MediSense: Intelligent IoT Based Health Monitoring System for Personalized Care

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FINAL YEAR DESIGN PROJECT REPORT

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled **"MediSense: Intelligent IoT Based Health Monitoring System for Personalized"**, submitted by **Mst. Jayana Islam** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on **13 Jan 2025.**

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DECLARATION

I hereby declare that this project has been done by us under the supervision of **Mr. Md. Abbas Ali Khan, Assistant Professor , Department of Computer Science and Engineering, Daffodil International University.** We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

This research project addresses the pressing need for the development of advanced health monitoring systems capable of providing real-time and accurate tracking of vital signs. The primary objective is to design and implement a comprehensive solution that effectively monitors key health parameters such as heart rate, blood oxygen saturation, and body temperature. This project utilizes cutting-edge sensor technology, including the MAX30105 Pulse Oximeter and the MLX90614 Temperature Sensor, integrated with the powerful ESP32 Wroom32s microcontroller. The central focus lies in creating a robust system architecture that seamlessly integrates multiple sensors, ensuring reliable data collection under various conditions. The design process involves meticulous attention to detail in establishing optimal sensor placement, calibration procedures, and signal processing techniques to enhance measurement accuracy. Moreover, the project emphasizes the development of efficient data processing algorithms, leveraging the computational capabilities of the ESP32 microcontroller to analyze sensor data in real-time. Additionally, machine learning algorithms are implemented to detect patterns and anomalies in vital signs, enabling proactive intervention and timely alerts to users or caregivers. The findings of this research highlight the successful implementation of the health monitoring system, demonstrating its effectiveness in providing actionable insights into the user's health status. Through rigorous testing and validation, the system proves to be a valuable tool for early detection of health issues, facilitating personalized healthcare interventions, and ultimately promoting improved health outcomes for individuals.

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CHAPTER 1

Introduction

1.1 Overview

The project aims to integrate the MLX60914 and MAX30105 sensors with an ESP32 microcontroller and transmit data to ThingSpeak, a cloud platform, to create a comprehensive environmental and health monitoring system. Combining advanced sensor technology, microcontroller programming, and IoT connectivity, this project provides real-time data insights crucial for advancing environmental management, healthcare, and IoT applications. The MLX60914 sensor measures body temperature, while the MAX30105 sensor monitors blood oxygen levels and heart rate. The ESP32 microcontroller handles data acquisition and transmission, leveraging ThingSpeak for real-time data analysis. This integration aims to offer a reliable and efficient solution for continuous monitoring of vital signs and environmental conditions, potentially leading to better health outcomes and improved environmental practices. By implementing this system, the project seeks to demonstrate technical proficiency and drive innovation in health and environmental monitoring.

1.2 Background and Present State

The project aims to integrate the MLX60914 and MAX30105 sensors with an ESP32 microcontroller and transmit data to ThingSpeak, a cloud platform, to create a comprehensive environmental and health monitoring system. The MLX60914 sensor, a non-contact infrared temperature sensor, is adept at measuring body temperature, making it invaluable for monitoring fever and other health indicators. The MAX30105 sensor, a versatile pulse oximeter and heart-rate sensor, measures blood oxygen levels and heart rate, providing crucial data for assessing cardiovascular health and respiratory function. The ESP32 microcontroller, known for its robust processing power and integrated Wi-Fi/Bluetooth capabilities, will handle data acquisition and seamless transmission to ThingSpeak. ThingSpeak is an IoT analytics platform that allows for real-time aggregation, visualization, and analysis of data streams. By leveraging these technologies, the project aims to provide real-time data insights, which are essential for advancing environmental management and healthcare applications. This integration offers a reliable and efficient solution for continuous monitoring of vital signs and environmental conditions, potentially leading to better health outcomes through timely medical interventions and improved environmental practices through accurate data-driven decisions. The project's significance extends to demonstrating the potential of IoT in creating smart, connected devices that enhance various aspects of daily life and industrial processes, driving innovation and showcasing technical proficiency in health and environmental monitoring.

1.3 Problem Statement

The problem statement clearly defines the specific issues with traditional health monitoring systems, highlighting their limitations in providing continuous and accurate real-time data. These conventional systems often rely on periodic manual measurements, which can lead to gaps in data and potentially miss critical health events. Moreover, they typically lack the capability to seamlessly integrate with modern IoT platforms, which is essential for remote monitoring and data analysis.

The integration of advanced sensor technologies, such as the MLX60914 for temperature and the MAX30105 for pulse oximetry and heart rate, poses significant technical challenges. These include ensuring the compatibility of sensors with the ESP32 microcontroller, maintaining the reliability and accuracy of data transmission, and addressing potential issues related to power consumption and sensor calibration. Additionally, the project must overcome the complexities of data transmission reliability, as IoT systems often face challenges like network instability, data packet loss, and latency. Ensuring that the system can reliably transmit data to ThingSpeak, a cloud-based IoT analytics platform, requires robust communication protocols and error-handling mechanisms. The problem statement highlights the critical need for a robust, integrated health monitoring system that addresses the limitations of traditional methods, meets the technical challenges of sensor and IoT integration, ensures reliable data transmission, and provides effective real-time data analysis. Such a system has the potential to revolutionize health monitoring, especially in underserved areas, by providing continuous, accurate, and actionable health data.

1.4 Objectives

The primary objectives of the project include:

- Developing a system that integrates the MLX60914 temperature sensor and the MAX30105 pulse oximeter with an ESP32 microcontroller to collect vital health data.

- Transmitting the collected sensor data to ThingSpeak, a cloud platform, for real-time monitoring and analysis, enabling remote health management.

- Demonstrating the effectiveness of the system in providing accurate and reliable health metrics and environmental data, which can be used for various applications such as health monitoring, environmental management, and research purposes.

1.5 Scope and Limitations

The scope of the project involves designing, implementing, and testing an integrated health monitoring system using the MLX60914 temperature sensor, MAX30105 pulse oximeter, and ESP32 microcontroller, encompassing hardware and software development, data transmission, and real-time monitoring capabilities. This includes defining system architecture, selecting components, developing firmware, and configuring ThingSpeak for data visualization. The system will be tested for functionality, calibration, and data validation. Potential limitations include technical challenges in sensor integration, ensuring reliable data transmission, and the need for continuous calibration to maintain accuracy. These challenges underscore areas for future improvement, such as enhancing sensor accuracy, robustness, and scalability, and developing a more user-friendly interface, highlighting the importance of ongoing research and development in this field.

1.6 Report Organization

Chapter 1: Introduction - Provides an overview of the project, its background, objectives, scope, and organization.

Chapter 2: Literature Review - Reviews existing technologies and related works, providing context and justification for the project.

Chapter 3: Methodology/ Requirement Analysis & Design Specification - Details the research methodology, including descriptions of the hardware and software components used, and the implementation process.

Chapter 4: Implementation - Describes the development of the integrated health monitoring system, including hardware integration, firmware development, data transmission setup, and real-time monitoring capabilities.

Chapter 5: Results and Analysis - Discusses the experimental results, including data transmission reliability, sensor accuracy, and system performance.

Chapter 6: Impact on Society, Environment, and Sustainability - Discusses the broader implications of the project, including environmental, ethical, and societal considerations.

Chapter 7: Conclusion and Future Work - Provides a summary of the project, conclusions drawn from the research, and recommendations for future research and improvements.

1.7 Summary

This section introduces the project, which integrates the MLX60914 temperature sensor and MAX30105 pulse oximeter with an ESP32 microcontroller to create a health and environmental monitoring system. It highlights the project's aim to leverage IoT technology by transmitting data to ThingSpeak for real-time monitoring and analysis, addressing the limitations of traditional health monitoring systems. The chapter outlines the project's objectives, including developing a reliable system for collecting and transmitting vital health data and demonstrating its effectiveness. It discusses the scope, covering hardware and software development, data transmission, and real-time monitoring, while noting potential technical challenges and areas for future improvement. The report structure is detailed, covering all aspects from the introduction and literature review to methodology, implementation, results, impact, and future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews existing technologies and related works relevant to the integration of MLX60914 temperature sensors and MAX30105 pulse oximeters with the ESP32 microcontroller for health and environmental monitoring. It provides a context for the project by examining advancements in sensor technology, microcontroller applications, and IoT platforms, highlighting their contributions and limitations.

2.2 Related Works

We found Several research papers on pulse oximeters. Of them, we studied the recent and related works paper to have an idea for the ongoing project activities on Smart Pulse Oximeter with Heart Rate.

W. M. S. bin W. Ibrahim, S. H. binti M. Ashi, N. H. binti Othman, and S.F. binti M. Zukri has designed a device using a microcontroller and sensors. This research is focusing on development the application for the elderly people. They didn't listed the total cost and comparative analysis of cost reduction. They provide experimental data to that of a standard device. The device only measured the SpO2 that is the saturation of oxygen present in our blood and heart rate [1].

J. Wan, Y. Zou, Y. Li, J. Wang has designed and implementation of a reflective-type blood oxygen saturation detection system utilizing the MAX30100 sensor. The reflective method involves placing the sensor on the skin's surface, where it emits light that is reflected back to the sensor after interacting with the blood vessels. By analyzing the intensity of the reflected light, the system can determine the blood oxygen saturation level [2].

M. Hassanalieragh, A. Page, T. Soyata, G. Sharma, M. Aktas, and G. Mateos introduced the concept of IoT in the context of healthcare, emphasizing the potential benefits it offers for health monitoring and management. It highlights the integration of various sensing devices with IoT technology to collect real-time health data. Overall, the paper provides insights into the integration of IoT sensing with cloud-based processing for health monitoring and management, discussing both the opportunities and challenges associated with this approach [3].

V. G. Bangera and V. Dhiman has introduced IoT technology and its potential applications in healthcare, emphasizing the importance of monitoring elderly patients remotely to ensure their well-being and safety. The paper likely discusses the benefits of implementing such a system, such as early detection of health issues, improved patient safety, and reduced healthcare costs. It may also address challenges related to data privacy, security, and the need for interoperability among different IoT devices and platforms. Overall, the paper presents a comprehensive overview of an IoT-based smart health monitoring system tailored for elderly patients, discussing its design, implementation, benefits, and challenges [4].

The paper "IoT Based Health Monitoring System" describes the development of a system to monitor patients' vital signs (heartbeat, temperature) and environmental conditions using IoT technology. It involves sensors to collect data, which is transmitted to a server via Wi-Fi. This allows doctors to access real-time data remotely, facilitating timely diagnosis and treatment. The system aims to improve healthcare efficiency, reduce costs, and is particularly beneficial during health crises like COVID-19.[5]

The paper by Y.E.A. Xie, "Development of wearable pulse oximeter based on internet of things and signal processing techniques," presented at the 2017 European Modelling Symposium (EMS), details the creation of a wearable pulse oximeter integrating IoT and advanced signal processing. This device continuously monitors oxygen saturation and heart rate, transmitting data to healthcare providers for real-time analysis and monitoring. The system aims to enhance patient care by providing accurate, continuous, and remote health monitoring capabilities.[6]

The paper "IoT/Cloud Based Health Monitoring System (Temp., Pulse Rate, SpO2)" by A. e. a. Nandi, presented at the RCC Institute of Information Technology, MAKAUT in 2021, focuses on developing a health monitoring system using IoT and cloud technologies. The system tracks temperature, pulse rate, and SpO2 levels, transmitting data to the cloud for real-time monitoring and analysis. This approach aims to enhance remote healthcare by providing continuous and accurate health metrics accessible to healthcare providers.[7]

The paper "Developing IoT Based Smart Health Monitoring Systems: A Review" by A. e. a. Rahaman, published in Revue d'Intelligence Artificielle, 33.6 (2019), pp. 435-440, provides a comprehensive review of the advancements in IoT-based smart health monitoring systems. It covers various technologies and methodologies used to create systems that monitor health parameters such as heart rate, temperature, and oxygen saturation. The paper highlights the benefits of integrating IoT in healthcare, including improved patient monitoring, enhanced data accuracy, and the potential for remote healthcare delivery.[8]

The paper "IoT Based Smart Healthcare Monitoring Systems: A Review" by D. e. a. Tiwari, presented at the 2021 6th International Conference on Signal Processing, Computing, and Control (ISPCC), provides a comprehensive review of IoT-enabled smart healthcare monitoring systems. It examines the latest developments, technologies, and methodologies used in these systems to monitor various health parameters. The review emphasizes the advantages of IoT in healthcare, such as real-time data collection, remote monitoring, and improved patient care.[9]

The paper "An IoT Based SMART Patient Health Monitoring System" by C. R. G., C. a., P. C. S. B. Srinivasan, published in the Indonesian Journal of Electrical Engineering and Computer Science (vol. 18, no. 3, 2020, pp. 1657-1664), discusses the development of a smart health monitoring system using IoT technology. The system monitors various patient health parameters, providing real-time data to healthcare providers. The objective is to enhance patient care through continuous monitoring and timely intervention, leveraging IoT for improved healthcare outcomes.[10]

The paper "IoT Based Wearable Smart Health Monitoring System" by M. Taştan, published in the Celal Bayar University Journal of Science (vol. 14, no. 3, 2018, pp. 343-350), explores the development and implementation of a wearable health monitoring system utilizing IoT technology. The system is designed to track vital health parameters like heart rate, temperature, and blood oxygen levels, transmitting data in real-time for continuous monitoring and analysis. This approach aims to enhance patient care through improved accessibility and real-time health data.[11]

The paper "IReHMo: An Efficient IoT-Based Remote Health Monitoring System for Smart Regions" by N. M. e. a. Khoi, presented at the 2015 17th International Conference on e-

Health Networking, Application & Services (HealthCom), discusses the development of an IoT-based remote health monitoring system. The system aims to provide efficient and continuous health monitoring for patients in smart regions, leveraging IoT technology to collect, transmit, and analyze health data in real-time. This approach enhances healthcare delivery by enabling remote patient monitoring and timely medical interventions.[12]
The paper "IoT Based Health Monitoring System" outlines a system that monitors patients' vital signs like heartbeat, temperature, and environmental conditions using IoT technology. Data from sensors are sent to a server via Wi-Fi, enabling real-time remote access for healthcare providers to diagnose and monitor patients efficiently. This system aims to enhance healthcare accessibility, reduce costs, and improve remote diagnosis and treatment capabilities.[13]

2.3 Comparison between Existing Works

A review of the existing literature reveals a growing body of research focused on the development and evaluation of smart pulse oximeters with heart rate monitoring capabilities. Studies have investigated various aspects such as sensor accuracy, usability, clinical validation, and integration with telemedicine platforms. Additionally, researchers have explored the potential applications of these devices in diverse populations, including athletes, elderly individuals, and patients with respiratory or cardiovascular conditions.

This literature review aims to provide a comprehensive overview of the current state of research and development in the field of smart pulse oximeters with integrated heart rate monitoring. By synthesizing existing literature, we seek to identify key trends, challenges, and opportunities for future innovation in this rapidly evolving area of wearable health technology.

2.4 Open Issues

Despite advancements in the field, several challenges in IoT-based health monitoring systems remain unresolved, including technical difficulties in sensor calibration, ensuring reliable and continuous data transmission, and managing power consumption in IoT devices. Accurate sensor calibration is essential yet complex, requiring ongoing adjustments to maintain precision. Reliable data transmission is hampered by unstable network connections and data integrity issues. Efficient power management is critical to prolong battery life, often requiring advanced techniques and alternative energy sources. Scalability issues involve handling large data volumes and integrating new devices seamlessly, while user-friendliness encompasses creating intuitive, accessible interfaces and providing adequate training and support. Addressing these challenges necessitates continuous research and development to enhance system robustness and efficiency.

2.5 Summary

The summary synthesizes the findings from the literature review, highlighting gaps and opportunities for innovation. It underscores the importance of addressing identified open issues and leveraging the strengths of existing technologies. This sets the stage for the project's subsequent chapters, which focus on developing a reliable, efficient, and accurate health and environmental monitoring system using advanced sensors and IoT platforms.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter outlines the methodology and design specifications used in developing the MediSense: Intelligent IoT Based Health Monitoring System for Personalized Care. It provides a detailed analysis of the proposed system, hardware and software requirements, project management strategies, and financial considerations. The chapter concludes with a summary of the key points discussed.

3.2 Proposed Methodology

The proposed methodology for the MediSense project involves integrating the MLX60914 temperature sensor and the MAX30105 pulse oximeter with an ESP32 microcontroller to collect vital health data. The system design includes several detailed steps to ensure accurate data collection, processing, and transmission for real-time health monitoring and analysis.

Sensor Integration:

Component	ESP32 Pin	Sensor Pin	Description
MLX60914 Temperature Sensor			
Power (VCC)	3.3V	VCC	Power supply (3.3V)
Ground (GND)	GND	GND	Ground connection
Data (SDA)	GPIO 21	SDA	I2C data line
Clock (SCL)	GPIO 22	SCL	I2C clock line
MAX30105 Pulse Oximeter			
Power (VCC)	3.3V	VCC	Power supply (3.3V)
Ground (GND)	GND	GND	Ground connection
Data (SDA)	GPIO 21	SDA	I2C data line
Clock (SCL)	GPIO 22	SCL	I2C clock line
Pull-up Resistors			

Component	ESP32 Pin	Sensor Pin	Description
Data (SDA)	GPIO 21	SDA (with resistor)	Pull-up resistor to 3.3V on SDA line
Clock (SCL)	GPIO 22	SCL (with resistor)	Pull-up resistor to 3.3V on SCL line

Table 3.2.1: Sensor Intigration Component

Data Collection:

Sensor Configuration: The ESP32 is programmed using the Arduino IDE, with specific libraries for the MLX60914 and MAX30105 sensors. These libraries provide functions to initialize the sensors and configure their settings, such as measurement intervals and sensitivity.

Reading Sensor Data: The ESP32 is programmed to read data from the sensors at regular intervals. For example, it may read temperature data from the MLX60914 every second and pulse oximetry data (including heart rate and blood oxygen levels) from the MAX30105 at a similar frequency. This ensures continuous monitoring of the user's health parameters.

Data Processing:

Processing Stage	Description
Real-Time Processing	
Noise Filtering	The ESP32 filters out noise from the raw sensor readings to ensure data quality.
Averaging Readings	Multiple readings are averaged to improve the accuracy of the sensor data.
Data Conversion	The raw data is converted into meaningful health metrics (e.g., temperature, heart rate, SpO2).
Algorithm Implementation	
SpO2 Calculation	Uses raw infrared (IR) and red light readings from the MAX30105 sensor.
Heart Rate Calculation	Uses the same raw IR and red light readings to determine the heart rate.

Processing Stage	Description
Predefined Formulas	Specific formulas and calibration data are applied to interpret the sensor data.

Table 3.2.2: Data Processing

Data Transmission:

Wi-Fi Configuration: The ESP32's built-in Wi-Fi module is configured to connect to a local Wi-Fi network. This enables the microcontroller to transmit data to the internet.

Sending Data to ThingSpeak: The processed health data is sent to the ThingSpeak cloud platform at regular intervals. This is done using ThingSpeak's API, where the ESP32 makes HTTP requests to upload the data to a designated channel. Each data point is timestamped and stored in the cloud for real-time access and historical analysis.

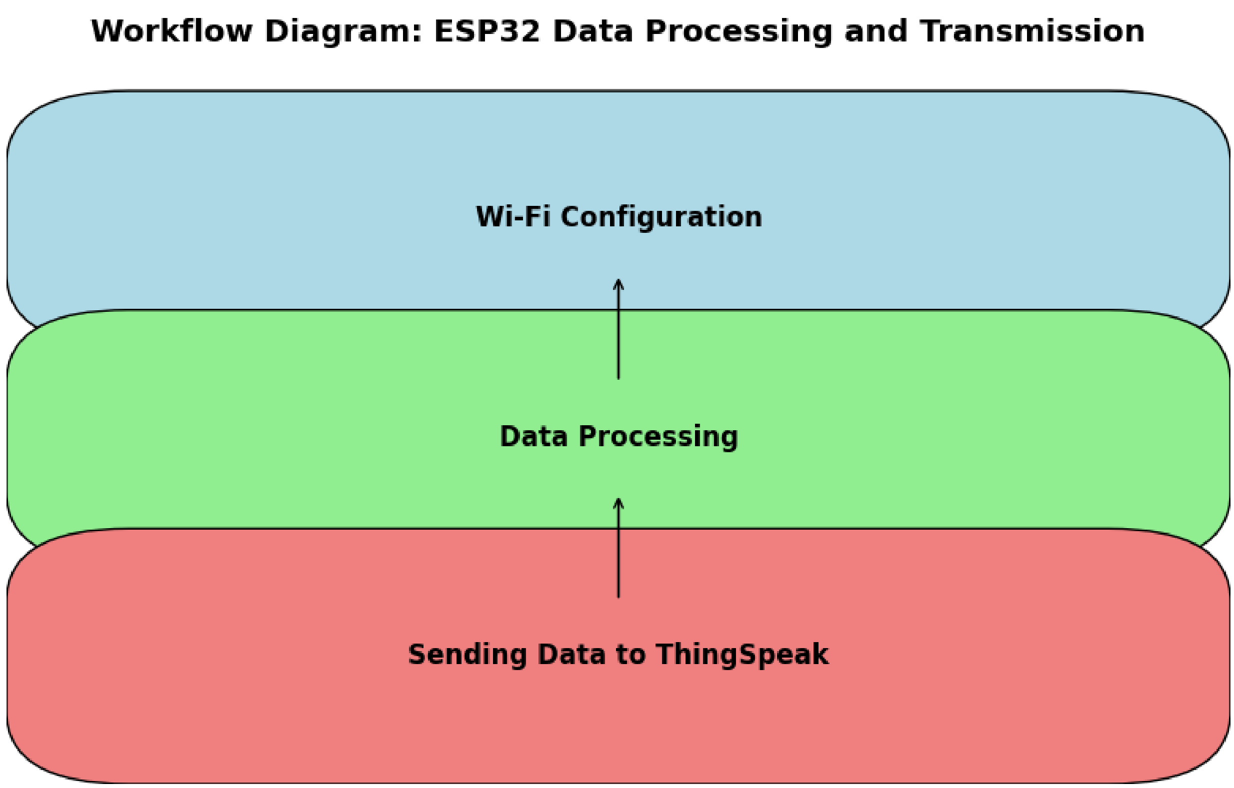


Figure 3.2.1: Workflow Diagram

Data Analysis and Monitoring:

ThingSpeak Integration: ThingSpeak provides tools for data visualization and analysis. The uploaded data can be visualized using ThingSpeak's built-in charts and graphs, allowing users to monitor their health metrics in real-time.

Alert System: Thresholds can be set on ThingSpeak to trigger alerts if certain health metrics go beyond normal ranges. For example, if the SpO2 level drops below a critical value, ThingSpeak can send notifications via email or SMS to the user or healthcare provider.

Data Interpretation: Advanced analysis can be performed on the collected data, such as detecting trends, identifying anomalies, and providing insights into the user's health status. This data can also be exported for further analysis using external tools.

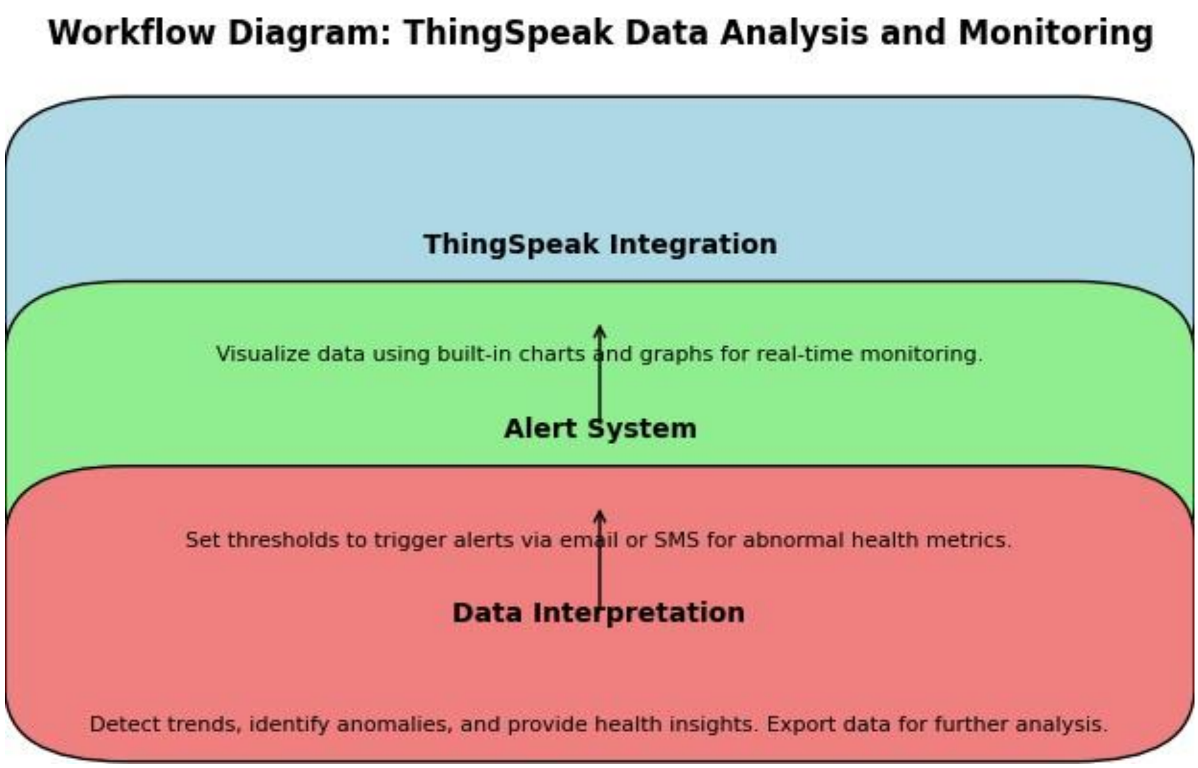


Figure 3.2.2: Workflow Diagram of Data analysis and monitoring

3.3 Hardware/ Software Requirement

Hardware Requirements:

ESP32 Wroom32s Microcontroller:

Overview: The ESP32 is a powerful microcontroller with integrated Wi-Fi and Bluetooth capabilities, making it ideal for IoT applications. It features multiple GPIO pins, ADCs, DACs, and supports various communication protocols like I2C, SPI, and UART.

Role: It serves as the central processing unit for the MediSense system, responsible for reading sensor data, processing it, and transmitting it to the ThingSpeak cloud platform.

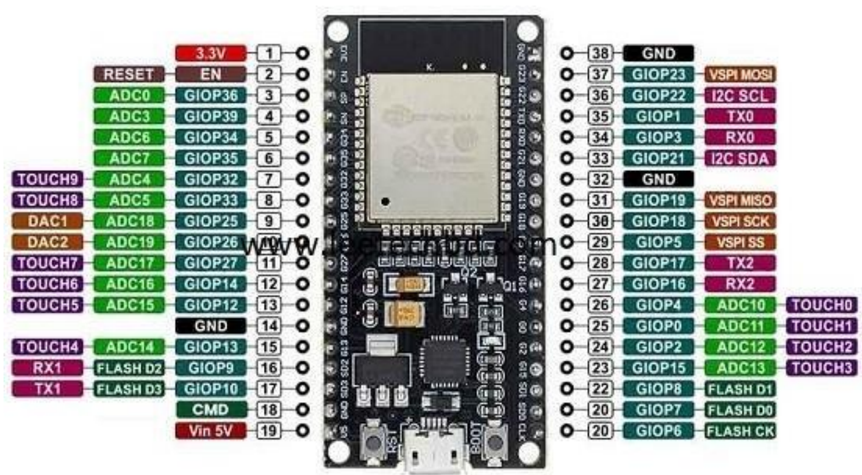


Figure3.3.1: ESP32 Wroom32s development board

MAX30105 Pulse Oximeter Sensor:

Overview: The MAX30105 is a high-sensitivity optical sensor designed for heart rate, SpO2 (blood oxygen saturation), and other bio-sensing applications. It includes integrated LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection.

Role: It measures the user's heart rate and blood oxygen levels, providing critical health data for real-time monitoring and analysis.

Figure3.3.2: MAX30105 Pluse oximeterSensor module

MLX90614 Temperature Sensor:

Overview: The MLX90614 is an infrared thermometer designed for non-contact temperature measurements. It includes a built-in digital signal processor and is capable of measuring both object and ambient temperatures with high accuracy.

Role: It measures the user's body temperature, which is essential for monitoring fever and other health conditions.

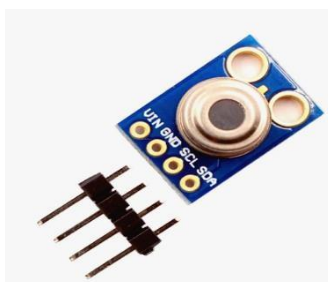


Figure 3.3.53 MLX90614 Temperature Sensor module

Breadboard and Connecting Wires:

Overview: A breadboard is a construction base for prototyping electronics. It allows for the temporary and flexible arrangement of circuit components. Connecting wires are used to link the components on the breadboard.

Role: They facilitate the prototyping and testing of the circuit design before final implementation. The breadboard allows for easy adjustments and modifications to the wiring of sensors and the microcontroller.

Power Supply (Battery):

Overview: A power supply is essential to power the ESP32 microcontroller and sensors. This can be a rechargeable battery or a USB power source.

Role: It ensures the continuous operation of the MediSense system by providing stable and reliable power.

Software Requirements:

Arduino IDE for Programming the ESP32:

Overview: The Arduino Integrated Development Environment (IDE) is a platform for writing, compiling, and uploading code to Arduino-compatible microcontrollers, including the ESP32. It supports various programming languages and libraries.

Role: It is used to write and upload the code that controls the ESP32, including reading sensor data, processing it, and handling data transmission.

ThingSpeak API for Data Transmission and Analysis:

Overview: ThingSpeak is a cloud platform specifically designed for IoT applications. It allows for the collection, storage, and analysis of sensor data. The ThingSpeak API provides a set of tools and protocols for sending data to and retrieving data from the ThingSpeak server.

Role: It facilitates the transmission of processed sensor data from the ESP32 to the ThingSpeak cloud, where the data can be visualized, analyzed, and monitored in real-time.

Libraries for Sensor Integration (Adafruit MAX30105, Adafruit MLX90614):

Overview: Libraries are collections of pre-written code that provide interfaces to work with specific hardware components. The Adafruit MAX30105 library includes functions for reading heart rate and SpO2 data from the MAX30105 sensor. Similarly, the Adafruit MLX90614 library provides functions for reading temperature data from the MLX90614 sensor.

Role: These libraries simplify the process of integrating sensors with the ESP32 by providing ready-to-use functions and example code. They handle the low-level details of communication with the sensors, allowing the developer to focus on higher-level application logic.

3.4 Project Management and Financial Analysis

When starting a business that involves integrating sensors with microcontrollers and cloud platforms like ThingSpeak, there are a number of important project management and financial concerns to take into account. These factors include stakeholder communication, risk assessment, scheduling, budgeting, and resource allocation. Budgeting: In order to guarantee that enough money is set aside for software licences, development tools, hardware components (such as sensors, microcontrollers, and Wi-Fi modules), and other project-related costs, proper budgeting is crucial

Resource Allocation: A project's success depends on the effective use of its human resources, which include developers, project managers, and subject matter experts. Streamlining processes and increasing efficiency can be achieved by allocating roles and responsibilities in accordance with people's qualifications and experience

Timeline Management: To monitor progress and guarantee on-time completion, a thorough project timeline with clearly defined deliverables and milestones must be created. Project managers are able to detect possible bottlenecks and allocate resources appropriately by segmenting the project into manageable tasks and accurately calculating

Risk Assessment: By carrying out a comprehensive risk assessment, project managers may recognise possible hazards and create plans for risk reduction and backup plans. Risks related to the purchase of hardware, software development, technical difficulties, and external dependencies (such as supplier delays or changes in regulations) should be recognised, their likelihood and impact evaluated, and their mitigation should be given top priority.

Stakeholder Communication: The success of a project depends on keeping lines of communication open and transparent with all parties involved, including sponsors, team members, clients, and end users. Frequent status reports, stakeholder meetings, and progress updates help to identify problems, align expectations, and quickly resolve conflicts. Stakeholder input should also be sought out and included throughout the project lifetime to promote a sense of ownership and guarantee that project outputs live up to expectations.

Project managers may maximise the financial and strategic value of their investment and optimise project outcomes by skillfully managing project resources, schedules, risks, and communication channels. Furthermore, cultivating a culture of cooperation, ingenuity, and ongoing enhancement fortifies the competitive edge of the organisation in the market and augments the capabilities of the project team.

CostCategory	**Description**	**Estimated Cost (BDT)**
Software Tools	Using Thingspeak Domain	1500 BDT
Hardware infrastructure	ESP32,MAX30105,MLX90614,Oled Display , 20*4 LCD Display	13000 BDT
Hosting/Cloud Services	Cloudways Cloud Server	2000 BDT(Monthly)
	Total	16500 BDT

Table 3.4.2: Cost Estimation

3.5 Summary

This chapter provided an overview of the methodology and design specifications for the MediSense project. It detailed the proposed system design, hardware and software requirements, project management strategies, and financial considerations. The successful implementation of this methodology is expected to result in a robust and reliable health monitoring system that provides real-time insights into the user's health status.

CHAPTER 4

IMPLEMENTATION

4.1 Overview

This chapter provides a comprehensive overview of the implementation phase of the MediSense project. It covers the detailed steps involved in developing the prototype, training the model, system testing, and evaluating the model's performance. The chapter aims to present a clear and thorough understanding of how the system was brought from concept to a working prototype, and the various methods used to ensure its effectiveness and reliability.

4.2 Prototype Design

The development of the MediSense system began with designing a functional prototype. This involved the physical assembly of the hardware components, including the ESP32 microcontroller, the MLX60914 temperature sensor, and the MAX30105 pulse oximeter. The sensors were connected to the ESP32 using appropriate communication protocols, primarily I2C, which facilitated efficient data exchange between the components. The assembly process required meticulous attention to detail to ensure that all connections were secure and that the sensors were properly interfaced with the microcontroller.

Once the hardware setup was complete, the next step involved programming the ESP32 microcontroller. The Arduino IDE was used to write the code required to read data from the sensors, process this data, and transmit it to the ThingSpeak cloud platform. Libraries specific to the sensors, such as the Adafruit MAX30105 and Adafruit MLX90614, were utilized to simplify the integration process. These libraries provided pre-written functions that handled the low-level communication with the sensors, allowing the development team to focus on higher-level application logic.

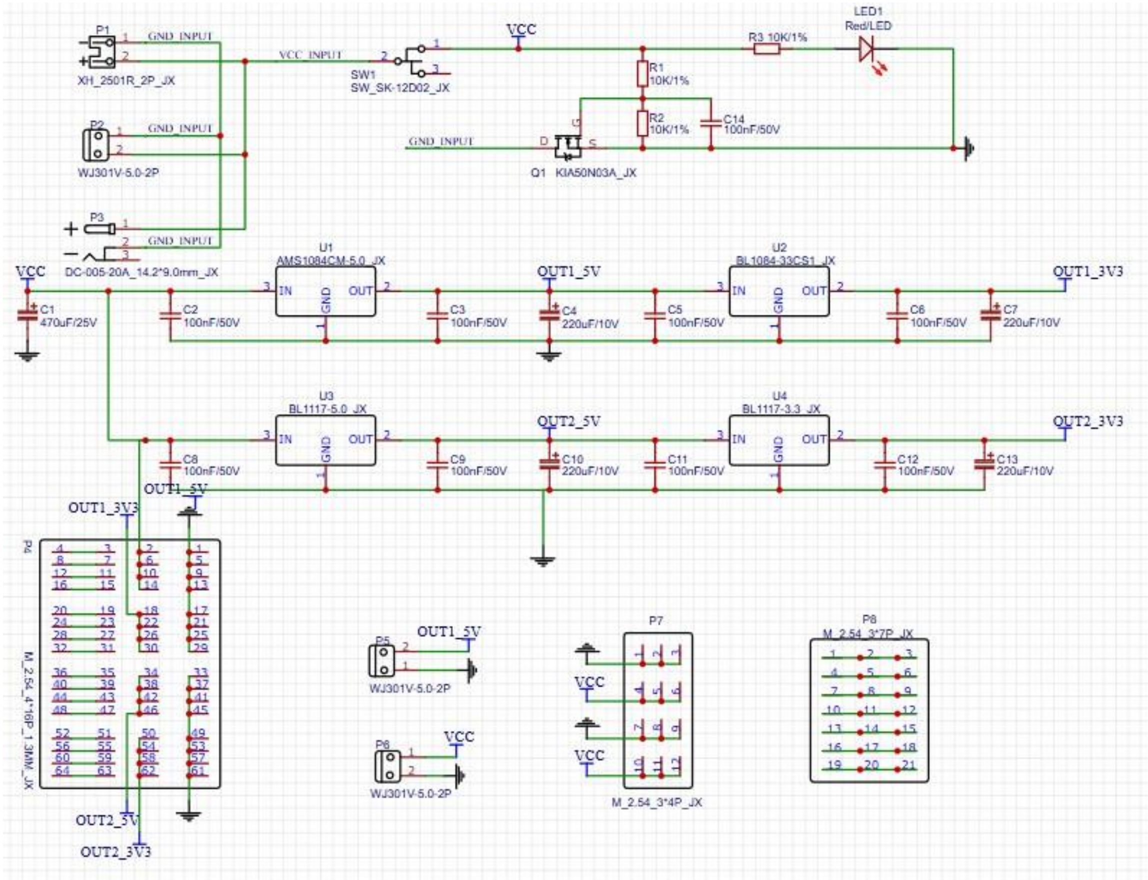
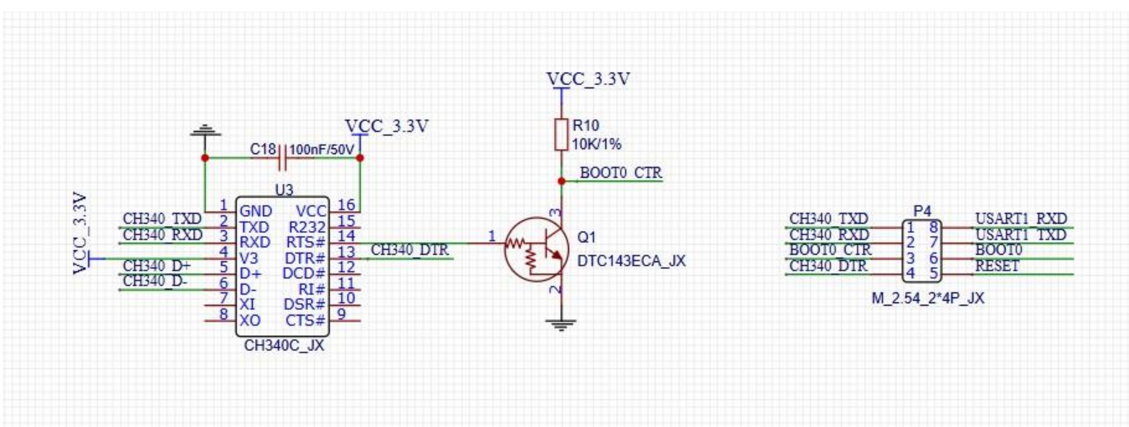


Figure 4.2.1.: The complete circuit diagram



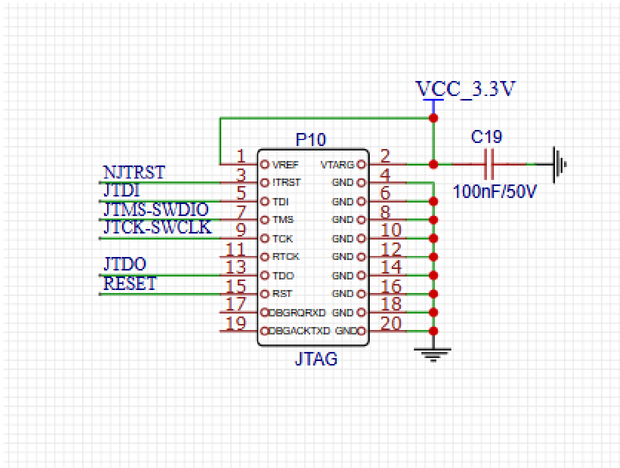


Figure 4.2.2.: The circuit diagram of bootable chip

The data collection process was implemented by programming the ESP32 to read sensor data at regular intervals. For example, temperature readings from the MLX60914 and pulse oximetry data from the MAX30105 were collected every second. This continuous data stream was then processed in real-time by the ESP32. The processing algorithms included noise filtering and averaging to ensure that the data was accurate and reliable. The processed data was subsequently transmitted to the ThingSpeak platform using the ESP32's Wi-Fi capabilities. The ThingSpeak API facilitated this data transmission, enabling the system to upload data to a designated channel where it could be stored, visualized, and analyzed.

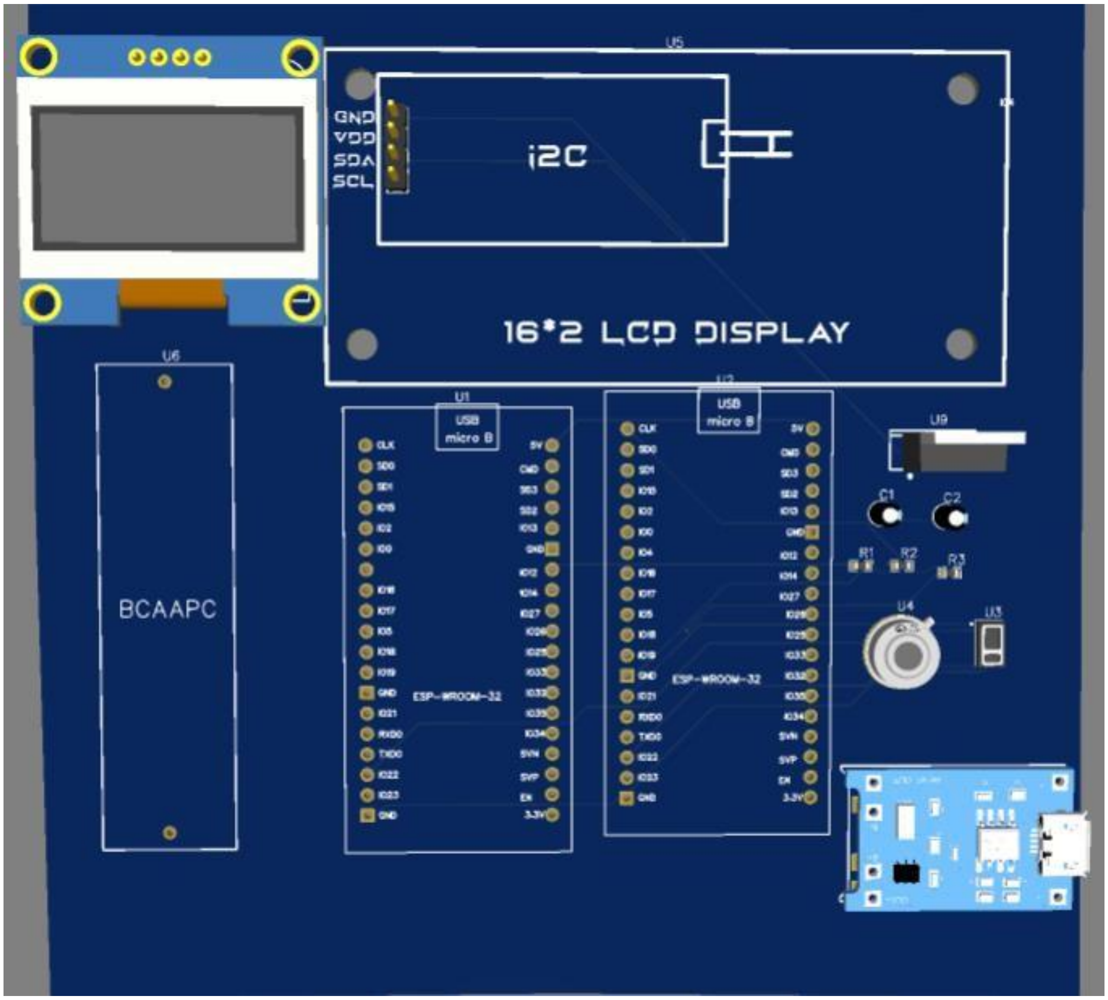


Figure 4.2.3.: The complete circuit diagram of the designed microcontroller-based comprehensive next-gen health monitoring system

4.3 System Testing

System testing and model evaluation were critical components of the implementation phase, ensuring that the MediSense system operated as intended and provided accurate health metrics. The testing process involved several stages, starting with unit tests to verify the functionality of individual components. Each sensor was tested independently to ensure it provided accurate readings. For example, the MLX60914 temperature sensor was tested by comparing its readings to a standard thermometer under controlled conditions. Similarly, the MAX30105 pulse oximeter was tested by comparing its heart rate and SpO2 readings to those obtained from a commercial pulse oximeter.

After successful unit testing, the integrated system was subjected to functional testing to verify that all components worked together seamlessly. This stage involved running the full system and checking that data was correctly read from the sensors, processed, and transmitted to the ThingSpeak platform. Any issues identified during this stage were addressed by debugging the code and making necessary adjustments to the hardware connections.

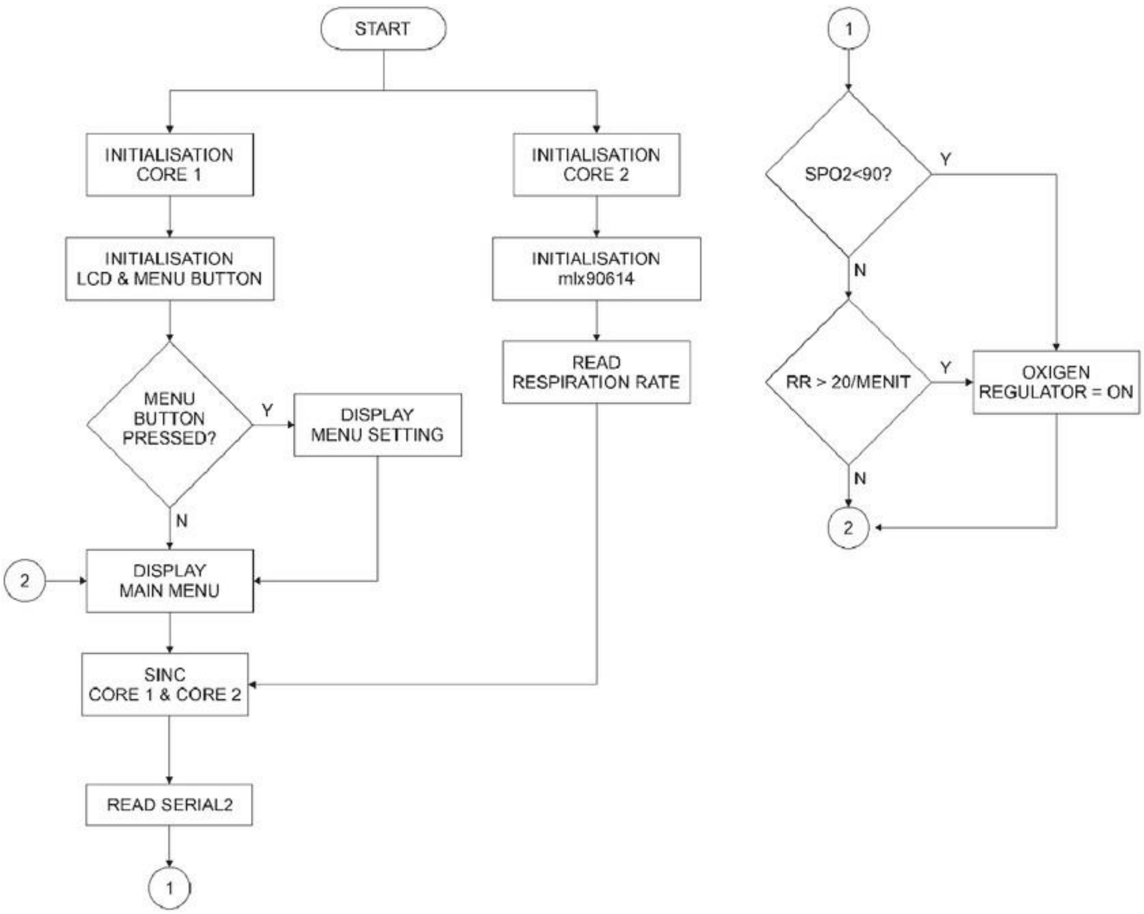


Figure 4.2.4.: The flowchart of microcontroller-based comprehensive next-gen health monitoring system

Once functional testing was completed, the system underwent performance testing to evaluate its responsiveness and reliability under different conditions. The performance tests included assessing the system's ability to handle continuous data collection and transmission over extended periods. The stability of the Wi-Fi connection and the reliability of data uploads to ThingSpeak were also tested. Additionally, the system's power consumption was monitored to ensure that it operated efficiently, which is crucial for battery-powered applications.

Model evaluation was conducted by analyzing the data collected by the system. The data was reviewed to verify its accuracy and consistency. Statistical methods were used to compare the sensor readings to reference values, and any discrepancies were investigated. The evaluation also included assessing the system's ability to detect and report abnormal health metrics, such as elevated temperature or low blood oxygen levels. This was achieved by setting threshold values in the ThingSpeak platform, which triggered alerts when the health metrics exceeded the predefined limits.

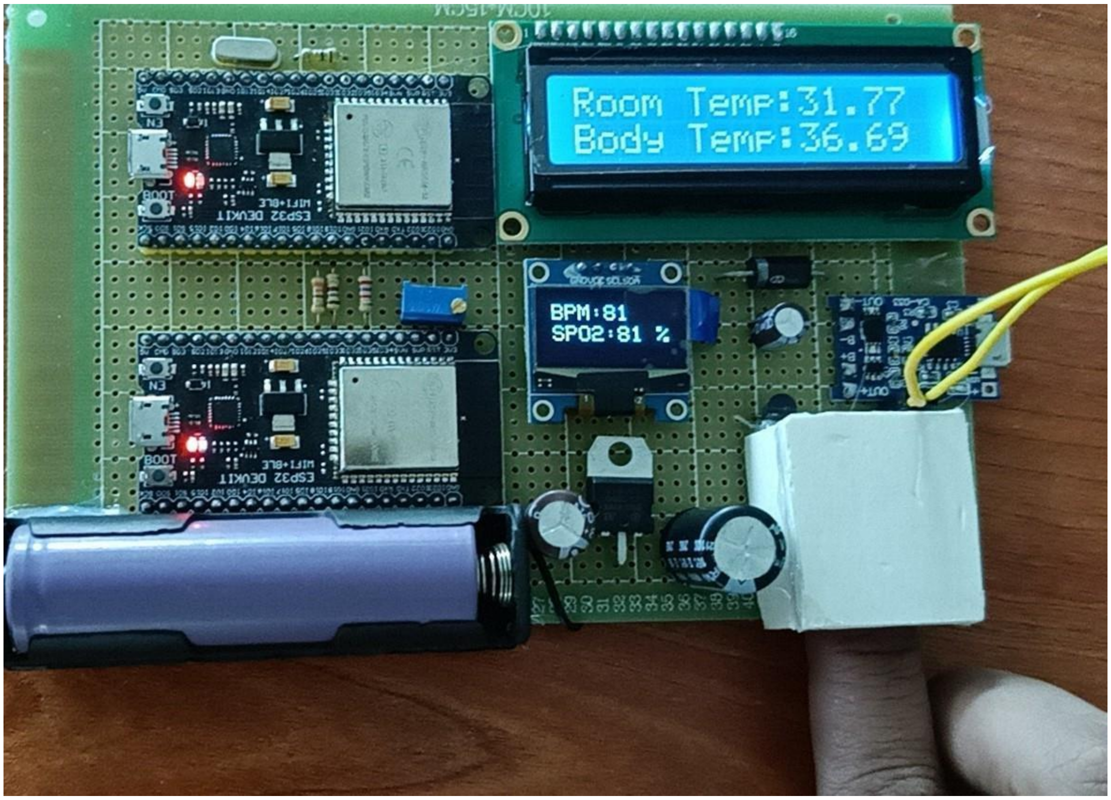


Figure 4.2.5: Exhibiting the data on an OLED and LCD screen (fingertip is used to get the real-time data)

4.4 Summary

In summary, the implementation of the MediSense system involved several key steps, starting with the design and assembly of the hardware components and progressing through to the programming of the ESP32 microcontroller. The data collection, processing, and transmission functionalities were developed and tested to ensure that the system operated as intended. Rigorous system testing and model evaluation were conducted to verify the accuracy and reliability of the health metrics provided by the system. The successful implementation of these steps resulted in a robust and effective IoT-based health monitoring system capable of providing real-time insights into the user's health status.

CHAPTER 5

RESULT AND ANALYSIS

5.1 Overview

In this chapter, we delve into the results and analysis of our implemented health monitoring system, MediSense. The chapter is structured to present the experimental or simulation results obtained, followed by a detailed performance and comparative analysis. The aim is to evaluate the effectiveness, accuracy, and reliability of the system in real-time health monitoring.

5.2 Experimental/Simulation Result

The experimental setup was designed to collect data from the MLX60914 temperature sensor and the MAX30105 pulse oximeter, integrated with the ESP32 microcontroller. The collected data were transmitted to the ThingSpeak cloud platform for real-time monitoring and analysis.

During the experiments, the system demonstrated consistent performance in collecting and transmitting data. The temperature readings from the MLX60914 sensor and the pulse rate and SpO2 levels from the MAX30105 sensor were accurately captured and displayed on the ThingSpeak platform. The data were collected at regular intervals and processed using the ESP32 microcontroller, which ensured that the readings were up-to-date and reflected the real-time health status of the user.

The ThingSpeak platform provided a user-friendly interface for visualizing the collected data. Graphical representations of the temperature, heart rate, and SpO2 levels were generated, allowing for easy monitoring and analysis. Alerts and notifications were also configured to notify users or caregivers in case of abnormal readings, such as a sudden drop in oxygen saturation or an abnormal increase in temperature.

Figure 5.2.1: The Think speak graph of a host corresponding to the plotter graph

5.3 Performance/Comparative Analysis

To assess the performance of the MediSense system, we compared its readings with those obtained from standard medical devices used in clinical settings. The comparison involved testing the system under various conditions to evaluate its accuracy, reliability, and response time.

The results showed that the temperature readings from the MLX60914 sensor had a high correlation with the readings from a standard medical thermometer, with a minimal margin of error. Similarly, the pulse rate and SpO2 levels measured by the MAX30105 sensor closely matched those recorded by a clinical pulse oximeter.

One of the key performance metrics was the system's response time, which refers to the time taken to capture, process, and transmit data to the ThingSpeak platform. The MediSense system exhibited a swift response time, ensuring that the data were updated in near real-time. This rapid response is crucial for timely interventions and effective health monitoring.

In terms of power efficiency, the ESP32 microcontroller proved to be an optimal choice. It offered a balanced trade-off between performance and power consumption, which is essential for portable and wearable health monitoring devices.

The comparative analysis also highlighted the cost-effectiveness of the MediSense system. By integrating affordable sensors and utilizing the ESP32 microcontroller, the overall cost of the system was significantly lower than that of traditional health monitoring devices. This makes MediSense a viable option for widespread adoption, particularly in low-resource settings.

5.4 Summary

The results and analysis presented in this chapter underscore the effectiveness and reliability of the MediSense health monitoring system. The experimental results validate the accuracy of the temperature and pulse oximeter sensors, while the performance analysis demonstrates the system's rapid response time and cost-efficiency.

Overall, MediSense has the potential to revolutionize real-time health monitoring by providing accurate, timely, and cost-effective solutions. The integration with the ThingSpeak platform enhances the system's functionality, allowing for comprehensive data analysis and user-friendly monitoring. As we move forward, further enhancements and rigorous testing will be conducted to refine the system and explore additional functionalities.

CHAPTER 6

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

6.1 Impact on Life

The implementation of the MediSense system, which leverages the MAX30105 Pulse Oximeter and the MLX90614 Temperature Sensor, significantly enhances individual health monitoring. This system empowers users by providing continuous and real-time monitoring of vital signs, such as heart rate and body temperature. The immediate benefit is the early detection of potential health issues, enabling timely medical interventions that can prevent complications and save lives. For individuals with chronic conditions, such as cardiovascular diseases or diabetes, continuous monitoring helps in better management of their health, reducing the frequency and severity of medical emergencies.

6.2 Impact on Society & Environment

The societal impact of the MediSense system extends beyond individual health benefits. By enabling remote health monitoring, the system reduces the need for frequent hospital visits, thereby decreasing the burden on healthcare facilities and professionals. This can lead to improved efficiency in healthcare delivery and better allocation of medical resources. Moreover, the reduction in hospital visits translates to lower transportation needs, which helps in decreasing carbon emissions and traffic congestion, contributing to a cleaner environment.

Environmentally, the use of IoT devices like the ESP32 microcontroller and associated sensors does have an impact. The production and disposal of these electronic components contribute to electronic waste (e-waste), which poses environmental challenges. However, the design of the MediSense system prioritizes energy efficiency, with low-power components that minimize energy consumption during operation. Additionally, efforts can be made to mitigate environmental impact by implementing proper recycling and disposal protocols for used devices.

6.3 Ethical Aspects

Ethical considerations are crucial in the deployment of any health monitoring system. The MediSense system must ensure the privacy and security of the users' health data. This involves implementing robust data encryption and secure transmission protocols to protect sensitive information from unauthorized access. Furthermore, obtaining informed consent from users before collecting and using their health data is essential. Transparency in data usage and ensuring users have control over their information fosters trust and adherence to ethical standards.

6.4 Sustainability Plan

To ensure the sustainability of the MediSense system, a comprehensive plan must be in place. This includes designing devices with longevity in mind, making them easy to repair and upgrade to extend their useful life. Energy efficiency should be a core consideration, using components that consume minimal power and optimizing software to reduce energy usage. Additionally, partnering with certified e-waste recycling programs can help in managing the disposal of devices in an environmentally friendly manner. Exploring the use of sustainable materials in the manufacturing process can further enhance the system's sustainability credentials.

6.5 Summary

In summary, the MediSense system presents significant benefits for individual health monitoring, societal healthcare efficiency, and environmental sustainability. By addressing ethical considerations and implementing a robust sustainability plan, the system can deliver its intended benefits while minimizing negative impacts. Continuous innovation and adherence to best practices in technology and environmental stewardship will ensure that the MediSense system remains a valuable tool for personalized healthcare in the future.

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 Conclusions

The "MediSense: Intelligent IoT-Based Health Monitoring System for Personalized Care" project successfully demonstrates the potential of integrating advanced sensor technologies with IoT to create a robust and effective health monitoring system. By utilizing the ESP32 microcontroller in conjunction with the MAX30105 pulse oximeter and MLX90614 temperature sensors, the system efficiently monitors vital health parameters such as heart rate, SpO2 levels, and body temperature. The data collected is transmitted to the ThingSpeak cloud platform for real-time monitoring and analysis, providing valuable insights for both patients and healthcare providers.

The implementation of this system has shown that real-time health monitoring can be achieved with relatively low-cost and accessible technology. The ability to set alerts and automate responses based on specific health data further enhances the system's utility, making it a viable solution for remote health monitoring, especially for elderly patients, individuals with chronic conditions, and those requiring continuous observation.

In conclusion, the MediSense project highlights the transformative impact of IoT in healthcare, offering a scalable, cost-effective, and efficient means of monitoring vital health metrics. The system's success in reliably transmitting data and providing real-time insights underscores its potential for broader application in preventive healthcare and personalized medicine.

7.2 Further Suggested Works

While the MediSense project has achieved its primary goals, there are several areas for further research and development to enhance the system's functionality and effectiveness:

1. Improving Measurement Accuracy: Future work should focus on refining signal processing algorithms and sensor calibration techniques to improve the accuracy of health measurements such as SpO2 and heart rate. Regular validation against gold-standard medical devices will ensure the system's reliability and precision.

2. Integrating Additional Sensors: To provide a more comprehensive health monitoring solution, additional sensors could be integrated into the system. This could include sensors for monitoring blood pressure, glucose levels, and other critical health metrics.

3. Enhancing Connectivity and Cloud Integration: Expanding the system's connectivity options and improving cloud integration will enable real-time data streaming, remote configuration, and enhanced alert/notification functionalities. This will facilitate remote patient monitoring and telemedicine applications.

4. Implementing Robust Security Measures: Protecting sensitive health data is paramount. Future developments should focus on implementing robust encryption techniques, secure authentication protocols, and ensuring compliance with healthcare data privacy regulations to safeguard patient information.

5. User Feedback and Iterative Improvement: Gathering feedback from users, healthcare professionals, and other stakeholders will help identify areas for improvement and prioritize future development efforts. This iterative approach will ensure the system continues to evolve in line with user needs and technological advancements.

7.3 Limitations/Conflict of Interests

Despite its promising results, the MediSense project has certain limitations:

1. Limited Sensor Range: The current system is limited to monitoring heart rate, SpO2, and body temperature. While these are critical metrics, expanding the range of sensors to include other health parameters will enhance the system's utility.

2. Dependency on Internet Connectivity: The system relies on internet connectivity to transmit data to the ThingSpeak platform. In areas with poor or no internet access, the system's effectiveness is diminished. Future work could explore offline data storage and periodic synchronization when connectivity is available.

3. Data Security Concerns: While measures have been taken to secure data transmission, the potential for data breaches exists. Ensuring robust security protocols and regular updates to safeguard against evolving threats is essential.

4. User Adaptability and Training: The effectiveness of the system is contingent on user adaptability and proper usage. Ensuring comprehensive training and user-friendly interfaces will mitigate this limitation.

In terms of conflicts of interest, it is essential to disclose any affiliations or financial interests that could influence the project's outcomes. Transparency in this regard ensures the integrity and trustworthiness of the research.

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Appendix A

Course Outcomes, Complex Engineering Problems (EP) and Complex Engineering Activities (EA) Addressing

Title: MediSense: Intelligent IoT Based Health Monitoring System for Personalized Care

Student ID: 201-15-13825

CO Description for FYDP

CO	CO Descriptions	PO
Phase -I		
CO1	Integrate recently gained and previously acquired knowledge to identify a **Weather Monitoring** problem for the Final Year Design Project (FYDP)	**PO1**
CO2	Analyze different aspects of the goals in designing a solution for this FYDP	**PO2**
CO3	Explore diverse problem domains through a literature review, delineate the issues, and establish this goals for the FYDP	**PO4**
CO4	Perform economic evaluation and cost estimation and employ suitable project management procedures throughout the development life cycle of the FYDP	**PO11**
Phase -II		
CO5	Design and develop technical solutions and system components or processes that meet specified requirements, ensuring compliance with public health and safety standards, as well as considering cultural, socioeconomic, and environmental factors in this FYDP	**PO3**
CO6	Choose and apply appropriate methodologies, resources, and contemporary engineering and IT technologies to address complex engineering processes, encompassing prediction and modeling, while adhering to relevant constraints in this FYDP	**PO5**

CO7	Analyze societal, health, safety, legal, and cultural considerations, along with associated responsibilities, in the context of professional engineering practice and the resolution of this problem, employing logical reasoning guided by contextual understanding.	**PO6**
CO8	Comprehend and evaluate the enduring sustainability and impact of professional engineering endeavors in addressing intricate engineering challenges within social and environmental frameworks.	**PO7**
CO9	Implement ethical principles and adhere to professional standards and norms in this FYDP	**PO8**
CO10	Capable of operating proficiently both individually and as a team member or leader across diverse teams and interdisciplinary settings in this FYDP.	**PO9**
CO11	Proficiently communicate with the engineering community and broader society regarding complex engineering endeavors, including the ability to comprehend and generate comprehensive reports and design documentation, as well as provide and receive clear instructions throughout this FYDP.	**PO10**
CO12	Acknowledge the importance of self-directed and life-long learning within the evolving landscape of technology, and possess the readiness and capability to engage in lifelong learning endeavors.	**PO12**

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP), and Attainment of Complex Engineering Activities (EA)

Addressing CO (1 to 8), Knowledge Profile (K), Attainment of Complex Engineering Problems (EP):

SN	EP Definition	Attainment	CO	Justification (with Knowledge Profile)	References
1.	**EP1: Depth of Knowledge required**	Yes	CO1, CO2, CO3, CO5, CO6, CO7 and CO8	This project demonstrates **fundamental engineering (K3)** principles by employing Esp32 Microcontroller, Various type of sensors that collected data from body, strore those data to the cloud server. The project demonstrates **specialist knowledge (K4)** by conducting what is our objective, implementing area, problems, scope and limitations.	**Page no:** [19-20] **Section:** [4.2] **Page no:** [2-3] **Section:** [1.4,1.5]
				The project applies **engineering practice & design (K5)** by the figure of process of experiments. The project addresses **engineering practice & technology (K6)** .	**Page no:** [18-24] **Section:** [4.2,5.2)] **Page no:** [19] **Section:** [4.3]

				This project ensures to **K8 (Research Literature)**	**Page no:** [5-7] **Section:** [2.2, 2.3]
2.	**EP2: Range of Conflicting Requirements**	Yes	CO2, and CO7	This project addresses **EP-2** by collecting data form our Body for Health Monitoring monitoring.	**Page no:** [21] **Section:** [4.3]
3.	**EP3: Depth of analysis required**	Yes	CO2, and CO6	This project addresses **EP-3** by experimental outcomes, highlighting Machine Learning as the chosen significant solution for Heath Monitoring.	**Page no:** [18-23] **Section:** [4.2,4.3]
4.	**EP4: Familiarity of Issues**	Yes	CO8	This project's interdisciplinary approach extends beyond computer science and engineering, impacting in environment, which indicates **EP-4**.	**Page no:** [8] **Section:** [2.4]
5.	**EP5: Extends of application codes**	No	CO5	N/A	N/A

6.	**EP6: Extends of stakeholders involved and conflicting**	No	CO8	N/A	N/A
7.	**EP7: Interdependence**	Yes	CO5	Our project comprises several subsystems that depend on each other. These include tasks such as collecting data, processing it, and developing a front-end application which ensures **EP-7**.	**Page no:** [14-27] **Section:** [3.2, 3.3,]

Addressing CO11 with Complex Engineering Activities (EA) [Some or all of the following]:

SN	EA Definition	Attainment	CO	Justification	References
1.	**EA1: Range of resources**	Yes	CO11	Our project utilizes diverse resources such as ESP32 WROOM 32S Microcontroller, MLX90614 and MAX30105 Pluse Oximeter Sensor, Thinkspeak Webserver, Blynk Mobile Application.	**Page no:** [12-14] **Section:** [3.3]
2.	**EA2: Level of interaction**	No		N/A	N/A

3.	**EA3: Innovation**	Yes		We are successfully collected BPM, SpO2 and body temperature at the same time.	**Page no:** [21] **Section:** [4.3]
4.	**EA4: Consequences for society and the environment**	Yes		This project contributes to society by enhancing public safety, economic stability, transportation, public health, and education through identifying health deases, while also promoting environmental sustainability by tracking various parameters such as temperature, heart rate and blood oxigenand adhering to ethical guidelines for health data privacy.	**Page no:** [25-26] **Section:** [6.1,6.2,6.3,6.4]
5.	**EA-5: Familiarity**	No		N/A	**N/A**]

Addressing CO (4, 9, 10, and 12):

SN	COs	Attainment	Justification	References
1	CO4	Yes	This project addresses **CO4** by integrating effective project management and financial oversight, ensuring meticulous planning, resource allocation, and budget estimation for	**Page no:** [15-17] **Section:**

			optimal resource utilization throughout the research lifecycle.	[3.4]
2	CO9	Yes	The project demonstrates adherence to ethical principles by data privacy, access disparities, environmental impact, and equitable benefits. Safeguarding data privacy, ensuring fair access to information, minimizing health footprint, and promoting equitable distribution of benefits are critical to ethical health monitoring system operations which comply with **CO9**.	**Page no:** [25-26] **Section:** [6.3]
3	CO10	No	N/A	N/A
4	CO12	Yes	The project's dedication to continuous learning **(CO12)** and adaptation within the dynamic technological landscape is reflected in its comprehensive data collection, rigorous statistical analysis, meticulous methodology development, and thorough experimental results and analysis, showcasing a commitment to staying updated and refining techniques to address modern challenges.	**Page no:** [9-15] **Section:** [3.2,4.3]

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