Development of an IoT Based Portable Health Monitoring System

Submitted in partial fulfillment of the requirements for the degree

of

Bachelor of Science in Information and Communication Engineering

by

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APPROVAL

This is to certify that the entitled Development of a IoT Based Portable Health Monitoring System, submitted by Syada Shorifa Yasmin (Student ID: 201-50-024) and Atikul Islam (Student ID: 201-50-025) are undergraduate students of the Department of ICE has been examined. Upon recommendation by the examination committee, we hereby accorded our approval of it as the presented work. We submitted a report that fulfils the requirements for its acceptance in partial fulfilment for the degree of Bachelor of Science in Information and Communication Engineering.

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Project Title	**Development of a IoT Based Portable of Heath Monitoring System**
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We, **Atikul Islam** and **Syada Shorifa Yasmin**, now declare that our capstone project, the Development of an IoT Based Portable Health Monitoring System, is wholly our own unless otherwise noted or recognized. This project's content is the outcome of our investigation and work, and we adhered to all academic and ethical requirements.

We are aware of the negative effects of academic dishonesty and are aware that any ethical norms broken throughout this research could result in disciplinary action, according to Daffodil International University's policies.

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Syada Shorifa Yasmin

Atikul Islam

ABSTRACT

The proliferation of Internet of Things (IoT) technology has ushered in a new era of healthcare, enabling real-time monitoring and management of patient health. This project focuses on the development of an IoT-based health monitoring system designed to remotely track vital parameters such as heart rate, blood pressure, blood oxygen levels, and body temperature. The system comprises wearable sensors, a data acquisition module, and a cloud-based platform for data storage, analysis, and visualization. The proposed system aims to empower individuals to proactively manage their health by providing timely insights into their physiological conditions. By leveraging IoT and cloud computing technologies, the system facilitates remote patient monitoring, early detection of health anomalies, and efficient healthcare resource allocation. The project encompasses the design, implementation, and evaluation of the IoT-based health monitoring system, with a focus on data privacy, security, and user experience.

Keywords: IoT, health monitoring, wearable sensors, cloud computing, remote patient monitoring, data analysis, healthcare.

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Chapter 1

INTRODUCTION

With every technological advancement that the human race makes, health is always a top priority. The recent coronavirus outbreak, which has severely damaged China's economy, is one instance of how health care has grown to be crucial. It is usually a better idea to use health monitoring technologies to keep an eye on these patients in locations where the pandemic is spreading.

The " IoT Based Portable Health Monitoring System (HMS)" is a sensor-based health monitoring system that gathers patient data via wearable wired sensors, forecasts patients' health conditions and gives patients feedback on an LCD monitor. Patients can also use their laptop or computer serial monitor to engage in the healthcare process, allowing them to access their health information at any time.

Chronic illnesses, including cancer, diabetes, asthma, heart disease, sleep difficulties, and arthritis, affect millions of people worldwide. In cases like this, particular attention is required. It requires diets and therapy regimens tailored to the illness. An early diagnosis of symptoms and unfavorable changes in a patient's health status can be achieved by the use of physiological sensors, such as an electrocardiogram (ECG), which will enable prompt clinical intervention.

1.1 Project Background

- More emphasis is being placed on the need for continuous patient health monitoring in today's rapidly evolving healthcare environment to ensure early detection of potential health issues and improve overall treatment outcomes. The increasing prevalence of chronic illnesses such as diabetes, hypertension, and heart disease cannot be effectively controlled by conventional healthcare methods, which often rely on infrequent visits to medical specialists. More proactive health management is also required to address the ageing global population in order to maintain quality of life and reduce the burden on healthcare systems. Clothed in the undertaking.

The rise in chronic illnesses and the ensuing rises in healthcare costs have exposed serious inadequacies in the traditional methods of patient monitoring and management. New approaches to solving these problems have been made possible by recent technical advancements. Real-time vital sign monitoring, including blood pressure, heart rate, oxygen saturation, glucose levels, and more, is now feasible thanks to the proliferation and advancement of wearable health devices, mobile applications, and cloud-based solutions. These technologies have the potential to drastically alter the way healthcare

- is provided by offering continuous, real-time data that can help with distant patient monitoring, more tailored and timely interventions, and early diagnosis of health issues.

- These needs and technological improvements led to the inception of the Development of a IoT Based Portable Health Monitoring System (HMS) project. The goal is to develop a comprehensive system that uses various technologies to continuously and remotely monitor patients' health. By fusing wearable sensors and serial monitors, the HMS aims to create a seamless and simple experience for patients and healthcare practitioners. This strategy will not only raise the caliber of care but also promote patient involvement and self-management, which will enhance health outcomes and optimize the system's resources.

- The idea aligns with the patient-centered services, remote monitoring, and preventative care paradigms that are driving worldwide trends in healthcare. By completing the holes in the current protocols, the HMS effort has the potential to change the way healthcare is delivered drastically.

1.2 Project Definition

The Health Monitoring System (HMS) project aims to develop and implement a cutting-edge, real-time system that enables the ongoing monitoring and analysis of an individual's vital health information. Through the use of wearable technology, smartphone apps, and cloud-based technologies, this system will collect and process health data, providing consumers and healthcare practitioners with insightful information for proactive health management.

Project goals:

- Continuous Monitoring: Establish a system that is able to continuously monitor vital health indicators such as heart rate, blood pressure, oxygen saturation, and more.
- Real-Time Data presentation: Spot anomalies and potential health risks by monitoring collected data in real-time using it.
- Automated LED Alerts: Set up a system that lights up and alerts users or healthcare practitioners when they cross critical health thresholds.

Deliverables for the project:

Health sensors are gadgets that can monitor important health indicators on a constant basis.

- Serial monitor: An easy-to-use way for data visualization and health insights.
- LCD: An attached LCD will also show the data collected by the sensor.

1.2.1 Problem Statement

The current healthcare system often cannot keep track of patients' vital health indicators continuously and in real time. Conventional methods are insufficient for managing chronic illnesses or detecting the early warning signs of failing health since they depend on routine physical examinations and manual data collection. A delayed diagnosis, inadequate care, and increased workload for healthcare facilities and personnel could result from this failure to maintain continuous surveillance.

Important health events could go unnoticed until they get worse if patients with chronic conditions, including diabetes, hypertension, and cardiovascular diseases, do not have access to real-time monitoring. Healthcare systems are additionally burdened by the ageing population and the increased incidence of chronic illnesses, which results in higher costs and worse care quality.

1.2.2 Context and Scope

All around the world, pressure is being put on healthcare facilities to reduce expenses and enhance patient outcomes. The COVID-19 pandemic has highlighted the importance of remote patient monitoring even more since it reduces the risk of viral transmission by enabling medical personnel to check patients' health without having to visit them in person.

Technological advancements in wearables, cloud computing, data analytics, and mobile health applications have made it possible to construct a comprehensive health monitoring system that can continually track, evaluate, and report on vital health metrics. Our project makes use of these technologies to produce a solution that assists patients and healthcare professionals in managing health more successfully. The Health Monitoring System project encompasses the hardware, software, and cloud-based service solution design, development, testing, and implementation. The project will encompass the subsequent crucial components:

- **Wearable Technology:** Development and application of wearable sensors that continuously monitor key health parameters such as blood pressure, heart rate, oxygen saturation, and blood glucose levels. ensuring device compatibility
  .

1.2.3 Significance and Implications

significance:

Healthcare management and delivery have advanced dramatically with the help of the HMS. This very much matches a pressing demand for continuous and real-time health monitoring given the alarming growth in chronic diseases, aging populations, and a need for personalized healthcare. There are various ways to determine the project's importance, including:

- **Better Patient Outcomes:** The early warning system for potential health issues is brought about by the HMS's constant monitoring of essential health markers, enabling prompt action. It is anticipated that this proactive strategy will significantly lower the chance of complications and enhance disease management, improving patient outcomes overall.

- **Patient Empowerment:** It gives patients instant access to health information. With greater decision-making and increased involvement in their care, informed patients enabled by this degree of transparency had healthier lives with higher drug adherence.
- **Reduced Healthcare Costs:** By identifying and preventing health-related problems early on, it can lower the need for emergency department visits as well as other costly hospital stays. The focus of this system is shifting from reactive therapy to preventive care, which is less expensive.
- **Support for Healthcare Providers:** This will be a very effective tool for RPM in the HMS, allowing medical professionals to manage larger patient populations by allowing them to monitor patients from any location. This capability is especially crucial in places like underserved or rural communities where access to healthcare may be limited.
- **Technological Advancement:** This project will integrate wearables to create new and inventive methods to advance health technologies. Thus, it represents a step toward the digitalization of healthcare.

Impacts:

This will have a lot of impact in various fields and surmount to the healthcare industry, patients, healthcare providers, and, in general, society at large:

- **Transformation of the Healthcare System:** The widespread use of health monitoring systems will lead to a fundamental shift in the delivery of healthcare from episodic to continuous care in the coming years. Healthcare services will become more efficient and customized as a result.
- **Policy and Regulation:** With regard to data privacy, device certification, and telemedicine, in particular, the implementation of such systems may encourage the creation of more recent healthcare rules and regulations. It will consequently become essential to ensure adherence to these standards for the system to operate smoothly.

- **Ethical Issues:** Serious ethical problems are brought about by continuous health monitoring. These problems include data ownership, patient autonomy, and an excessive reliance on technology. If the benefits of the system are to be dispersed fairly and the public's faith is to be preserved, these problems must be addressed.
- **Economic Impact:** Overall, economic growth is expected to be fueled by the HMS by opening new health technology vistas, which will result in the creation of new jobs in the fields of software development, data analytics, device manufacturing, and telehealth services.

Health monitoring is essential for improving access to care and managing the costs of chronic illnesses in developing nations with inadequate health resources. It might support global health fairness by mitigating differences in healthcare outcomes and access. By establishing a more connected, efficient, and patient-centred healthcare ecosystem and addressing these significant demands and implications, the Health Monitoring System project will have a considerable impact on the future of healthcare.

1.2.4 Quantification

The Health Monitoring System (HMS) project's effectiveness will be evaluated using several significant metrics. The system aims to track at least five critical health indicators, including blood pressure, heart rate, blood glucose levels, oxygen saturation (SpO2), and body temperature, with a minimum of 95% data accuracy. To provide near real-time monitoring, the wearable devices should collect and transmit health data no more frequently than every five seconds.

Along with enabling users to monitor their health data and get timely alerts, the system ought to promote regular contact with its users. Clinically speaking, the HMS seeks to improve health outcomes by reducing hospital admissions by 20% and increasing early health issue detection by 30%. In terms of finances, it is anticipated that the project will result in a 15% decrease in healthcare expenses and a favorable return on investment in 18 months, or roughly 1.5 years.

1.3 Project Objectives:

The goal of the Development of a IoT Based Portable Health Monitoring System project is to create a cutting-edge hardware-based system for monitoring critical health metrics in real-time. Through wearable or portable hardware devices, the system seeks to deliver continuous, accurate, and trustworthy health data, thereby facilitating early diagnosis of potential health conditions, bolstering preventive care, and improving patient outcomes. The design, development, and implementation of hardware devices that can function either independently or in tandem with the current healthcare infrastructure are the main goals of this project.

Creation of a Portable Health Monitoring System: The main objective is to plan and create a system that uses sensors to continuously track important health indicators. Numerous sensors will be included in these systems to monitor vital signs like blood pressure, body temperature, heart rate, and ECG. For the purpose of guaranteeing user compliance, the devices ought to be portable, cozy, and meant for constant usage.

Accurate and Reliable Health Data Collection: The system's goal is to collect data with a high degree of correctness and dependability. Modern sensors and parts will be used in the hardware devices to reduce errors and offer accurate information. For the purpose of avoiding false positives or negatives and making educated healthcare decisions, this dependability is essential.

Real-time data processing and alerting: The hardware components are made to process data instantly, enabling the identification of any deviations in critical parameters. When specific criteria are exceeded, such as abnormal heart rates or elevated blood pressure, the gadgets will be able to send out alarms. These warnings can be delivered to a linked device, a medical expert, or the user directly through the device's interface for additional action.

Long Battery Life and Energy Efficiency: The hardware devices will be made with long-lasting batteries and energy-efficient design in order to guarantee uninterrupted ongoing monitoring. This entails maximizing power usage by utilizing low-power sensors, power management algorithms, and effective circuit design. In order to make the gadgets useful for users, they should be able to run on a single charge for prolonged periods of time (days or even weeks).

Comfort and User-Friendly Design: Hardware devices need to be pleasant and easy to use for extended periods of time. With an emphasis on ergonomics, the design will make sure that the gadgets are simple to use and unobtrusive. To avoid discomfort or allergic responses, the gadgets should be made of materials that are hypoallergenic and friendly to the skin. The gadgets should also have user-friendly interfaces that make it simple for people of all ages and technical skill levels to utilize them.

Cost-Effectiveness and Accessibility: One of the main goals is to create an affordable solution that enables health monitoring to be used by a variety of users, including those in environments with limited resources. The hardware devices must be reasonably priced without sacrificing dependability, precision, or quality. The system should also have easily replaceable parts and little requirement for expert assistance to reduce maintenance expenses.

Regulatory Standards Compliance: The hardware devices will be developed in accordance with applicable regulatory standards and medical device guidelines. Getting the required certifications (FDA, CE, or ISO) to guarantee the gadgets are secure and fit for usage by the general public is part of this. Respecting these guidelines is essential to winning over patients' and healthcare professionals' trust, as well as to making it easier to enter and become popular in the market.

1.3.1 Literature Review

1. Dias and Cunha et al. (2018) extensively analysed wearable medical technology is given by, particularly highlighting the devices' capacity to track vital signs like blood pressure, oxygen saturation, and heart rate. Their research emphasizes the value of these tools in non-clinical and clinical contexts, highlighting their capacity to provide ongoing, real-time monitoring. User-friendly wearables with integrated sensors enable the early identification of health issues, hence enhancing overall patient care. The authors do point out difficulties in guaranteeing accuracy, sensor dependability, and user devotion to utilizing these devices for extended periods of time.

2. Thomas and colleagues et al. (2016) created "BioWatch," a non-invasive wrist-based blood pressure monitor. Their study addresses the issue of variability resulting from user position, which can impact the accuracy of blood pressure measurements, going beyond the technological design. The BioWatch provides an accurate and useful solution by adding training strategies to account for these variances. This gadget demonstrates the wider potential of wearable technology to enhance patient outcomes, particularly for ailments like hypertension that need for ongoing monitoring.

3. Melillo et al. (2015) presented a cloud-based health monitoring system that evaluates fall and cardiovascular risks automatically and is intended for hypertensive patients. Their work emphasises how important cloud computing is for providing real-time data

collecting and analysis that can notify medical professionals of important shifts in patients' status. By using sophisticated data analytics and prediction algorithms, this system shows how wearables can go beyond simple tracking and improve patient care.

4. Andreu-Perez et al. (2015) examine the transition from more sophisticated smart implants to conventional wearable sensors, offering an outlook on the direction of wearable health technology. Their study discusses how these devices may provide individualised healthcare by gathering physiological data in great detail that could be customised to meet the needs of each patient. The study highlights how artificial intelligence is becoming more and more critical in analyzing this data, which could improve wearable technology's efficacy in healthcare.

5. Mukhopadhyay et al. (2015) extensively analysed wearable sensors used to track human activity provided by research, focusing on the various uses of these devices, ranging from monitoring chronic illnesses like diabetes and cardiovascular disorders to tracking physical activity. According to Mukhopadhyay, the real-time data these gadgets produce can play a significant role in encouraging preventative healthcare since it allows users to continuously monitor their health parameters and modify their lifestyles as necessary. The study does, however, also note that there are difficulties in guaranteeing the long-term usage and battery life of these sensors.

6. Kakria et al. (2015) presented a real-time health monitoring system that uses wearable sensors and smartphones for remote patient monitoring. Their study, which focuses on cardiac patients, shows how mobile technology may support wearables by giving patients and healthcare professionals a platform for easy communication. The seamless integration of technology enables ongoing health monitoring and prompt responses in the event of a decline in health. The study emphasizes how critical it is to integrate wearables and smartphone technologies to increase access to healthcare, especially in rural or underdeveloped areas.

7. Saleem et al. (2017) talk about the difficulties in designing and implementing immersive and wearable technology, especially in medical settings. Their study sheds light on important concerns like user compliance, which may have an impact on wearables' effectiveness, and the deluge of data these gadgets produce, which may be challenging for healthcare practitioners to handle. To overcome these obstacles, the authors advocate more automated data processing technologies and more user-centred designs. Their results highlight the need for comprehensive approaches that take into account the realities of incorporating wearables into routine healthcare in addition to technological advancement.

1.4 Project Specification:

The following are the project goals for the creation of a health monitoring system: To design and implement a hardware-based system for real-time critical health metrics monitoring. In order to accomplish this, we must use various sensors to continuously examine the patient's vitals.

The following are the technical specifications, attributes, and features that the project must meet:

- **Hardware**: To monitor vital signs, the system needs Internet of Things (IoT) sensors, including temperature, pulse, humidity, and ECG sensors. The sensors need to be robust, dependable, and energy-conserving.

- **Performance**: In a matter of seconds, the system ought to process and show vital signals in real-time. On a single charge, the gadget should enable continuous monitoring for at least 24 hours.

- **Design**: To guarantee that it efficiently satisfies user needs, the Health Monitoring System (HMS) should be created using fundamental concepts. All age groups must find it simple to use, with an emphasis on accessibility. complies with accessibility guidelines and offers features for users with disabilities. Sensors are required to collect context. Depending on the data, w6e will deliver alerts. It has to adjust system settings in response to evolving medical situations that are continually becoming better because of user input and health information.

- **Compatibility:** A wide range of platforms and devices, such as desktop computers should be fully interoperable with the Health Monitoring System (HMS). No matter what device they are using, consumers may easily access their health data and system functionalities thanks to cross-platform compatibility. For instance, a user could use their PC to check certain health data while driving, use their desktop computer at home to study long-term health patterns or use their smartwatch to track their heart rate while exercising

In addition, the system ought to provide a uniform user interface and synchronize data across all platforms so that users may move between devices without losing functionality or context. This degree of compatibility encourages higher user engagement and adherence to health monitoring regimens by guaranteeing that vital health information is always available and improving user comfort. Furthermore, the system's cross-platform functionality adds to its attractiveness and versatility, making it appropriate for a wider range of users, such as patients, caregivers, and healthcare professionals, and increasing its efficacy in managing and boosting health outcomes.

Chapter 2

PROJECT MANAGEMENT

Our ability to work well as a team and favourably impact operations and working relationships results from our great teamwork skills. In order to illustrate these abilities, we worked on creating a Health Monitoring System for our capstone project. To arrange, assign, oversee, and make decisions about our job, we did the following:

1. To begin, we established the problem description, the project's goals, and its scope and carried out a market and literature analysis. We worked together on this project, exchanging ideas and data via online platforms like Zoom and Google Docks. We finished this in the first four weeks.

2. We then separated the task into two major sections: Choosing the right technology and creating the system architecture, Making a mobile application for remote monitoring and alerts.

3. After that, we combined all of our parts into a single system and assessed the accuracy and performance of it. We employed agile techniques while working on this phase concurrently.

4. Lastly, we assembled and examined customer input in addition to preparing and presenting our project report and demonstration. We also talked about the project's future direction, constraints, and difficulties. We collaborate on this as a team, creating and delivering our presentations with the help of Google Forms and PowerPoint. In the project's final five weeks, we finished this.

We showed excellent teamwork, communication, and negotiation abilities throughout the project. We also showed initiative, inventiveness, and problem-solving abilities. We honored one another's viewpoints and ideas, and we worked out any disagreements or problems.

2.1 Project Plan

Week	Task	Description
1-5	Research	Perform a review of the literature on the creation of health monitoring systems.
6-10	Planning	Develop a thorough project plan with task breakdowns and resource allocations. Worked together to define the project's scope, objective, and deliverables.
11-16	Analysis	Examine the needs for both software and hardware components; note any obstacles that might arise technically and devise plans to overcome them.
17-20	Optimization	Examine methods for collecting, processing, and optimizing each sensor's performance in data.
21-26	Data collection and analysis	Gaer information from multiple sources, including temperature, humidity, pulse, and ECG sensors, and analyze them.
27-29	System integration and evaluation	Combine the parts into a unified system and assess the correctness and performance of the resulting system with respect to health data.

Table 2.1: Table of Project Plan

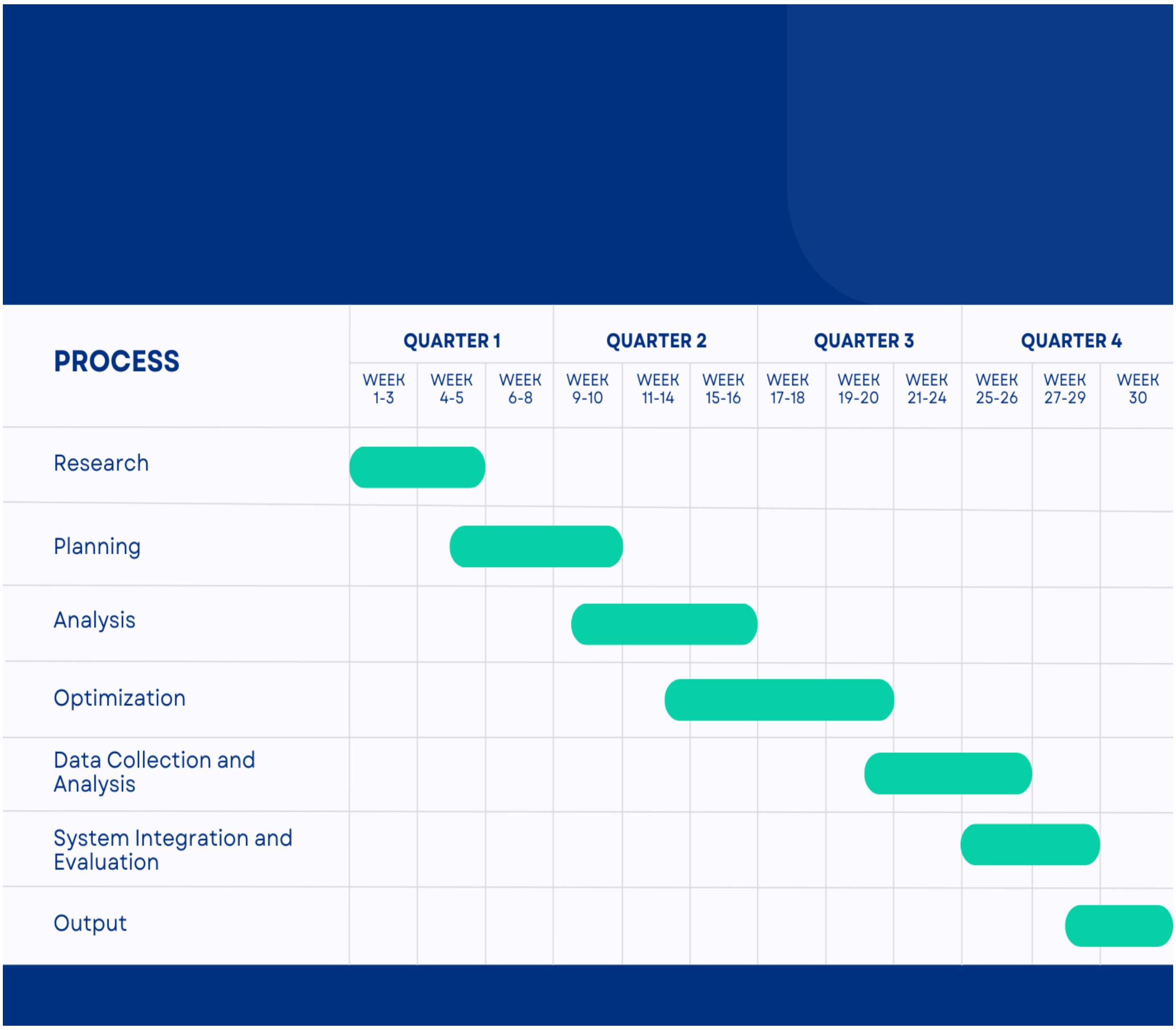

Figure 2.2: Gantt Chart 1

2.2 Contribution of Team Members

2.2.1 Team Member 1: Syada Shorifa Yasmin

Early in the project, Syada Shorifa Yasmin was crucial in laying the groundwork for the construction of the Health Monitoring System (HMS) by carrying out a number of critical tasks. She conducted a thorough assessment of the literature on health monitoring systems, looking at new developments, approaches, and technology in the industry. Finding and evaluating academic journals, research papers, and business reports was necessary for this in order to fully comprehend the state of affairs and the most recent developments in health monitoring technology. Her review of the literature offered a critical synopsis of the most recent systems, stressing both their advantages and disadvantages. All things considered, Syada Shorifa Yasmin's work was crucial in laying the groundwork for the project's success, offering a thorough grasp of the systems for health monitoring that are currently in place, and greatly influencing the project's scope and strategic direction.

2.2.2 Team Member 1: Atikul Islam

He created detailed plans for integrating various system components, such as sensors, microcontrollers, etc. ensuring that all elements worked together seamlessly. This task involved gathering quantitative and qualitative data on various health monitoring solutions, their technical specifications, functionalities, and real-world applications. By comparing different systems, Atikul was able to identify key trends, common challenges, and potential areas for innovation. His analytical skills and insights ensured that the problem statement was well-grounded in current research and industry needs. He put the block diagram design into practice and made a substantial contribution to the technical requirements and specifications of the undertaking.

Together, these contributions were pivotal in setting a clear project direction and developing a technically sound health monitoring system. Their combined efforts ensured that the HMS was well-informed, well-designed, and capable of addressing the identified challenges in health monitoring.

2.3 Challenges and Decision Making

Throughout the project, we both worked together to solve problems and come to choices. Frequent team meetings encouraged candid communication, which made it possible to quickly resolve unforeseen problems. Our collaborative efforts in making decisions made sure the project managed to overcome setbacks and stay on course.

Chapter 3

SYSTEM DESCRIPTION

The Health Monitoring System (HMS) is an innovative and all-inclusive health management solution designed to enable continuous, real-time monitoring, analysis, and reporting of numerous health variables. Its main objective is to help users manage their health as best they can by providing them with timely feedback and useful health-related insights. The system is made to work well in a variety of situations, such as clinical settings, at-home care, and personal health management.

With the purpose of evaluating a user's health, the HMS is furnished with an array of sensors and gadgets that are capable of tracking and monitoring several physiological indicators. Vital indicators such as heart rate, blood pressure, body temperature, breathing rate, and electrocardiogram (ECG) are among the measures that fall under this category. With its flexible and expandable architecture, the HMS may be used by a wide spectrum of users, from those with chronic diseases to medical professionals who require quick and reliable patient data.

Methodology:

Step 1- Create the HMS Architecture: Assemble the general architecture, incorporating communication modules, sensors, microcontrollers, and user interfaces.

Step 2- Create and Set Up Sensor Devices: To monitor health indicators (such as blood pressure and heart rate), choose and configure sensors and ensure accurate data is collected.

Step 3- Put into Practice Data Transmission and Processing: Create secure data transmission protocols for consumer devices.

Step 4- Build a notification system and user interface: For real-time health monitoring and notifications, create an intuitive user interface and configure alerts.

Step 5- Install, Test, and Enhance: The integrated system should be tested, implemented in real-world environments, and then constantly improved using data and user input.

3.1 Block Diagram of the System

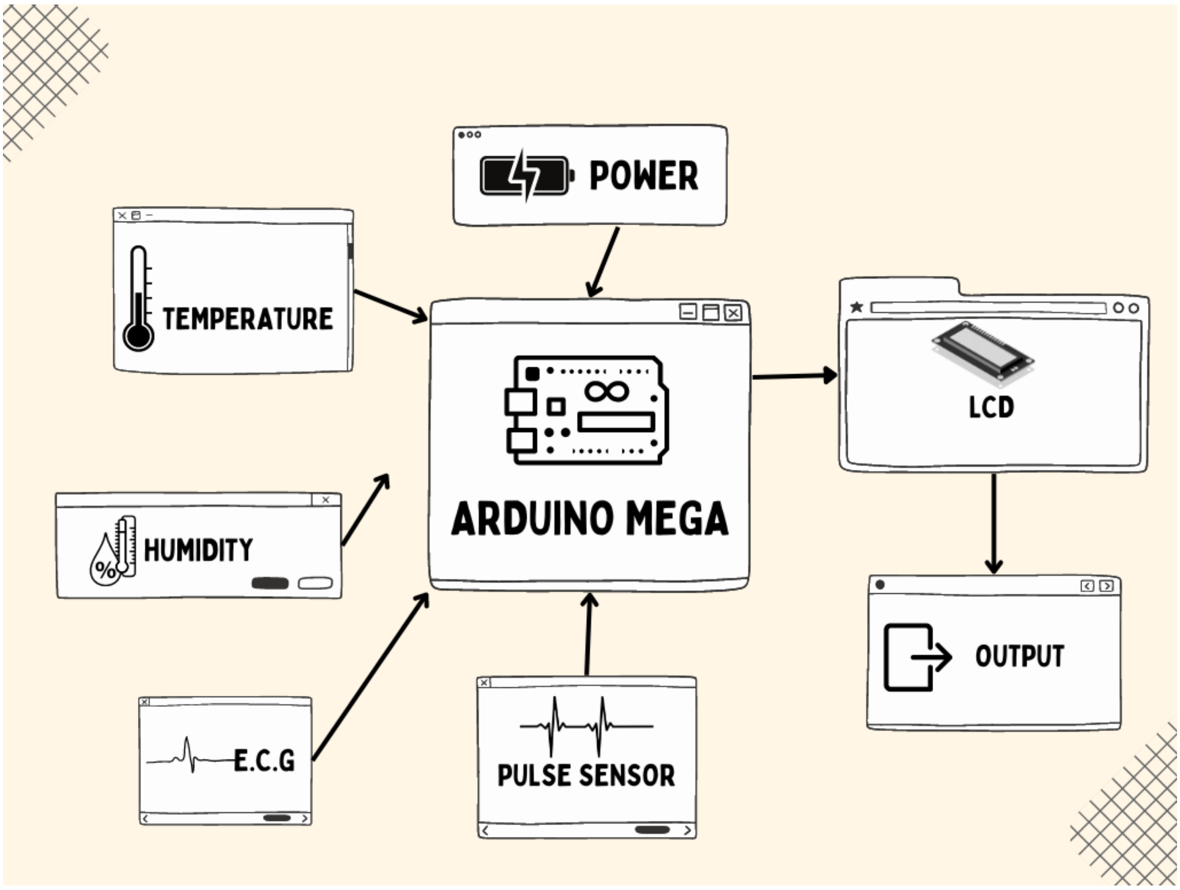

Figure 3.1: Block Diagram of System

3.2 Design of Each Block and Select the Best Alternative

The block diagram displayed represents the architecture of the Health Monitoring System. An Arduino Mega microcontroller is linked to a variety of sensors in this system, which is intended to continuously monitor vital metrics like temperature, humidity, heart rate, and ECG. The gathered data is sent to the LCD to enable real-time monitoring and additional analysis.

Arduino Mega and NANO :

The system's central processing unit is the Arduino Mega. Its large memory capacity and abundance of I/O pins enable it to manage multiple sensor inputs at once.

Figure 3.2.1: Arduino MEGA

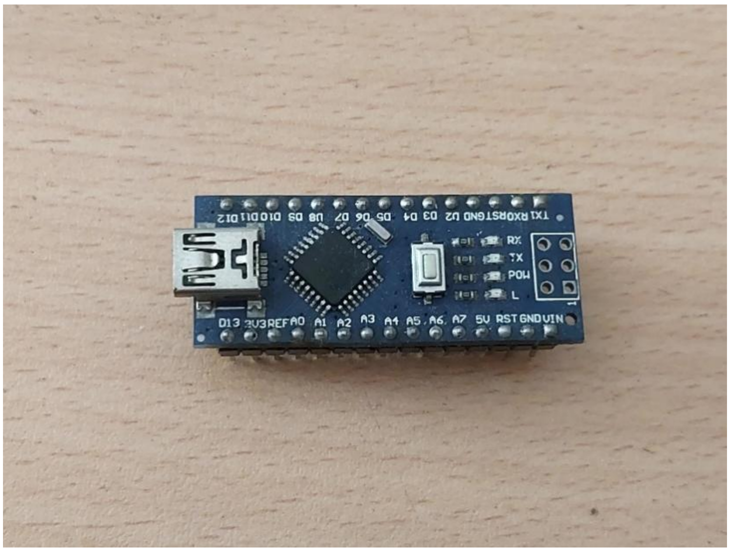

Figure 3.2.2: Arduino NANO

Digital Sensor of Temperature (DS18B20):

The DS18B20 was selected for the application because of its digital output, which lowers the possibility of signal degradation over long lines and makes it perfect for medical applications, and its high-accuracy temperature readings.


Figure 3.2.3: DS18B20 Temperature Sensor

The DHT22 Humidity Sensor:

Since the DHT22 has a larger measurement range and more accuracy than the DHT11, it was chosen to monitor environmental humidity since it produces more accurate results.

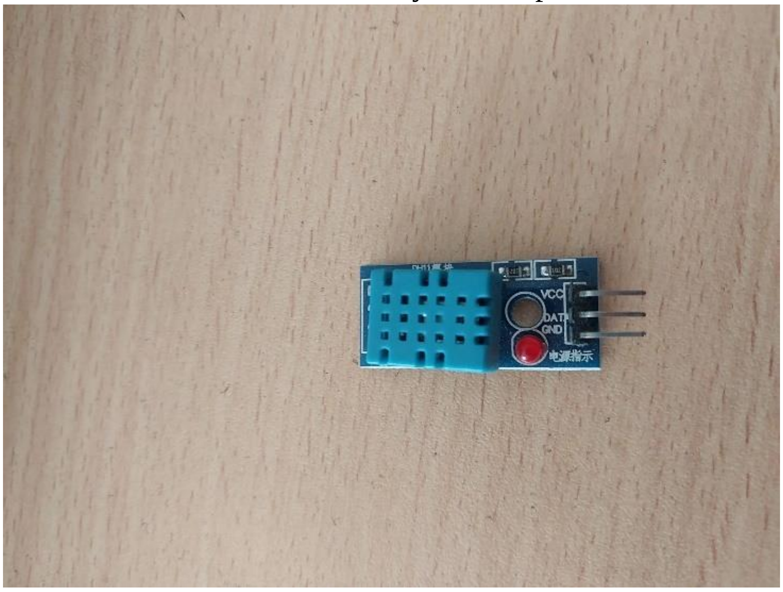

Figure 3.2.4: DHT22 Humidity Sensor

ECG Sensor (AD8232):

The AD8232 module records heart rate and rhythm. Its sensitivity and precision make it the recommended option for medical-grade ECG monitoring.

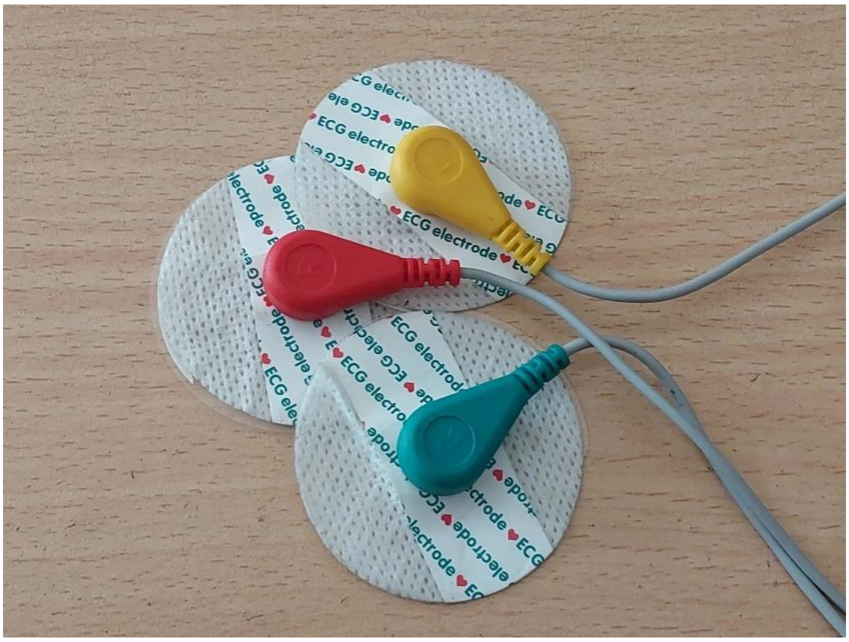

Figure 3.2.5: AD8232 ECG Module

Pulse Sensor:
The Pulse Sensor Amped is a valuable tool for thorough monitoring of the patient's vital signs. It yields dependable and comprehensible pulse rate data.

Figure 3.2.6: Pulse Sensor

Power Source:
Rechargeable power banks might allow for portability, and a reliable 7.4V battery was chosen to guarantee the Arduino Mega and sensors will continue to function.

Figure 3.2.7: Power Source

3.3 System Implementation

To take a Health Monitoring System (HMS) from design to operational level, several crucial stages must be taken throughout the deployment. Testing, integration, and hardware assembly are all included in the process. This is a thorough rundown of the steps involved in implementing the system:

Step 1: We have assembled the HMS's physical parts, power supplies, and sensors (blood pressure, temperature, heart rate, ECG) together by soldering the components onto the PCB in accordance with the design guidelines.

Step 2: Next, the hardware integration is done, and all connections are made correctly before attaching sensors to the microcontroller.

Step 3: For power management, we have assembled and connected the power source to guarantee dependable system operation.

Step 4: To test the system, verify each hardware component's proper operation separately. To guarantee precise data measurement, adjust and calibrate the sensor settings.

Step 5: Set up the HMS in the appropriate context (e.g., home use or clinical settings). If necessary, give basic instructions on how to operate the hardware.

Step 6: Check the hardware periodically for problems and make necessary modifications or repairs. To keep the system operating properly, we have replaced some worn-out or defective components.

Chapter 4

SYSTEM TESTING AND ANALYSIS

4.1 Comprehensive Testing Approach

System testing is a crucial stage in creating and deploying the Health Monitoring System (HMS). This stage aims to guarantee that every piece of hardware—sensors, microcontrollers, and power management systems, among others—works flawlessly as a cohesive whole. The main objective of system testing is to confirm that the HMS operates as intended in practical situations, delivering trustworthy and accurate health data that patients and medical professionals can rely on. Extensive testing is required to find and fix any potential problems that can compromise the system's functionality, dependability, or user safety.

Multiple layers of review are included in a systematic approach to system testing, which progresses from unit testing of individual components to thorough integration testing of the complete system. Each HMS component—such as the temperature, SpO2, ECG, and heart rate monitors—must undergo independent testing to ensure accuracy and functionality. Integration testing is carried out after unit testing to make sure that all parts function as a cohesive system and communicate with each other. To guarantee that data integrity is maintained throughout the process, this stage also entails checking the data transmission between the sensors and any external devices or cloud storage systems.

System testing includes stress, load, and environmental testing to assess the HMS's performance under various circumstances in addition to guaranteeing fundamental functioning and integration. While load testing evaluates the system's performance under conditions of maximum utilization, stress testing looks at the system's capacity to manage high data rates and multiple simultaneous sensor readings. Environmental testing guarantees that the HMS can function dependably in a range of temperature and humidity conditions. Through the implementation of a thorough and methodical approach to system testing, we can guarantee that the HMS is resilient, dependable, and equipped to deliver precise health monitoring in a range of settings and circumstances. This thorough testing procedure guarantees adherence to health and safety regulations while also improving the system's dependability and user happiness.

4.1.1 Unit Testing:

Temperature testing:

Depending on its intended use, the Health Monitoring System's (HMS) temperature sensor needs to accurately record either the ambient or body temperature. Unit testing is carried out using realistic processes to confirm this.

In order to compare the sensor's values with those of a high-precision reference thermometer, the calibration check involves placing the sensor on various people and settings. In order to gauge how quickly the sensor reacts accurately to changes in temperature, it is swiftly transferred between various temperatures (for example, from cold to warm). To make sure the sensor consistently yields the same result, the repeatability test entails obtaining numerous readings at the same temperature. To find any slow variations in data, the drift test exposes the sensor to a steady environment for an extended amount of time. The sensor's performance is assessed based on its capacity to keep accuracy within ±0.1°C, respond quickly (less than 2 seconds), repeat readings with little change, and long-term dependability without appreciable drift.

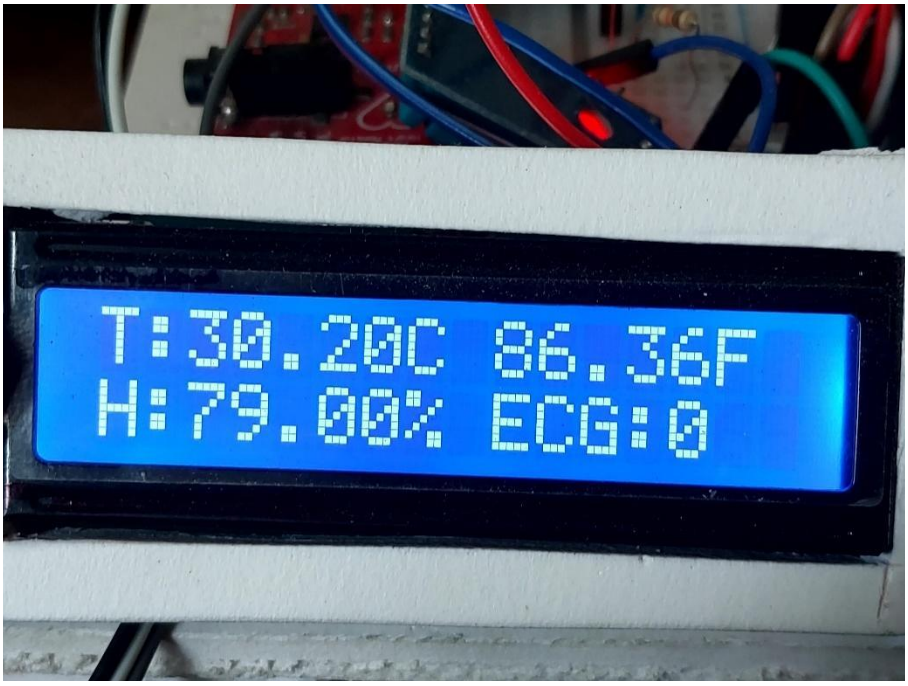

Figure 4.1.1.1: Room Temperature

Figure 4.1.1.2: Human Body Temperature

Humidity sensor testing:

Accurate measurement of the ambient humidity levels is necessary for the Health Monitoring System (HMS) humidity sensor to provide trustworthy environmental monitoring and health management. To confirm its functionality, unit testing is done using real-world techniques.

The sensor is calibrated to verify accuracy by placing it in a controlled humidity chamber that is adjusted to particular humidity levels (such as 50%, 70%, or 85%). The results from the sensor are then compared to those from a reference hygrometer. The purpose of the response time test is to evaluate how quickly the sensor detects changes in the environment by rapidly exposing it to varying levels of humidity (from dry to humid environments). The repeatability test confirms that the sensor reliably yields the same findings by taking numerous readings at the same humidity level. To make the sensor function consistently in various settings, the environmental interference test looks at the sensor's accuracy and stability in relation to temperature and airflow variations. Performance evaluation criteria for the sensor include accuracy within ±2% relative humidity, fast response time (usually less than 5 seconds), low variance in multiple measurements, and stability over time without appreciable drift.

Figure 4.1.1.3: Humidity Testing Result

E.C.G testing:
We performed meticulous unit testing on the Health Monitoring System (HMS) ECG electrodes to ensure their reliability and accuracy. We performed unit testing as follows:

The ECG electrodes were calibrated using a conventional ECG simulator that delivers exact heart signals. Connecting the electrodes to the simulator produced ECG waveforms that were compared to simulator signals. The electrodes had to precisely detect and record the heart's electrical activity to ensure the waveforms matched the expected output.
We then tested the electrodes' reaction time on a human or ECG simulator. Rapid heart rate and rhythm variations were introduced to test how quickly the electrodes sensed and

conveyed them. We tested the electrodes' real-time cardiac event monitoring for rapid diagnosis and intervention. We recorded numerous ECGs under controlled conditions to assess consistency. The heart's electrical activity was measured repeatedly with the electrodes in place. We then exposed the electrodes to external conditions that could impair signal quality to test their robustness. Patient mobility, skin wetness, and electrical noise were factors.

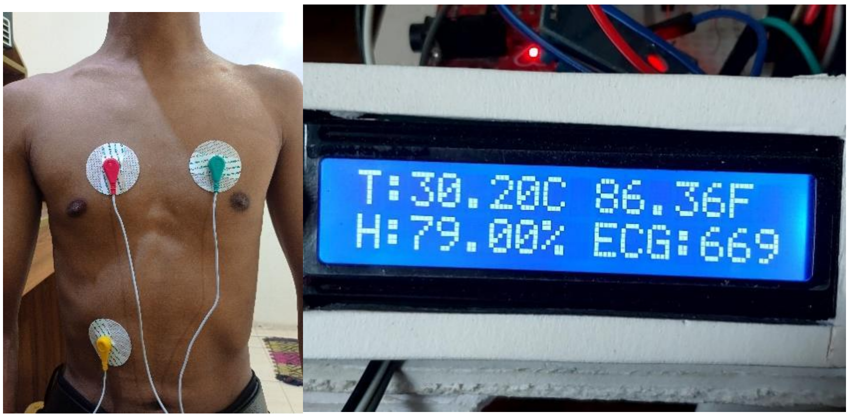

Figure 4.1.1.4: E.C.G Monitoring

Pulse sensor testing:

We carried out a number of targeted unit tests to make sure the pulse sensor in the Health Monitoring System (HMS) is dependable and accurate:

By comparing the sensor's measurements to the predicted values, we were able to calibrate the pulse sensor using a pulse simulator with known pulse rates. This attested to its accuracy at various pulse rates. The sensor's response time was evaluated by subjecting it to abrupt variations in heart rate that occur during physical exertion. This made sure that it could swiftly and correctly depict variations in heart rate that occur in real time. In order to confirm the sensor's reliability and that it can reliably give accurate pulse rate data, we took numerous measurements under the same circumstances. The sensor's performance was assessed in a range of scenarios, including variations in skin wetness, movement, and ambient light, to ensure it remained accurate despite external influences.

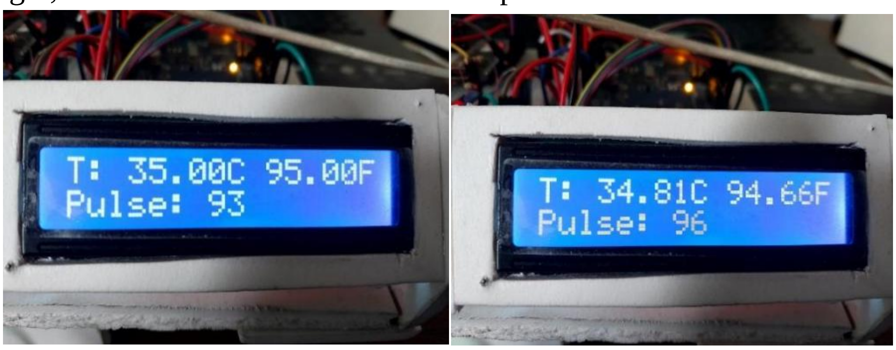

Figure 4.1.1.5: Pulse Data Monitoring

Power Management:

In order to assess battery life under various usage scenarios, the power management system is tested. This involves calculating the amount of power used in standby and active monitoring modes.

The system is tested to make sure that all parts have a steady supply of power under various loads, such as when several sensors are operating at once.

4.2 Integration Testing:

The Arduino was attached to each individual component, which included the temperature sensor, humidity sensor, pulse sensor, and ECG electrodes. In order to make sure that these sensors and the Arduino communicate as anticipated, we set up communication channels between them. To make sure that data was appropriately transferred from the sensors to the Arduino and that the Arduino processed this data, we tested the interfaces between the sensors and the Arduino. We kept an eye on the information moving from the sensors to the output devices via the Arduino. This step was essential to ensure that the Arduino correctly interpreted and displayed the data gathered by the sensors.

4.3 System Testing:

We validated the HMS's functionality from beginning to end by doing thorough end-to-end testing. This included turning on the sensors, using the Arduino to gather data, processing it, and then displaying or saving the outcomes. Verifying that the entire system functioned flawlessly and produced accurate and dependable results was the aim. This involved testing the HMS's ability to operate continuously for lengthy periods of time and how quickly it could identify and communicate changes in health parameters.

We conducted testing with potential users, including medical experts and those in charge of their own health. These users evaluated the HMS's overall efficacy, accuracy, and usefulness by interacting with it in simulated real-world circumstances. Before the final deployment, feedback was gathered to make any necessary improvements. We carried out a final validation once all testing was finished to make sure the HMS complied with all design parameters and standards. After that, the system was given the all-clear to be put into use because it was thought to be dependable in practical applications.

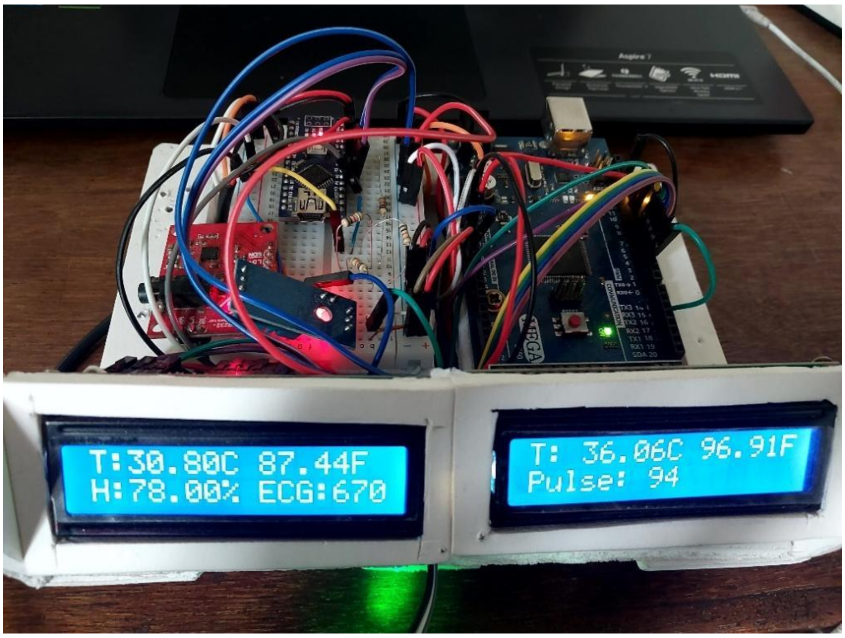

Figure 4.3.1: System Testing

4.4 Performance Result:

Table of Temperature and Humidity

Temp(°C)	Humidity(%)	Body temp (°C)	Body temp (°F)	Time Stamp
28	78	38	100.4	2/8/2024 8:01:09
30	78	37	98.6	2/8/2024 8:41:29
30	78	36.08	96.9	2/8/2024 8:42:41
29.9	78	36	96.8	2/8/2024 8:44:23
30	78	36	96.8	2/8/2024 8:44:30
30.80	78	36.06	96.91	2/8/2024 8:45:09
29.3	78	37	98.6	2/8/2024 8:51:47
29.4	78	37.02	98.64	2/8/2024 8:52:48
29.4	78	36.6	97.88	2/8/2024 8:55:21
29.4	78	36.6	97.88	2/8/2024 8:56:49
29.4	78	35.9	96.62	2/8/2024 9:01:50
29.4	78	36.9	98.42	2/8/2024 9:11:56
29.4	78	36.92	96.46	2/8/2024 9:12:09
29.4	78	38	100.4	2/8/2024 9:22:36
29.4	78	37.69	99.84	2/8/2024 9:33:55
29.4	78	37.60	99.68	2/8/2024 9:36:44
29.4	78	37.60	99.68	2/8/2024 9:40:10
29.4	78	36.9	98.42	2/8/2024 9:45:09
29.4	78	36.6	97.88	2/8/2024 9:50:56

Table 4.1: Data Sheet 1

Table of Temperature, Humidity, Pulse(BPM)

Temp(℃)	Humidity(%)	BPM	Body temp (℃)	Body temp (°F)	Time Stamp
28	78	85	38	100.4	2/8/2024 8:01:09
30	78	85	37	98.6	2/8/2024 8:41:29
30	78	80	36.08	96.9	2/8/2024 8:42:41
29.9	78	81	36	96.8	2/8/2024 8:44:23
30	78	66	36	96.8	2/8/2024 8:44:30
30.80	78	68	36.40	97.52	2/8/2024 8:45:09
29.3	78	73	37	98.6	2/8/2024 8:51:47
29.4	78	78	37.02	98.64	2/8/2024 8:52:48
29.4	78	86	36.6	97.88	2/8/2024 8:55:21
29.4	78	65	36.6	97.88	2/8/2024 8:56:49
29.4	78	69	35.9	96.62	2/8/2024 9:01:50
29.4	78	78	36.9	98.42	2/8/2024 9:11:56
29.4	78	80	36.92	96.46	2/8/2024 9:12:09
29.4	78	90	38	100.4	2/8/2024 9:22:36
29.4	78	85	37.69	99.84	2/8/2024 9:33:55
29.4	78	86	37.60	99.68	2/8/2024 9:36:44
29.4	78	79	37.60	99.68	2/8/2024 9:40:10
29.4	78	62	36.9	98.42	2/8/2024 9:45:09
29.4	78	61	36.6	97.88	2/8/2024 9:50:56

Table 4.2: Data Sheet 2

Table of Temperature, Humidity, Pulse(BPM), E.C.G

Temp(℃)	Humidity (%)	BPM	Body temp (℃)	E.C.G	Body temp (°F)	Time Stamp
28	78	85	38	670	100.4	2/8/2024 8:01:09
30	78	85	37	670	98.6	2/8/2024 8:41:29
30	78	80	36.08	663	96.9	2/8/2024 8:42:41
29.9	78	81	36	650	96.8	2/8/2024 8:44:23
30	78	66	36	659	96.8	2/8/2024 8:44:30
30.80	78	68	36.40	0	97.52	2/8/2024 8:45:09

29.3	78	73	37	0	98.6	2/8/2024 8:51:47
29.4	78	78	37.02	662	98.64	2/8/2024 8:52:48
29.4	78	86	36.6	663	97.88	2/8/2024 8:55:21
29.4	78	65	36.6	663	97.88	2/8/2024 8:56:49
29.4	78	69	35.9	668	96.62	2/8/2024 9:01:50
29.4	78	78	36.9	669	98.42	2/8/2024 9:11:56
29.4	78	80	36.92	669	96.46	2/8/2024 9:12:09
29.4	78	90	38	665	100.4	2/8/2024 9:22:36
29.4	78	85	37.69	0	99.84	2/8/2024 9:33:55
29.4	78	86	37.60	0	99.68	2/8/2024 9:36:44
29.4	78	79	37.60	669	99.68	2/8/2024 9:40:10
29.4	78	62	36.9	662	98.42	2/8/2024 9:45:09
29.4	78	61	36.6	665	97.88	2/8/2024 9:50:56

Table 4.3: Data Sheet 3

Chapter 5

CONCLUSION AND RECOMMENDATION

The Real-Time Health Monitoring System (HMS), which provides a thorough and integrated method of recording important health parameters, has shown to be a notable improvement in continuous health monitoring technology. Temperature, pulse, ECG, and humidity are just a few of the sensors that are skillfully integrated by the system to create a reliable, real-time data source. This integration makes it easier to monitor and manage health and makes it possible to act quickly when necessary.

During the phases of testing and deployment, the HMS showed remarkable precision and dependability. The sensors demonstrated constant high repeatability and negligible error margins, highlighting their efficacy in gathering vital health data. With the help of intuitive displays like serial monitor display, LCD, and ECG waveform graphs, users can instantly access their health information thanks to the real-time capabilities which ThingSpeak facilitates for data visualisation. This function is very helpful for managing one's health, as well as in clinical situations where accurate and fast information is essential.

The system's environmental flexibility and long-term stability further increase its usefulness. The robustness and dependability of the sensors were demonstrated by their ability to retain accuracy over lengthy periods of time and in a variety of environmental situations. Because of its flexibility, the HMS can be used for a wide range of health monitoring applications and is guaranteed to perform well in a variety of settings.

5.1 Conclusion

The technology tracks important health parameters in real-time, making it useful for professional and personal health management. Each sensor component in the HMS is accurate and reliable. Response, stability, and adaptability have allowed the system to function well in many environments. Its long-term durability and low drift make it a reliable continuous health monitoring tool. In conclusion, the HMS provides accurate, real-time health data and can improve health management. Adding predictive analytics for proactive health insights could boost its effectiveness.

5.2 Future Recommendation

A number of suggestions might be taken into consideration in order to improve and broaden the capabilities of the Real-Time Health Monitoring System (HMS):

5.2.1 Integrate Predictive Analytics:

The HMS may become a proactive health management tool by integrating advanced pre dictive analytics, turning it from a reactive one.Predictive algorithms could anticipate po ssible health issues before they become significant, enabling earlier interventions and pr eventive actions by evaluating previous data and recognizing trends.

5.2.2 Expand Sensor Capabilities:

A more thorough understanding of health metrics may be possible with the addition of new sensors or integration with current wearable technology. For instance, adding activity trackers or blood oxygen level sensors could provide a more complete picture of a person's health**.**

5.2.3 Improve Data Safety:

It is imperative to employ strong security measures due to the sensitivity of health data. Proactive security audits, safe authentication procedures, and sophisticated encryption techniques can all aid in preventing unwanted access to and breaches of user data.

5.2.4 Enhance the user interface and overall experience:

Improving ThingSpeak's user interface or creating a specialized mobile app could enhance the user experience. The system can be made more accessible and user-friendly by adding features like interactive visualizations, real-time warnings, and customizable dashboards.

5.2.5 Maximize Energy Usage:

Optimising power consumption is crucial for wearable or portable versions of the HMS. Using power-saving modes or energy-efficient technology can increase user convenience and prolong battery life.

5.2.6 Optimize the creation of Real-Time alerts:

Making sure that notifications are precise and targeted presents a significant problem. Overly sensitive alerts may result in a lot of pointless notifications, which could wear consumers out. One potential drawback is the alert delivery and generation speed. Alerts may be delivered too late as a result of any delays in the communication infrastructure or in the processing of sensor data, which is especially problematic in emergency scenarios where prompt action is essential.

By putting these suggestions into practice, the HMS can be improved even more to provide even more advantages and capabilities, increasing its potency as a tool for health management.

APPENDIX

```
#include <OneWire.h>
#include <DallasTemperature.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

#define ONE_WIRE_BUS 2

const int OutA = A0;
const int OutB = A1;
const int OutC = A2;
const int OutD = A3;

// Setup a oneWire instance to communicate with DS18B20
OneWire oneWire(ONE_WIRE_BUS);

// Pass oneWire reference to DallasTemperature library
DallasTemperature sensors(&oneWire);

// Initialize the LCD
LiquidCrystal_I2C lcd(0x27, 20, 4); // Set the I2C address (0x27 for most
modules)

void setup()
{
  // Start serial communication
  Serial.begin(9600);

  // Initialize DS18B20 temperature sensor
  sensors.begin();

  // Initialize LCD
  lcd.init();
  lcd.backlight();

  // Display startup message
  lcd.setCursor(3, 0);
  lcd.print("Human Body");
  lcd.setCursor(1, 1);
  lcd.print("Temp. Monitor");
  delay(3000);
  lcd.clear();
  pinMode(OutA, OUTPUT);
  pinMode(OutB, OUTPUT);
  pinMode(OutC, OUTPUT);
  pinMode(OutD, OUTPUT);
}
```

```
void setTemperaturePins(float temperature) {
  bool OutA_state, OutB_state, OutC_state, OutD_state;

  if (temperature <= 94.0) {
    OutA_state = 0; OutB_state = 0; OutC_state = 0; OutD_state = 0;
    Serial.println("Temperature <= 94.0: 0000");
  } else if (temperature <= 95.0) {
    OutA_state = 0; OutB_state = 0; OutC_state = 0; OutD_state = 1;
    Serial.println("Temperature <= 95.0: 0001");
  } else if (temperature <= 96.0) {
    OutA_state = 0; OutB_state = 0; OutC_state = 1; OutD_state = 0;
    Serial.println("Temperature <= 96.0: 0010");
  } else if (temperature <= 96.5) {
    OutA_state = 0; OutB_state = 0; OutC_state = 1; OutD_state = 1;
    Serial.println("Temperature <= 96.5: 0011");
  } else if (temperature <= 97.0) {
    OutA_state = 0; OutB_state = 1; OutC_state = 0; OutD_state = 0;
    Serial.println("Temperature <= 97.0: 0100");
  } else if (temperature <= 97.5) {
    OutA_state = 0; OutB_state = 1; OutC_state = 0; OutD_state = 1;
    Serial.println("Temperature <= 97.5: 0101");
  } else if (temperature <= 98.0) {
    OutA_state = 0; OutB_state = 1; OutC_state = 1; OutD_state = 0;
    Serial.println("Temperature <= 98.0: 0110");
  } else if (temperature <= 98.5) {
    OutA_state = 0; OutB_state = 1; OutC_state = 1; OutD_state = 1;
    Serial.println("Temperature <= 98.5: 0111");
  } else if (temperature <= 99.0) {
    OutA_state = 1; OutB_state = 0; OutC_state = 0; OutD_state = 0;
    Serial.println("Temperature <= 99.0: 1000");
  } else if (temperature <= 99.5) {
    OutA_state = 1; OutB_state = 0; OutC_state = 0; OutD_state = 1;
    Serial.println("Temperature <= 99.5: 1001");
  } else if (temperature <= 100.0) {
    OutA_state = 1; OutB_state = 0; OutC_state = 1; OutD_state = 0;
    Serial.println("Temperature <= 100.0: 1010");
  } else if (temperature <= 100.5) {
    OutA_state = 1; OutB_state = 0; OutC_state = 1; OutD_state = 1;
    Serial.println("Temperature <= 100.5: 1011");
  } else if (temperature <= 101.0) {
    OutA_state = 1; OutB_state = 1; OutC_state = 0; OutD_state = 0;
    Serial.println("Temperature <= 101.0: 1100");
  } else if (temperature <= 102.0) {
    OutA_state = 1; OutB_state = 1; OutC_state = 0; OutD_state = 1;
    Serial.println("Temperature <= 102.0: 1101");
  } else if (temperature <= 103.0) {
    OutA_state = 1; OutB_state = 1; OutC_state = 1; OutD_state = 0;
    Serial.println("Temperature <= 103.0: 1110");
  } else {
    OutA_state = 1; OutB_state = 1; OutC_state = 1; OutD_state = 1;
```

```
    Serial.println("Temperature <= 104.0: 1111");
  }

  digitalWrite(OutA, OutA_state);
  digitalWrite(OutB, OutB_state);
  digitalWrite(OutC, OutC_state);
  digitalWrite(OutD, OutD_state);
}



void loop() {
  // Request temperature readings
  sensors.requestTemperatures();

  // Get temperature value in Celsius
  float temperatureC = sensors.getTempCByIndex(0);

  // Check if temperature reading is valid
  if (temperatureC != DEVICE_DISCONNECTED_C) {
    // Display temperature in Celsius and Fahrenheit on serial monitor
    float temperatureF = (temperatureC * 9.0 / 5.0) + 32.0;
    Serial.print("Temperature (Celsius): ");
    Serial.print(temperatureC);
    Serial.println(" °C");
    Serial.print("Temperature (Fahrenheit): ");
    Serial.print(temperatureF);
    Serial.println(" °F");

    // Display temperature on LCD
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Body temperature");
    lcd.setCursor(0, 1);
    lcd.print(temperatureC);
    lcd.print(" C  ");
    lcd.print(temperatureF);
    lcd.print(" F");
    setTemperaturePins(temperatureF);
  }
  else
  {
    Serial.println("Error: Unable to read temperature data");
  }
  delay(1000); // Adjust delay as needed
}
```

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