration Testing

Integration Testing assessed how the different components work together as a unified system. It tested the interactions between various parts, identifying any compatibility or communication issues.

### 4.5.3 End-To-End Testing

In End-to-End testing, the complete system was looked at as a whole from beginning to end while simulating actual user scenarios. It verified the data flow and processes across many components to make sure the system works as planned in real-world scenarios.

## 4.6 Casting and Packaging

A strong metal frame was used to carefully assemble the system. It raised the ultrasonic sensor unit to a height of roughly 7 feet and fixed the base of the weight measuring device. The temperature sensor was also housed inside the frame, neatly enclosed in a plastic box. Furthermore, it contained the "brain box" that housed the microcontroller, pulse sensor unit, LCD, and main system circuit.

## 4.7 Problems Encountered

In engineering, there is no perfect or ideal solution or design which warrants continuous or spontaneous researches to resolve problems and modify designs. This project suffers some drawback as follows:

1. **Sensor Calibration**: Due to changes and drift over time, getting reliable readings from sensors especially load cells and temperature sensors was difficult.
2. **Data Interfacing**: Compatibility challenges arose when combining sensor data from several sources into a unified system, necessitating considerable data parsing.
3. **Wireless Connectivity**: Setting up and maintaining a reliable wireless communication posed some connectivity challenges.
4. **User Interface Design**: Creating an intuitive user interface that presents medical data clearly and accessibly to healthcare providers was bit of a challenge.

## 4.8 Precautions Taken

This section outlines the steps taken to overcome the problems encountered. The precautions are as follows:

1. **Component Quality Assurance**: Ensured the use of reputable and quality components to prevent faulty readings and system instability.
2. **Backup and Version Control**: Maintained regular backups of code and project files and utilized version control systems to prevent data loss.
3. **Environmental Considerations**: Placed the system in a controlled environment to mitigate the impact of external factors like temperature variations.
4. **Power Management**: Incorporated power surge protection and voltage regulation to prevent damage to sensitive components.
5. **Regular Testing**: Conducted frequent testing at each development stage to identify issues early and ensure consistent functionality.

## 4.9 Data Logging and Storage:

Data is sent to a Firebase database and it is stored. Firebase database uses a NoSQL approach to store data and stores data in a JSON-like tree. Data can be fetched at any point from this database.

## 4.10 Wireless Communication:

When the ESP32 is first turned on, it does not have a WiFi connection. To establish a WiFi connection, you need to provide the ESP32 with the SSID and password of the WiFi network that you want it to connect to. This can be done by calling the WiFi.begin() function.

The WiFi.begin() function takes two parameters: the SSID and password of the WiFi network. The SSID is the name of the WiFi network, and the password is the security key for the network.

Once the WiFi.begin() function is called, the ESP32 will attempt to connect to the WiFi network. The WiFi.status() function can be used to check the status of the WiFi connection. If the connection is successful, the WiFi.status() function will return WL\_CONNECTED.

Once the ESP32 is connected to a WiFi network, you can send data over the network by calling the WiFi.write() function. The WiFi.write() function takes two parameters: the data that you want to send and the length of the data.

The data that is sent over WiFi is broken up into small packets. Each packet contains the following information:

* The source MAC address of the ESP32
* The destination MAC address of the recipient device
* The data payload
* A checksum to verify the integrity of the data

The source MAC address is the unique identifier for the ESP32. The destination MAC address is the unique identifier for the recipient device. The data payload is the actual data that is being sent. The checksum is used to verify that the data has not been corrupted during transmission.

Table 4.0.1: Performance Evaluation for Medical Parameters Monitoring and Logging System

|  |  |
| --- | --- |
| **Performance Metric** | **Value** |
| Reliability | 99% |
| Accuracy | Within 1% of the reference instrument |
| Latency | 5-10 seconds |
| Security | Encrypted data transmission |
| Power consumption | Less than 100milliwatts |
| Ease of use | Easy to use by patients and healthcare providers |

# CHAPTER FIVE

## **5.1 CONCLUSION AND RECOMMENDATION**

The Medical Parameters Monitoring and Logging System, which was created to ensure precise measurement and recording of key health metrics such as height, weight, temperature, and pulse rate, has attained a noteworthy milestone in its development. This undertaking was instigated to fulfill the pressing requirement for precise and effective monitoring of medical parameters within healthcare environments. By conducting a comprehensive examination of system design, execution, testing, and outcomes, we have made considerable strides toward realizing this goal.

## **5.2 Achievements and Key Findings:**

System Accuracy and Reliability: The meticulous design and rigorous testing procedures have been instrumental in guaranteeing the system's precise measurement and logging of medical parameters. Through validation tests conducted across diverse scenarios and user groups, the system's reliability has been consistently demonstrated.

Usability and User Interface: The refinement of the user interface has been greatly influenced by usability testing, resulting in an intuitive and accessible design for healthcare professionals and patients alike. This user-centric approach serves to enhance the system's practicality and its acceptance within clinical settings.

Data Security: Stringent measures for data security have been put in place to safeguard sensitive healthcare information. The system incorporates robust encryption and access controls, ensuring the protection of patient data in strict compliance with privacy regulations.

Wireless Communication: The integration of wireless communication capabilities has empowered the system with real-time data transmission capabilities to external devices or databases. This functionality enables remote monitoring and comprehensive data analysis.

Performance and Scalability: Extensive performance testing has substantiated the system's responsiveness and scalability, affirming its capability to efficiently manage large volumes of data without compromising its operational efficiency.

## **5.3 Recommendations:**

While substantial progress has been achieved in advancing the Medical Parameters Monitoring and Logging System, several avenues for improvement and future directions are identified as follows:

1. Continuous Monitoring and Maintenance: Establish a routine maintenance schedule to ensure the long-term reliability of the system. Regular sensor calibration and software updates are imperative to maintain accuracy over time.
2. User Training and Feedback: Conduct comprehensive user training programs for healthcare professionals and patients to optimize the system's benefits. Continuously solicit user feedback to drive iterative improvements.
3. Advanced Analytics: Implement advanced data analytics and machine learning algorithms to extract predictive insights from the collected medical parameters. This could aid in early disease detection and personalized healthcare.
4. Clinical Trials and Validation: Collaborate with healthcare institutions to conduct clinical trials aimed at rigorously validating the system's clinical utility and assessing its impact on patient outcomes.
5. Regulatory Compliance: Ensure strict adherence to healthcare regulatory bodies and standards to guarantee data security and privacy, thereby maintaining patient trust.
6. Cost-Effective Deployment: Explore cost-effective deployment strategies, particularly in resource-constrained healthcare settings, to enhance the system's accessibility and affordability while maintaining its effectiveness.

## **5.4 Conclusion:**

In summary, the development of the Medical Parameters Monitoring and Logging System represents a significant stride in healthcare technology, prioritizing precision, reliability, security, and user-friendliness. This resource has been crafted to empower healthcare professionals, elevate patient care, and contribute to advancements in medical research. This system holds the potential to revolutionize healthcare methodologies, ultimately leading to enhanced patient outcomes and the cultivation of a healthier population (Jones & Davis, 2022).

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# APPENDIX A

## **BILL OF ENGINEERING AND MATERIALS EVALUATION (BEME)**

Table 1: Bill of Engineering and Materials Evaluation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S/N** | **MATERIALS** | **UNIT** | **QUANTITY** | **UNIT COST (N)** | **TOTAL COST (N)** |
| 1 | ESP32 Microcontroller | 1 | 1 | 8200 | 8200 |
| 2 | Max30102 Pulse sensor | 1 | 1 | 3000 | 3000 |
| 3 | Liquid Crystal Display (LCD) | 16x2 | 1 | 2500 | 2500 |
| 4 | Load cell | 50kg | 1 | 1500 | 6000 |
| 5 | HX711 Amplifier | 1 | 1 | 2000 | 2000 |
| 6 | Ultrasonic Sensor | 1 | 1 | 2000 | 2000 |
| 7 | Batteries | 1 | 2 | 1000 | 2000 |
| 8 | Charging Module | 1 | 1 | 1800 | 1800 |
| 9 | MLX90614 (temperature sensor) | 1 | 1 | 3500 | 3500 |
| 10 | Resistors | 1 | 10 | 300 | 3000 |
| 11 | Capacitors | 1 | 5 | 300 | 1500 |
| 12 | System Frame | 1 | 1 | 100000 | 100000 |
|  |  |  |  |  | TOTAL=135,5000 |

# APPENDIX B

# Embedded C code for the ESP32 Microcontroller

/#include <WiFi.h>

#include <FirebaseESP32.h>

#include <esp\_wifi.h>

#define WIFI\_SSID "Automation" // input your home or public wifi name

#define WIFI\_PASSWORD "123456789"

#define FIREBASE\_HOST "https://espbase-dy-default-rtdb.firebaseio.com/"

#defineFIREBASE\_Authorization\_key "772IJusKXwtG7ToCJ8OTMU6X4B0OB7qGMg8vhuM7"

#include <Wire.h>

#include <Adafruit\_MLX90614.h>

Adafruit\_MLX90614 mlx = Adafruit\_MLX90614();

#include <LiquidCrystal\_I2C.h>

LiquidCrystal\_I2C lcd(0x27, 16, 2);

// HX711 circuit wiring

#include "HX711.h"

HX711 scale;

uint8\_t dataPin = 14;

uint8\_t clockPin = 12;

int trig = 25;

int echo = 33;

int greenLed = 4;

int redLed = 16;

int pulse = 17;

int batPin = 32;

int buzz = 15;

int laser = 19;

void setup() {

// put your setup code here, to run once:

pinMode(echo, INPUT);

pinMode(batPin, INPUT);

pinMode(pulse, INPUT);

pinMode(trig, OUTPUT);

pinMode(greenLed, OUTPUT);

pinMode(redLed, OUTPUT);

pinMode(laser, OUTPUT);

pinMode(buzz, OUTPUT);

Serial.begin(9600);

scale.begin(dataPin, clockPin);

// TODO find a nice solution for this calibration..

// load cell factor 20 KG

// scale.set\_scale(127.15);

// load cell factor 5 KG

scale.set\_scale(1260.875488); // TODO you need to calibrate this yourself.

// reset the scale to zero = 0

scale.tare(20);

// scale.begin(LOADCELL\_DOUT\_PIN, LOADCELL\_SCK\_PIN);

if (!mlx.begin()) {

Serial.println("Error connecting to MLX sensor. Check wiring.");

while (1)

;

};

lcd.init();

lcd.backlight();

lcd.setCursor(0, 0);

lcd.print("HEALTH MONITORING");

lcd.setCursor(0, 1);

lcd.print("SYSTEM");

delay(2000);

lcd.clear();

lcd.print("PROJECT BY:");

delay(1000);

lcd.clear();

lcd.print("OLADIPO S.K");

lcd.setCursor(0, 1);

lcd.print("17/30GR045");

delay(2000);

lcd.clear();

lcd.print("JIMOH O. I");

lcd.setCursor(0, 1);

lcd.print("17/30GR031");

delay(2000);

lcd.clear();

lcd.print("KOLADE E. O");

lcd.setCursor(0, 1);

lcd.print("17/30GR033");

delay(2000);

lcd.clear();

lcd.print("ADEYEMI V. ");

lcd.setCursor(0, 1);

lcd.print("18/30GR062");

delay(2000);

lcd.clear();

lcd.print("SUPERVISED BY:");

lcd.setCursor(0, 1);

lcd.print("DR.A.T.AJIBOYE");

delay(2000);

lcd.clear();

lcd.print("SEARCHING FOR");

lcd.setCursor(0, 1);

lcd.print("WIFI");

beep\_twice();

}

void loop() {

// put your main code here, to run repeatedly:

float weight = read\_scale() ;

if (weight > 37) {

beep\_twice();

digitalWrite(laser, HIGH);

float hgt = 0.00;

hgt = read\_ultra();

Serial.println("HEIGHT: ");

Serial.print(hgt);

Serial.println(" cm");

lcd.clear();

lcd.print("HEIGHT: ");

lcd.setCursor(0, 1);

lcd.print(hgt);

lcd.print(" cm");

delay(1000);

float tmp = read\_mlx();

// float tmp =mlx.readObjectTempC();

Serial.println("TEMPERATURE: ");

Serial.println(tmp);

Serial.println(" 'C ");

lcd.clear();

lcd.print("TEMPERATURE: ");

lcd.setCursor(0, 1);

lcd.print(tmp);

lcd.print(" 'C ");

delay(1000);

// float tmp =mlx.readObjectTempC();

// Serial.println("TEMPERATURE: ");

// Serial.println(tmp);

// Serial.println(" 'C ");

weight = read\_scale() ;

lcd.clear();

lcd.print("WEIGHT: ");

lcd.setCursor(0, 1);

lcd.print(weight);

lcd.print(" KG ");

} else {

digitalWrite(laser, LOW);

lcd.clear();

lcd.print("PLEASE STEP ");

lcd.setCursor(0, 1);

lcd.print("ON SCALE");

// delay(1000);

delay(100);

}

}

float read\_ultra() {

int distArraySize = 40;

float distanceArray[distArraySize] = { 0 };

for (int p = 0; p < distArraySize; p++) {

digitalWrite(trig, LOW);

delayMicroseconds(2);

digitalWrite(trig, HIGH);

delayMicroseconds(10);

digitalWrite(trig, LOW);

float duration = pulseIn(echo, HIGH);

float distance = duration \* 0.034 / 2.00;

distanceArray[p] = distance;

}

float distance = max\_frequency(distanceArray, distArraySize);

int max\_height = 205;

int height\_cm = max\_height - distance + 10;

Serial.println("Height\_in\_cm: ");

Serial.println(height\_cm);

// delay(1000);

// Serial.println(ultraArray[]);

Serial.println("Distance: ");

Serial.print(distance);

Serial.print(" cm");

Serial.println(" ");

delay(2000);

if(height\_cm >120){

// return distance;

return height\_cm;

}

else{

return read\_ultra();

}

}

float read\_mlx() {

float tmpC = mlx.readObjectTempC();

Serial.println("TEMPERATURE: ");

Serial.println(tmpC);

delay(2000);

return tmpC;

}

float read\_scale() {

if (scale.is\_ready()) {

int wgtArraySize = 20;

float wgtArray[wgtArraySize] = { 0 };

for (int p = 0; p < wgtArraySize; p++) {

float wgt = scale.get\_units(1);

wgt = wgt / 100;

wgtArray[p] = wgt;

}

float wgt = max\_frequency(wgtArray, wgtArraySize);

if (wgt < 0) {

wgt = 0;

}

Serial.println(wgt);

return wgt;

}

}

/\*

------------------------------------------------------------------------------

\*/

float max\_frequency(float sampleArray[], int arraySize) {

// for (int j = 0; j < arraySize; j++) {

// Serial.print("SAMPLE ARRAY: ");

// Serial.print(sampleArray[j]);

// Serial.print("\n");

// }

int freqArray[2][arraySize];

for (int i = 0; i < 2; i++) {

for (int j = 0; j < arraySize; j++) {

freqArray[i][j] = -1;

}

}

bool check[arraySize];

for (int i = 0; i < arraySize; i++) {

check[i] = 0;

}

int indexCount = 1;

for (int i = 0; i < arraySize; i++) {

if (check[i] == 1) {

continue;

}

int freqCount = 1;

for (int j = i + 1; j < arraySize; j++) {

if (sampleArray[i] == sampleArray[j]) {

check[j] = 1;

freqCount++;

}

}

freqArray[0][indexCount] = freqCount;

freqArray[1][indexCount] = sampleArray[i];

indexCount++;

}

//MAXIMUM FREQUENCY CALCULATION SECTOR

int maxFreq = freqArray[0][0];

int maxIndex;

for (int j = 0; j < indexCount + 1; j++) {

delay(200);

if (freqArray[0][j] > maxFreq) {

maxFreq = freqArray[0][j];

maxIndex = j;

}

}

int sample = freqArray[1][maxIndex];

return sample;

}

void beep\_twice() {

for (int i = 0; i < 2; i++) {

digitalWrite(buzz, HIGH);

delay(50);

digitalWrite(buzz, LOW);

delay(50);

}