

VITAL LINK: NODEMCU IOT SOLUTION FOR REALTIME VITAL SIGNS SURVEILLANCE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in Computer Science and Engineering

By

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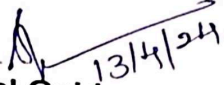
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ABSTRACT

In the realm of healthcare, the need for real-time monitoring and surveillance of vital signs has never been more critical. The "VitalLink" project, powered by NodeMCU IoT technology, represents a groundbreaking solution to this pressing demand. VitalLink redefines how healthcare professionals and patients' access, interpret, and act upon vital signs data in real-time, ultimately revolutionizing patient care. Vital signs, such as heart rate, blood pressure, temperature, and oxygen saturation, serve as vital indicators of a patient's health status. Timely and precise monitoring of these parameters is indispensable for early anomaly detection and prompt medical interventions, contributing to improved patient outcomes. The VitalLink system harnesses the capabilities of NodeMCU, an open-source IoT platform, to create an intricate network of devices, each equipped with advanced sensors for data collection. These NodeMCU devices work seamlessly to acquire vital signs data in real-time and transmit it securely to a central server. The data undergoes rigorous processing, analysis, and interpretation, allowing healthcare providers and patients to access critical information through intuitive and user-friendly interfaces. VitalLink incorporates features such as real-time alerting and notifications, ensuring that healthcare professionals are immediately apprised of changes in vital signs. Data privacy and security are at the forefront of VitalLink's design. Robust encryption and access control measures safeguard sensitive patient information. The system's scalability is engineered to accommodate an expanding number of patients and healthcare facilities, making it a flexible solution for a variety of healthcare settings. Importantly, VitalLink complies with stringent healthcare data privacy regulations, including HIPAA and GDPR, assuring patient data protection and legal adherence. The promise of VitalLink is to bring healthcare into the digital age, making real-time vital signs surveillance accessible, accurate, and user-friendly. Whether in a bustling hospital ward, a remote clinic, or within the comfort of a patient's home, this innovative IoT solution stands to enhance patient care, elevate healthcare outcomes, and empower professionals with the data they need for informed decision-making. VitalLink heralds a new era in healthcare, underscoring the role of technology in elevating the quality of care and improving patient well-being across the globe.

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LIST OF ABBREVIATIONS

ABBREVIATION

EXPANSION

EWS

Early Warning System

IDE

Integrated Development Environment

IoT

Internet of Things

OS

Operating Systems

WSN

Wireless Sensor Network

CHAPTER 1

INTRODUCTION

In the ever-evolving landscape of healthcare, the demand for innovative and efficient solutions to monitor and manage patients' vital signs in real-time has never been greater. The "VitalLink" project, powered by NodeMCU IoT technology, is a groundbreaking response to this demand. It seeks to revolutionize the way healthcare providers, patients, and caregivers access and interpret vital signs data, enabling real-time monitoring and enhanced decision-making.

Healthcare providers and patients alike in Fig. 1.1 understand the critical importance of real-time vital signs surveillance, particularly in clinical environments. Vital signs, which include parameters such as heart rate, blood pressure, temperature, and oxygen saturation, serve as the foundation for clinical assessment and patient care. Timely and accurate monitoring of these vital signs is essential for detecting anomalies, delivering swift interventions, and improving patient outcomes.

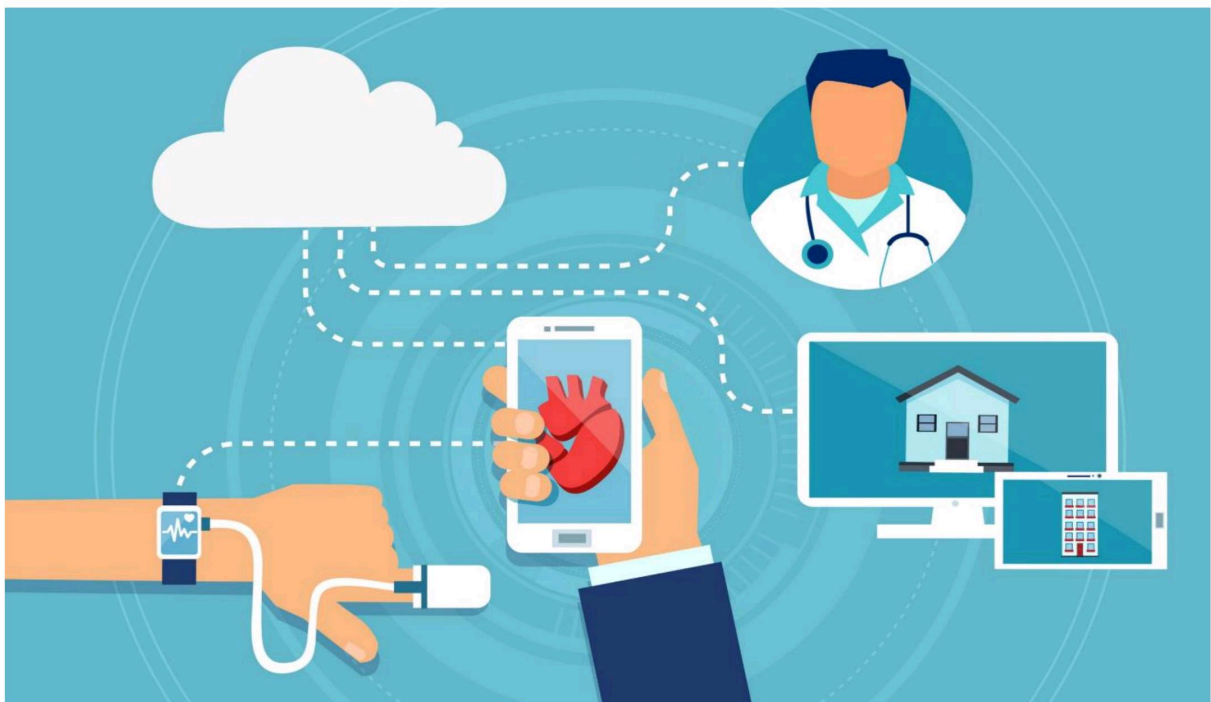


Fig 1.1: Wearable Technology

The VitalLink project leverages the power of NodeMCU, an open-source IoT platform based on the ESP32 WiFi module, to create a sophisticated and reliable system for real-time vital signs surveillance. This innovative solution incorporates a network of NodeMCU devices equipped with advanced sensors, capable of collecting and transmitting vital signs data in real-time. The data is then processed, analyzed, and made accessible through user-friendly interfaces, empowering healthcare professionals and patients with critical information at their fingertips.

The VitalLink project promises to transform healthcare by making real-time vital signs surveillance more accessible, accurate, and user-friendly. Whether in a hospital, clinic, or remote monitoring setting, this innovative IoT solution has the potential to enhance patient care, improve outcomes, and empower healthcare professionals with the data they need to make informed decisions. With VitalLink, the future of vital signs surveillance is here, bringing healthcare into the digital age and improving the quality of care for patients.

1.1 BACKGROUND AND MOTIVATION

The motivation behind VitalLink likely stems from the increasing demand for remote healthcare monitoring solutions. With advancements in IoT and wearable technology, there's a growing interest in developing systems that can monitor vital signs such as heart rate, blood pressure, temperature, and oxygen saturation remotely and in real-time. This is particularly valuable in scenarios where continuous monitoring is needed, such as in healthcare facilities, eldercare facilities, or even in home environments for patients with chronic conditions.

The NodeMCU platform is well-suited for such applications due to its compact size, low cost, and built-in WiFi capabilities. It allows developers to easily connect sensors for measuring vital signs, process the data locally, and transmit it to a central server or cloud platform for further analysis or action.

By creating VitalLink, we aim to provide a reliable and cost-effective solution for real-time vital signs surveillance, enabling healthcare professionals to monitor patients remotely, intervene promptly in case of emergencies, and gather data for long-term analysis and

trend identification. This can ultimately lead to improved patient outcomes, better management of chronic conditions, and reduced healthcare costs.

1.2 PROBLEM STATEMENT

In modern healthcare, there is a pressing need for efficient and cost-effective solutions that enable real-time monitoring of vital signs for patients, particularly in scenarios where continuous surveillance is essential. Traditional methods of vital signs monitoring often require patients to be physically present in healthcare facilities, limiting the ability to monitor them effectively in remote or home settings. This poses significant challenges, especially for patients with chronic conditions or those requiring long-term monitoring.

To address this issue, the VitalLink project aims to develop an innovative IoT solution using NodeMCU technology for real-time vital signs surveillance. The key problem areas that VitalLink seeks to tackle include:

1. Remote Monitoring: Many patients, especially those with chronic illnesses or elderly individuals, require continuous monitoring of vital signs such as heart rate, blood pressure, temperature, and oxygen saturation. However, existing monitoring systems are often bulky, expensive, and limited in their ability to provide real-time data remotely. VitalLink aims to overcome these limitations by offering a compact, affordable, and IoT-enabled solution that can transmit vital signs data over the internet in real-time.
2. Accessibility: Accessibility to healthcare services is a significant concern, especially in rural or underserved areas where access to medical facilities may be limited. By enabling remote monitoring capabilities, VitalLink seeks to improve access to healthcare services and ensure timely intervention for patients, regardless of their geographical location.
3. Data Accuracy and Reliability: Accurate and reliable monitoring of vital signs is crucial for effective healthcare management. VitalLink aims to address challenges related to data accuracy and reliability by implementing robust sensor technologies, data processing algorithms, and secure transmission protocols to ensure that healthcare professionals receive timely and accurate vital signs data for analysis and decision-making.

4. Scalability and Affordability: Scalability and affordability are essential factors to consider when deploying remote monitoring solutions, particularly in healthcare settings with limited resources. VitalLink seeks to develop a scalable and cost-effective solution that can be easily deployed and integrated into existing healthcare infrastructure, thereby minimizing implementation costs and maximizing accessibility to remote monitoring capabilities.

1.3 OBJECTIVE AND SCOPE

Objective

The objective of the VitalLink project is to develop and deploy an IoT solution using NodeMCU technology for real-time surveillance of vital signs, enabling remote monitoring of patients in healthcare settings. Integrate various sensors (e.g., Blood Oxygen Levels, Heart rate, temperature) with the NodeMCU to capture a comprehensive set of vital signs data. Implement mechanisms to ensure the accuracy and reliability of the collected vital signs data from the sensors. Set up an efficient and secure data transmission protocol between the NodeMCU device and the cloud for real-time surveillance. Create an intuitive and user-friendly interface for healthcare providers to access and interpret the vital signs data. Implement robust security measures to protect sensitive patient data during transmission and storage. Conduct extensive testing and validation to ensure the accuracy, reliability, and usability of the VitalLink IoT solution. Measure the performance of the VitalLink system in terms of data transmission speed, system responsiveness, and overall feasibility for real-world deployment.

Scope

The scope of the VitalLink project involves the development of an IoT solution using NodeMCU technology for real-time surveillance of vital signs in healthcare settings. This encompasses hardware and software development, sensor integration, connectivity, data processing, user interface design, testing, deployment, and compliance with healthcare regulations. The project aims to deliver a scalable and user-friendly system that enables remote monitoring of patient health status, facilitates timely intervention, and enhances patient outcomes.

1.4 APPLICATIONS OF VITAL SIGN SURVEILLANCE

VitalLink, with its versatile capabilities, serves a multitude of critical applications across various sectors. In healthcare settings, it revolutionizes patient monitoring by providing real-time surveillance of vital signs, enabling healthcare professionals to remotely track patients' health statuses and intervene promptly when necessary. In home healthcare scenarios, VitalLink offers peace of mind to patients and caregivers alike, allowing for remote monitoring and timely assistance for individuals with chronic conditions or those in need of continuous care. Moreover, its integration into telemedicine practices enhances the quality of virtual consultations by providing healthcare providers with immediate access to patients' vital signs data. VitalLink extends its impact to eldercare facilities, sports training environments, and occupational health settings, where it ensures the well-being and safety of individuals by facilitating real-time monitoring and early detection of health issues or risks. Additionally, in the realm of research and clinical trials, VitalLink enables remote data collection and monitoring, paving the way for more inclusive and efficient research methodologies. With its broad scope of applications, VitalLink emerges as a transformative solution, fostering improved patient outcomes, safety, and research advancements.

1.5 ORGANIZATION OF THESIS

The thesis is organized into several key sections to provide a comprehensive exploration of the VitalLink system. Beginning with an Introduction, the background, problem statement, objectives, scope, and applications are outlined to establish the context and significance of the project. A Literature Review follows, delving into existing research on IoT in healthcare, remote monitoring solutions, NodeMCU technology, vital signs monitoring, and telemedicine to inform the development process. The Methodology section details the approach taken for hardware development, sensor integration, software development, connectivity, data processing, analysis, user interface design, testing, and validation. Implementation discusses the practical realization of the VitalLink system, including hardware design, firmware development, connectivity setup, and user interface development.

Results and Discussion present findings from performance evaluation, reliability analysis, and user feedback, contextualizing them within existing literature. Case Studies and Applications explore the real-world implications of VitalLink in various healthcare scenarios, illustrating its potential impact. The Conclusion and Future Work section summarizes key findings, discusses contributions, limitations, and proposes avenues for future research and system enhancement. Finally, References and Appendices provide additional resources and supplementary materials to support the thesis content. Through this structured organization, the thesis offers a thorough examination of the VitalLink system from conceptualization to application, contributing valuable insights to the field of IoT-enabled healthcare monitoring.

1.6 KEY FEATURES OF VITALLINK:

Real-Time Monitoring: VitalLink provides continuous, real-time monitoring of vital signs, ensuring that critical data is available whenever needed.

Data Accuracy: The system is designed to provide highly accurate and reliable vital signs data, reducing the potential for errors in clinical decision-making.

Alerting and Notifications: VitalLink is equipped with intelligent alerting systems that notify healthcare providers and caregivers of any concerning changes in vital signs.

User-Friendly Interface: The project incorporates a user-friendly interface that allows healthcare professionals and patients to access vital signs data easily.

Data Security: Patient data privacy and security are paramount. VitalLink implements robust security measures to protect sensitive healthcare information.

Scalability: The system is designed to scale, accommodating a growing number of patients and healthcare facilities.

CHAPTER 2

LITERATURE SURVEY

This problem statement has been extensively studied by researchers to create a solution, and all their solutions vary. This project aims to develop a wearable that will be able to sense and monitor vital signs whenever necessary easily. The data is also stored in a web application and monitored.

2.1 OVERVIEW OF EXISTING RESEARCH AND LITERATURE

The study conducted by Kumar et al. [1] underscores the extensive utilization of wireless sensor networks (WSNs) for remote patient monitoring. Their research highlights the seamless integration of WSNs with cloud computing environments, enabling the storage and analysis of patient data in a centralized and scalable manner. Moreover, Kumar et al. emphasize the uninterrupted transmission of patient data through wireless networks, showcasing the reliability and efficiency of such systems in facilitating real-time monitoring and timely intervention. This research contributes to the growing body of literature on IoT-based healthcare solutions, demonstrating the transformative potential of WSNs in enhancing healthcare delivery and patient outcomes.

Nithin et al. [2] spoke about the importance of longitudinal data collection in remote patient monitoring systems. Their research focuses on wearable sensor networks, specifically Wireless Body Area Networks (WBANs), which are equipped with sensors capable of recording not only real-time data but also historical data from previous days. This accumulation of longitudinal data provides healthcare professionals with a rich dataset for analyzing trends and patterns in patients' physiological parameters over time. By transmitting the collected data to a gateway server via Bluetooth connection, WBANs enable continuous monitoring and seamless integration with healthcare systems. Nithin et al.'s work underscores the potential of WBANs in facilitating proactive healthcare interventions and personalized treatment strategies based on comprehensive longitudinal data analysis.

Mao et al. [3] provided an overview of Early Warning Systems (EWS), emphasizing their purpose in identifying signs of clinical deterioration and issuing early warnings for serious clinical events. They introduced a novel data mining framework designed to analyze

typical medical data, aiming to enhance the capabilities of EWS in predicting and preventing adverse health outcomes. This framework likely incorporates advanced analytical techniques to process large volumes of medical data efficiently, enabling healthcare professionals to make informed decisions and intervene proactively to mitigate risks associated with deteriorating patient conditions.

Page et al. [4] emphasized the lack of a reliable method for predicting cardiovascular diseases, specifically chronic heart failure. They highlighted the necessity for a comprehensive monitoring system to improve clinical diagnostics effectiveness. This implies a critical gap in current healthcare practices, underscoring the urgency for innovative solutions that can provide accurate and timely insights into cardiovascular health to facilitate early detection and intervention, ultimately enhancing patient outcomes.

Nazhatul Hafizah Kamarudin et al. [5] highlighted that a product may transition into the exhaustive retirement phase due to one of two primary reasons: either it undergoes updates with new software, or it becomes outdated and incompatible with the company's operations over time. This observation underscores the dynamic nature of technological products and the need for companies to continually adapt and evolve their systems to remain compatible with changing requirements and technological advancements.

Yang et al. [6] presented a new perspective on the homecare robotic systems that depended upon cyber-physical systems (CPS-HRS) that emphasized closed loops. Evidence based deployment of CPS-HRS enabling technologies has been looked at, which shows how well each CPS-HRS method works. This research shows that the CPS-HRS presented here have the potential as useful tools for home care services; nevertheless, they need to be expanded upon and enhanced.

In order to forecast when an elderly person may fall, Pinheiro et al. [9] recommended using a mobile network robot equipped with mapping and positioning capabilities in an indoor context. It uses sensor fusion, simultaneous localization and mapping (SLAM), and wall-following to see and map its surroundings. Breadth-First Search, DFS, and Wall-Following were the algorithms investigated and compared.

Richards and Caldwell [8] introduced eADVICE, a novel approach aimed at addressing the challenges posed by chronic health conditions that, while not life-threatening, significantly impact patients' quality of life and burden healthcare specialists. These conditions often prolong treatment duration and strain healthcare resources. To mitigate these challenges, eADVICE proposes the implementation of a virtual expert for patients accessible through an interactive website. This virtual expert serves as a personalized platform where individualized healing recommendations and patient-specific information can be stored and accessed. By leveraging technology to provide tailored guidance and support, eADVICE seeks to streamline treatment processes, enhance patient outcomes, and alleviate the burden on healthcare professionals.

Márquez et al. [3] conducted a systematic mapping study (SMS) aimed at identifying, organizing, and categorizing security concerns within telehealth systems. Their comprehensive analysis included the selection and listing of over 1,000 primary studies, focusing on three main areas: detecting assaults, avoiding or mitigating attacks, and responding to attacks. The results of the SMS underscored the critical role of software architecture, requirements, and templates in establishing stable telehealth systems. By emphasizing these aspects, healthcare organizations can better address security challenges and implement robust measures to safeguard patient data and ensure the integrity and reliability of telehealth services.

Zhu et al. [4] used a home-based cardiac rehabilitation (CR) exercise program to look at the relationship between the patient and the healthcare provider in the context of heart management. The concept incorporates a wearable device, a portable application, and a stationary medical facility. The standard CR activities that can be done at home were added, and their usefulness was discussed. In addition, they validated that the proposed approach will be a useful CR fitness tool for the electronic transmission of CR exercise prescriptions and activity records between a patient and healthcare.

2.2 INFERENCES FROM LITERATURE SURVEY

Researchers and developers are actively engaged in improving object detection accuracy and speed, particularly for real-time applications. IoT technology has gained prominence in healthcare for its potential to enhance patient care, improve data accuracy, and streamline healthcare processes. Researchers have demonstrated the feasibility of IoT-based vital signs monitoring systems. NodeMCU and similar IoT platforms offer cost-

effective and accessible options for sensor integration and data transmission. The literature shows the suitability of such platforms for healthcare applications.

Integrating various sensors, such as pulse oximeters, temperature sensors, ECG sensors, and blood pressure monitors, is a common practice in IoT-based vital signs surveillance systems. Researchers have explored different sensor types and their accuracy. The integration of wireless sensor networks with cloud computing environments highlights the shift towards centralized data storage and analysis. This integration enables real-time monitoring, seamless data transmission, and scalability, facilitating more efficient and comprehensive healthcare solutions. Ensuring data security and patient privacy is a paramount concern. Literature emphasizes the need for robust encryption, access control, and compliance with healthcare data protection regulations (e.g., HIPAA, GDPR).

Scalability is a key consideration, particularly in healthcare environments with a growing number of patients. Literature highlights the importance of designing systems that can easily scale to accommodate additional devices and patients. Limitations associated with microcontroller options like Arduino UNO, such as memory constraints and form factor issues, highlight the need for alternative solutions with enhanced capabilities and compatibility. Additionally, addressing cost concerns is crucial to ensure the affordability and accessibility of wearable healthcare systems, ultimately enabling their widespread adoption and impact in improving healthcare delivery and patient outcomes. Issues related to form factor compatibility and cost-effectiveness underscore the importance of optimizing the design and manufacturing processes of wearable healthcare devices. Ensuring compatibility with breadboards and reducing the overall cost of the system are crucial factors in improving accessibility and affordability, thereby increasing the reach of wearable healthcare solutions to a broader population.

2.3 OPEN PROBLEMS IN EXISTING SYSTEM

The features have been limited according to the availability of the sensors as said in the literature survey. These systems having Arduino UNO as the microcontroller that has lesser memory and processor capability.

More over the Arduino UNO cannot be inserted into the breadboard due to its size and pin orientation. In most of these systems, Arduino UNO is used as the base microcontroller in them that makes the wearable expensive which may not be affordable by all the people who are in need of them.

The existing systems face several challenges and open problems, including:

1. Limited Features due to Sensor Availability: The functionality of these systems is restricted by the availability of compatible sensors. This limitation hampers the system's ability to monitor a comprehensive range of vital signs and physiological parameters.

2. Microcontroller Constraints: The use of Arduino UNO as the microcontroller imposes limitations due to its lesser memory and processing capabilities. This constraint may hinder the system's ability to handle large volumes of data or perform complex computations efficiently.

3. Form Factor and Compatibility Issues: Arduino UNO's size and pin orientation make it incompatible with breadboards, complicating the prototyping and development process. This limitation may restrict the flexibility and scalability of the system during design and implementation phases.

4. Cost and Affordability: The reliance on Arduino UNO as the base microcontroller contributes to the overall cost of the wearable system, making it potentially unaffordable for individuals who require such devices but may have limited financial resources. This affordability barrier undermines the accessibility and inclusivity of wearable healthcare solutions.

Addressing these open problems requires innovative approaches in sensor selection, microcontroller design, form factor optimization, and cost-effective manufacturing processes. Solutions that leverage advanced microcontrollers with enhanced processing capabilities, modular sensor interfaces, compact form factors, and cost-efficient components can mitigate these challenges and enhance the accessibility and effectiveness of wearable healthcare systems.

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 FEASIBILITY STUDIES AND RISK ANALYSIS OF THE PROJECT

3.1.1 *Feasibility Studies*

Technical Feasibility:

Assess the technical feasibility of implementing real-time vital signs surveillance with NodeMCU. Ensure the hardware and software capabilities can meet the project's requirements.

Market Feasibility:

Analyze the market demand for such a solution. Research potential customers, competitors, and potential growth in the healthcare or monitoring industry.

Financial Feasibility:

Estimate the project's cost, including hardware, software, development, and ongoing operational expenses. Determine if the project is financially viable and if you can secure funding.

Legal and Compliance Feasibility:

Investigate regulatory requirements related to healthcare data and IoT devices. Ensure the project complies with laws and industry standards like HIPAA and GDPR.

Operational Feasibility:

Examine if your team has the skills and resources to develop and maintain the system. Consider the scalability, maintenance, and support requirements.

Schedule Feasibility:

create a timeline for the project, including development, testing, and deployment. Ensure it aligns with your goals and market demand.

3.1.2 *Risk Analysis:*

Technology Risks:

Identify potential technical challenges such as compatibility issues, network reliability, and data security. Develop contingency plans for each.

Market Risks:

Market shifts, competition, or changing regulations can affect the project's success. Continuously monitor and adapt to these changes.

Financial Risks:

Budget overruns, unexpected costs, or funding challenges can hinder the project. Establish a financial buffer and contingency plan.

Legal and Compliance Risks:

Failure to meet regulatory requirements can lead to legal issues and damage the project's reputation. Regularly update your compliance strategy.

Operational Risks:

Employee turnover, resource shortages, or technical failures can disrupt operations. Have backup plans and ensure cross-training.

Security Risks:

Data breaches and unauthorized access are significant risks in healthcare IoT. Implement strong security measures, encryption, and constant monitoring.

User Adoption Risks:

Users may resist or struggle to adopt new technology. Conduct user training and provide excellent customer support.

Scalability Risks:

As the project grows, scalability challenges may arise. Plan for future expansion and ensure your infrastructure can handle it.

Vendor Risks:

If you rely on third-party vendors for components or services, assess their reliability and have backup options in case they fail to deliver.

Natural and Environmental Risks:

Natural disasters, power outages, or other environmental factors can affect the project. Implement disaster recovery and backup power solutions.

Data Privacy Risks:

Safeguarding patient data is paramount. Regularly audit data handling processes to minimize privacy risks.

Regulatory Changes:

Be prepared for changes in healthcare regulations, which can impact the project's compliance and operations.

To mitigate and manage these risks, it's important to conduct ongoing assessments, maintain strong communication with stakeholders, and have contingency plans in place. Regularly reassess both feasibility and risk factors as the project progresses and circumstances change.

3.2 SOFTWARE REQUIREMENTS SPECIFICATION DOCUMENT

NodeMCU Firmware: NodeMCU board has the latest firmware, which supports Wi-Fi connectivity.

Programming Language: C/C++ language is written code used for NodeMCU.

IoT Platform: An IoT platform to manage the data from NodeMCU devices like AWS IoT, Google Cloud IoT, Microsoft Azure IoT, Blynk.

Database Management System (DBMS): Storing and analyzing vital sign data, is done using a DBMS like MySQL, SQLite, MongoDB.

Data Visualization Tools: Tools like Tableau, Power BI help in creating visual dashboards to monitor vital signs data.

Integrated Development Environment (IDE): For developing server-side components of the project, any IDE like VS Code, Eclipse depending on the programming languages used is needed.

Web Development Tools: project involves creating a web interface, you'll need web development tools like HTML, CSS, JavaScript.

Operating System (OS): Ensuring the development environment will run on the choice of OS, whether it's Windows, macOS, or Linux.

Security Tools: Implementing security measures to protect sensitive data. This includes using encryption and following best practices for IoT security.

Documentation Tools: Using documentation tools like Microsoft Word for project documentation.

Testing, Debugging Tools: Depending on the complexity of the project, tools like Postman for API testing and Wireshark for network analysis.

CHAPTER 4

DESCRIPTION OF PROPOSED SYSTEM

The proposed system represents a remarkable leap in the way people can use the wearable technology created efficiently and easily. The system aims to provide a comprehensive solution for real-time vital signs surveillance, addressing the needs of healthcare professionals and patients while ensuring data privacy, security, and compliance with healthcare regulations. Its scalability, user-friendliness, and integration capabilities make it a powerful tool for enhancing patient care and clinical decision-making.

In this system, some additional features will be added along with the existing ones to make the system more efficient. This system will be using NodeMCU instead of Arduino which is of low cost compared to the former due to which the final module can be easily afforded by everyone as in Fig 4.1. The health data of the person using this system will be displayed in an application on the mobile or PC. Since this system is proposed for elderly and terminally ill people. The health data collected can be managed either by family doctors or close relatives.

NodeMCU boards are deployed on or near patients to collect vital signs data. Each device is equipped with sensors for monitoring parameters such as heart rate, blood pressure, temperature, and oxygen saturation. NodeMCU devices continuously acquire vital signs data from the sensors. This data is transmitted securely to a central server via Wi-Fi or other appropriate wireless communication protocols.

Real-time data analysis is performed on the central server. This includes data validation, normalization, and the execution of algorithms for interpreting vital signs. Processed vital signs data is securely stored in a database system. The system provides efficient data retrieval and archiving capabilities for historical analysis. A user-friendly web-based and mobile application is developed to provide healthcare professionals, patients, and caregivers with easy access to vital signs data. The interface offers real-time data visualization and historical trend analysis. The system is equipped with intelligent alerting mechanisms that trigger notifications in response to critical vital signs readings or anomalies. Alerts can be delivered via SMS, email, or in-app notifications.

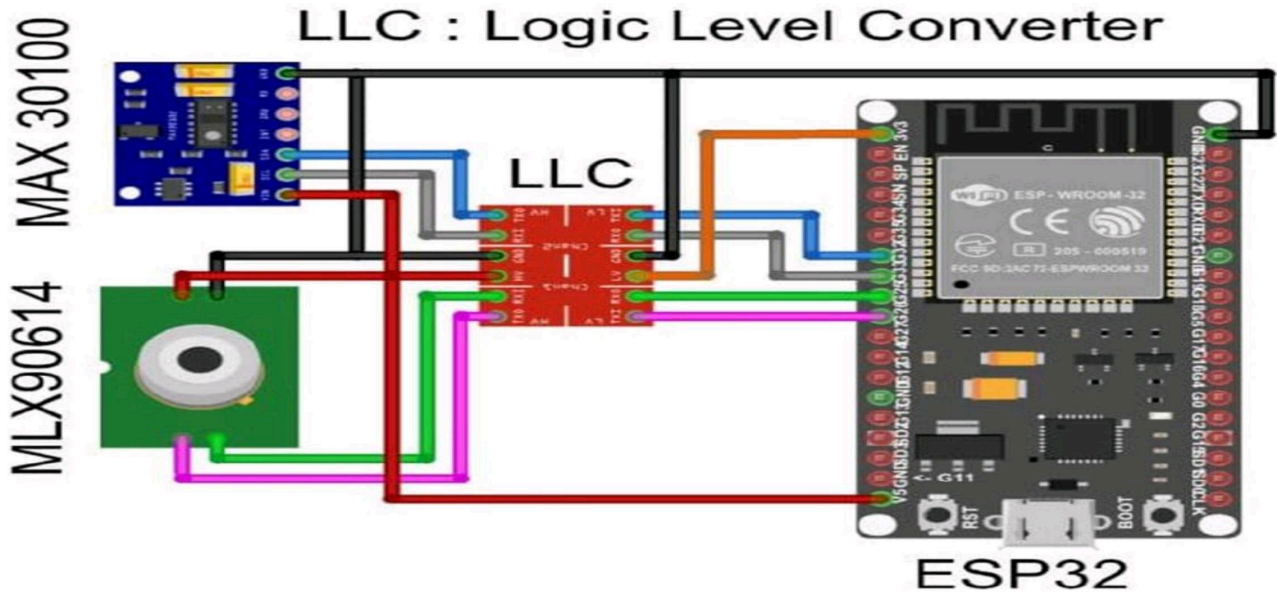


Fig 4.1: A Representation of the wearable (VitalLink)

4.1 SELECTED METHODOLOGY OR PROCESS MODEL

The success of a software project relies heavily on the methodology or process model chosen for its development. so, we have carefully evaluated and chosen the Agile development methodology as the most suitable approach for our project.

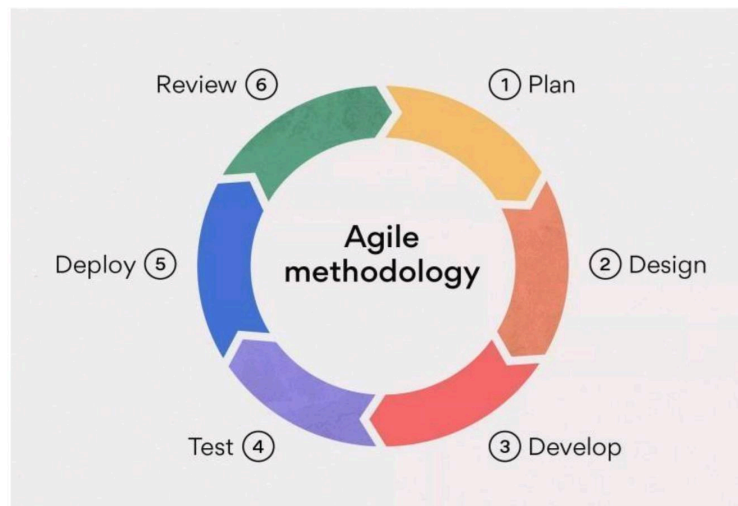


Fig 4.2: Agile Methodology

Agile is a dynamic and iterative approach to software development that emphasizes flexibility. It is well-aligned with the nature and goals of our project, which involves creating a vital signs surveillance system in a multicultural market as shown in Fig 4.2.

Iterative Development: Agile encourages iterative development, where the project is divided into smaller increments. For our system, this means breaking down the development process into manageable phases or sprints, each focused on achieving specific goals.

Continuous Testing: Agile emphasizes continuous testing and feedback loops. Through regular testing, we can identify and address issues promptly, ensuring a more robust and reliable system.

By adopting the Agile methodology, our development process will be dynamic, and highly responsive to the evolving needs of our project.

4.2 OVERALL ARCHITECTURE DESIGN OF PROPOSED SYSTEM

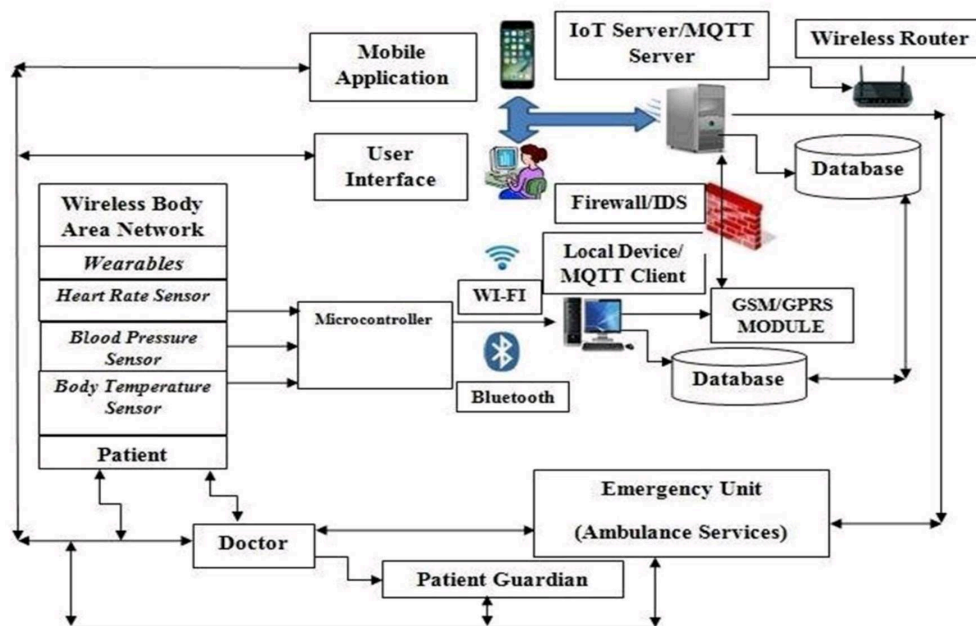


Fig 4.3: System Architecture

The overall architecture design of the proposed system for the VitalLink NodeMCU IoT solution for real-time vital signs surveillance is a crucial aspect of the project which is shown in Fig 4.3.

The architecture should provide a clear structure for how various components of the system interact and work together to achieve the project's goals. Below is a high-level architectural

overview of the system:

1. NodeMCU Devices: NodeMCU boards equipped with sensors (e.g., pulse oximeters, temperature sensors, ECG sensors) are deployed on or near patients to collect vital signs data. These devices will be responsible for data acquisition and initial data processing.

2. Data Transmission: Data collected by NodeMCU devices are transmitted securely to a central server for processing and storage.

Communication can be achieved using Wi-Fi, Bluetooth, or other appropriate wireless technologies.

3. Central Server: The central server is the core component of the system responsible for receiving, processing, and storing vital signs data.

It handles data ingestion, validation, and normalization.

4. Data Processing and Analysis: Data received from the NodeMCU devices undergo real-time analysis, including checking for anomalies and trends.

Algorithms for vital signs interpretation and alert generation are executed at this stage.

5. Data Storage: Processed data is stored in a secure and scalable database system. It should support efficient data retrieval and archiving for historical analysis.

Redundancy and backup mechanisms are in place to ensure data integrity.

6. User Interface: A user-friendly web-based or mobile application is provided for healthcare professionals, patients, and caregivers.

This interface allows users to view real-time vital signs data, historical trends, and alerts.

User authentication and access control are implemented to ensure data privacy.

7. Alerting System: The system generates alerts in case of critical vital signs readings or anomalies.

Alerts can be sent via various channels, including SMS, email, and in-app notifications.

8. Data Security: Robust security measures, including encryption, access control, and authentication, are implemented to protect patient data and system integrity.

Compliance with healthcare data privacy regulations (e.g., HIPAA, GDPR) is maintained.

9. Scalability and Redundancy: The architecture should be designed for scalability to accommodate a growing number of patients and devices.

Redundancy and fail over mechanisms are in place to ensure system availability.

10. Integration with Electronic Health Records (EHR):

Integration with existing EHR systems in healthcare facilities is a consideration, allowing seamless access to patient data.

11. Reporting and Analytics: The system should provide tools for generating reports and conducting analytics on patient data for research and healthcare improvement.

12. Maintenance and Support: Provisions for system maintenance, updates, and customer support are essential to ensure the system's reliability.

13. Data Backups and Disaster Recovery: Regular data backups and disaster recovery procedures are in place to protect against data loss or system outages.

14. Compliance and Audit Trail: Maintain audit logs and compliance records to track system access and changes to patient data.

4.3 DESCRIPTION OF SOFTWARE FOR IMPLEMENTATION AND TESTING PLAN OF THE PROPOSED MODEL

4.3.1 Software Components and Tools:

The software components, tools, and technologies essential for implementation and testing.

Arduino IDE: The Arduino Integrated Development Environment (IDE) is commonly used for programming NodeMCU, which is based on the ESP32 chip. It provides a user-friendly interface for writing, compiling, and uploading code to the NodeMCU.

NodeMCU Firmware: The NodeMCU firmware is essential to provide Wi-Fi functionality and to interface with sensors. It's typically written in C/C++ and allows NodeMCU to connect to Wi-Fi networks, communicate with servers, and manage sensors.

Sensor Libraries: Various libraries are available for interfacing with sensors that measure vital signs. For example, libraries for pulse oximeters, temperature sensors, and blood pressure monitors may be used to read and process sensor data.

Wi-Fi Libraries: Wi-Fi libraries, often provided by the NodeMCU platform, are used to connect the NodeMCU to Wi-Fi networks. These libraries enable the device to send data to a central server or the cloud.

MQTT (Message Queuing Telemetry Transport) Protocol: MQTT is a lightweight and efficient publish-subscribe protocol commonly used for IoT communication. It enables real-time data transmission between the NodeMCU and a central server or other IoT devices.

Database Management System: A database management system (DBMS), such as MySQL or NoSQL databases like MongoDB, can be used to store and manage vital sign data. The NodeMCU can connect to the DBMS to store collected data.

The testing plan for the proposed human activity recognition system can include several stages, such as:

- 1. Unit testing** - This involves testing the individual components of the system, such as the data collection and pre-processing, model development and training, and model evaluation and validation, to ensure that they are working as expected.
- 2. Integration testing** - This involves testing the integration of the different components of the system to ensure that they are working together as expected.
- 3. Performance testing** - This involves testing the performance of the system, such as the accuracy, precision, and recall of the model, to ensure that it meets the required performance metrics.
- 4. Acceptance testing** - This involves testing the system in a real-world setting with end-users to ensure that it is meeting their needs and requirements.

4.3.2 Implementation Steps

The implementation of the VitalLink system follows these steps:

1. Hardware Setup:

Connect Sensors: Establish connections between the sensors (e.g., heart rate, temperature, oxygen saturation) and the NodeMCU device to enable data capture.

Power NodeMCU: Ensure the NodeMCU device is adequately powered using a suitable power source, such as USB or battery.

2. Software Development:

Firmware Development: Develop firmware for the NodeMCU utilizing platforms like Arduino IDE or similar development environments.

Algorithm Implementation: Implement algorithms within the firmware for data acquisition, processing, and transmission to effectively handle sensor data.

Wi-Fi Configuration: Configure Wi-Fi settings on the NodeMCU to enable internet connectivity for data transmission.

3. Data Collection:

Start NodeMCU: Activate the NodeMCU device to commence real-time data collection from connected sensors.

Verification: Validate the accuracy and stability of sensor readings to ensure reliable data capture.

4. Data Transmission:

Establish Wi-Fi Connection: Establish a stable Wi-Fi connection from the NodeMCU to the designated server or cloud platform for data transmission.

Secure Transmission: Implement secure data transmission protocols such as MQTT to safeguard the integrity and confidentiality of transmitted data.

5. Real-time Monitoring:

Continuous Monitoring: Monitor the received data continuously on the designated server or cloud platform to ensure real-time surveillance of vital signs.

Visualization Tools: Develop or integrate visualization tools within the monitoring platform to facilitate real-time display of vital signs data for healthcare professionals.

Alert Mechanisms: Set up alert mechanisms within the monitoring platform to notify healthcare providers of any abnormal readings or critical events, enabling timely intervention.

4.4 PROJECT MANAGEMENT PLAN:

The project aims to develop a "VitalLink: NodeMCU IoT Solution for Real-Time Vital Signs Surveillance" in a college project aims to deliver a structured approach to successfully executing the project. It commences with a comprehensive project initiation phase, encompassing the clear definition of project objectives and scope, followed by a detailed analysis of stakeholder expectations and requirements. Key team members will be identified, and roles and responsibilities will be clearly defined to ensure a smooth workflow.

The project will be structured into well-defined phases, with specific timelines and deliverables, including sensor integration, data transmission, cloud platform development, mobile app creation, alert system setup, and data security implementation. Throughout the project, continuous communication, regular team meetings, and transparent progress

tracking will ensure that the project stays on course.

Testing and quality assurance will be paramount, with dedicated phases for system testing and evaluation. Comprehensive documentation, including design specifications, code documentation, user manuals, and safety guidelines, will be created to support the project's implementation and future reference.

Module descriptions for the VitalLink: NodeMCU IoT Solution for Real-Time Vital Signs Surveillance project. These modules break down the project into distinct components, making it easier to manage and develop.

1. Sensor Module:

The Sensor Module encompasses the hardware and software components of NodeMCU devices. It is responsible for data acquisition from various vital signs sensors, such as pulse oximeters, temperature sensors, and blood pressure monitors. This module also handles data preprocessing and initial validation.

2. Data Transmission Module:

Data collected by the Sensor Module is transmitted to the central server. The Data Transmission Module manages the wireless communication protocols, such as Wi-Fi or Bluetooth, and ensures secure and reliable data transmission.

3. Central Server Module:

The Central Server Module serves as the core component of the system. It is responsible for receiving, storing, and processing data from all NodeMCU devices. This module manages data ingestion, validation, normalization, and storage in a secure and scalable database.

4. Data Processing and Analysis Module:

Real-time data analysis is performed by the Data Processing and Analysis Module on the central server. It checks for anomalies, interprets vital signs data, and generates alerts when necessary. This module also handles the execution of algorithms for data interpretation.

5. User Interface Module:

The User Interface Module encompasses the development of user-friendly interfaces, including web-based and mobile applications. It provides healthcare professionals, patients,

and caregivers with real-time access to vital signs data, historical trends, and alerts. This module includes data visualization and user interaction components.

6. Alerting and Notification Module:

The Alerting and Notification Module is responsible for real-time alert generation in response to critical vital signs readings or anomalies. It manages the delivery of alerts to healthcare professionals and caregivers through various channels, including SMS, email, and in-app notifications.

7. Data Security and Privacy Module:

The Data Security and Privacy Module ensures the robust protection of patient data. It encompasses security measures like encryption, access control, and user authentication to safeguard sensitive healthcare information. Compliance with healthcare data privacy regulations, such as HIPAA and GDPR, is a priority.

8. Scalability and Redundancy Module:

Scalability and Redundancy Module addresses the system's capacity to accommodate a growing number of patients and devices. It also includes failover mechanisms to ensure high availability and data integrity in case of system failures.

9. Integration with EHR Module:

The Integration with Electronic Health Records (EHR) Module ensures that the system can seamlessly integrate with existing EHR systems in healthcare facilities. This enables efficient access to and updating of patient data.

10. Reporting and Analytics Module:

The Reporting and Analytics Module provides tools for generating reports and conducting analytics on vital signs data. This supports research and healthcare improvement initiatives, enabling data-driven decision-making.

11. Maintenance and Support Module:

The Maintenance and Support Module includes provisions for system maintenance, updates, and customer support. It ensures the ongoing reliability and efficiency of the system.

12. Data Backups and Disaster Recovery Module:

The Data Backups and Disaster Recovery Module is responsible for regular data backups and procedures to safeguard against data loss or system outages.

These project modules provide a structured framework for the development of the VitalLink system, ensuring that each component is designed, implemented, and tested independently while contributing to the overall functionality of the system.

4.5 TRANSITION OF SOFTWARE TO OPERATIONS PLAN:

The transition of software to operations plan for a NodeMCU IoT solution for real-time vital signs surveillance is critical for a successful deployment and ongoing maintenance of the system. This plan outlines the steps and considerations for moving the developed software from the development phase to the operational phase, where it is used for real-time monitoring of vital signs.

1. Documentation:

Comprehensive Documentation: Thoroughly document all aspects of the software, including design, configuration, and code, in a clear and understandable manner for operational staff to reference during system maintenance and troubleshooting.

2. Quality Assurance and Testing:

Final Testing: Conduct a final round of testing to validate that the software functions as intended in the operational environment, ensuring all features work correctly and reliably.

Bug Fixing: Address and resolve any identified issues or bugs discovered during testing to enhance the software's stability and performance before deployment.

3. Deployment:

Environment Setup: Prepare the operational environment by configuring necessary infrastructure components such as servers, databases, and network settings.

Deployment Strategy: Develop a deployment plan outlining the sequence and procedure for installing and configuring the software on target devices or servers. Consider factors such

as deployment timelines, rollback procedures, and communication channels with stakeholders.

4. Data Management:

Data Migration: Transfer relevant data from the development or testing environment to the operational environment, ensuring data integrity and consistency.

Data Validation: Validate the accuracy and completeness of migrated data, conducting checks to confirm that data is accessible and usable for operational purposes.

5. Security and Compliance:

Security Audits: Perform security assessments and audits to identify and address potential vulnerabilities in the software and operational environment, ensuring compliance with security standards and regulations.

Access Control: Implement robust access controls and authentication mechanisms to protect sensitive data and prevent unauthorized access to the system.

Compliance Checks: Ensure that the software meets regulatory requirements and standards relevant to the healthcare industry, such as HIPAA or GDPR, by conducting compliance checks and implementing necessary safeguards.

6. Training and Support:

User Training: Provide training sessions for operational staff to familiarize them with the software's features, functionality, and maintenance procedures.

Ongoing Support: Establish mechanisms for providing ongoing technical support and assistance to operational staff, including helpdesk support, knowledge bases, and documentation repositories.

7. Monitoring and Maintenance:

Monitoring Tools: Implement monitoring tools and alerts to proactively detect and address issues with the software's performance, availability, and security.

Maintenance Schedule: Develop a maintenance schedule outlining regular updates, patches, and system checks to keep the software and operational environment up to date and secure.

CHAPTER 5

IMPLEMENTATION DETAILS

5.1 DEVELOPMENT AND DEPLOYMENT SETUP

The development and deployment setup for the VitalLink system is a critical aspect of ensuring its successful implementation and integration into healthcare settings. This section outlines the key components and considerations involved in setting up the development environment and deploying the system for real-world use.

Hardware Configuration: Selecting appropriate hardware components, including sensors, microcontrollers (such as NodeMCU), and communication modules. Ensuring compatibility and reliability of hardware components for seamless integration and operation. Configuring hardware settings, connections, and power supply to optimize performance and durability.

Software Development: Developing firmware and software algorithms for data acquisition, processing, and transmission. Choosing suitable programming languages and development environments, such as Arduino IDE or platform-specific SDKs. Implementing robust error handling mechanisms, debugging tools, and software testing procedures to ensure reliability and stability.

Networking and Connectivity: Configuring wireless communication protocols (e.g., Wi-Fi, Bluetooth) for data transmission between sensors and server/cloud platforms. Establishing secure network connections and implementing encryption protocols to protect sensitive data during transmission. Testing network reliability, bandwidth, and latency to ensure smooth and uninterrupted data flow.

Cloud Infrastructure Setup: Setting up cloud servers or platforms (e.g., AWS, Azure) for hosting data storage, processing, and analytics services. Configuring database systems, file storage, and data management tools to efficiently store and retrieve vital signs data. Implementing security measures, access controls, and backup procedures to safeguard data integrity and confidentiality.

User Interface Design: Designing intuitive and user-friendly interfaces for healthcare professionals to monitor and analyze vital signs data. Incorporating visualization tools, alerts, and notifications to facilitate real-time monitoring and decision-making. Conducting usability testing and gathering feedback from end-users to iterate and improve the user interface design.

Deployment Strategy: Planning and executing the deployment of VitalLink systems in healthcare facilities, clinics, or patient homes. Training healthcare professionals and end-users on system operation, data interpretation, and troubleshooting procedures. Monitoring system performance, collecting feedback, and addressing any issues or concerns that arise during deployment.

By meticulously setting up the development and deployment environment for the VitalLink system, healthcare organizations can ensure smooth integration, reliable operation, and maximum benefit from real-time vital signs surveillance in improving patient care and outcomes.

5.2 ALGORITHMS

In the VitalLink system for real-time vital signs surveillance, several algorithms may be employed to process, analyze, and interpret the data collected from sensors. Some common algorithms used in such systems include:

Signal Processing Algorithms: Filtering algorithms (e.g., low-pass, high-pass, band-pass filters) to remove noise and artifacts from sensor data. Signal decomposition techniques (e.g., Fourier transform, wavelet transform) to extract relevant frequency components from physiological signals. Feature extraction algorithms to identify key characteristics or parameters of vital signs signals, such as heart rate variability (HRV), respiratory rate, and temperature fluctuations.

Predictive Modeling Algorithms: Time series analysis techniques (e.g., autoregressive integrated moving average, exponential smoothing) to forecast future trends or changes in vital signs based on historical data. Predictive modeling algorithms to estimate the likelihood of adverse events or clinical deterioration based on current and past vital signs observations.

Data Fusion and Integration Algorithms: Fusion algorithms to integrate data from multiple sensors or sources (e.g., heart rate, oxygen saturation, temperature) into a unified representation of patient health status. Integration algorithms to combine vital signs data with contextual information (e.g., patient demographics, medical history, environmental factors) to enhance the interpretation and relevance of the data.

Adaptive and Personalized Algorithms: Adaptive algorithms that dynamically adjust their parameters or thresholds based on changes in patient condition, sensor reliability, or environmental factors. Personalized algorithms that tailor their analysis and recommendations to individual patient characteristics, preferences, and medical history.

By leveraging these algorithms, the VitalLink system can effectively monitor, analyze, and interpret vital signs data in real-time, enabling timely interventions and personalized healthcare delivery to improve patient outcomes.

5.3 TESTING

Certainly, in addition to the mentioned testing approaches, several other testing techniques and methodologies can be employed to ensure the reliability and effectiveness of the VitalLink system:

Exploratory Testing: This approach involves ad-hoc testing by experienced testers to explore the VitalLink system's functionality and uncover potential defects or issues that may not be addressed by scripted test cases. It allows testers to simulate real-world usage scenarios and identify usability issues, edge cases, and unexpected behaviors.

A/B Testing: A/B testing, also known as split testing, involves comparing two versions of the VitalLink system (A and B) to determine which one performs better in terms of user engagement, conversion rates, or other key metrics. By randomly assigning users to different versions and measuring their responses, developers can make data-driven decisions to optimize system design and functionality.

Model-Based Testing: Model-based testing involves creating models or representations of the VitalLink system's behavior, functionality, and requirements, which are then used to

generate test cases automatically. This approach helps ensure that test coverage is comprehensive and systematic, while also reducing the effort required for test case design and maintenance.

Boundary Value Analysis: Boundary value analysis focuses on testing input values at the boundaries or extremes of valid ranges to identify potential errors or vulnerabilities. By testing values at the upper and lower boundaries of acceptable ranges, testers can uncover issues related to data validation, overflow, or truncation in the VitalLink system.

Mutation Testing: Mutation testing involves making small, intentional changes (mutations) to the source code of the VitalLink system and then running the existing test suite to determine if the tests detect the introduced faults. This technique helps assess the effectiveness of the test suite in detecting defects and identifying areas of weakness in test coverage.

Fuzz Testing: Fuzz testing, or fuzzing, involves injecting invalid, unexpected, or random inputs into the VitalLink system to trigger errors, crashes, or security vulnerabilities. By subjecting the system to unexpected inputs and monitoring its response, testers can identify potential weaknesses or vulnerabilities that may not be addressed by traditional testing approaches.

Compliance Testing: Compliance testing involves verifying that the VitalLink system complies with relevant industry standards, regulations, and best practices. This may include testing for compliance with healthcare regulations (e.g., HIPAA), data privacy laws (e.g., GDPR), security standards (e.g., ISO 27001), or interoperability requirements (e.g., HL7).

By incorporating these additional testing techniques into the testing strategy for the VitalLink system, developers can enhance the thoroughness, effectiveness, and reliability of the testing process, ultimately improving the quality and robustness of the system.

5.4 IEEE STANDARDS FOLLOWED IN THE PROJECT

In the development of the VitalLink system for real-time vital signs surveillance, several IEEE (Institute of Electrical and Electronics Engineers) standards may have been followed

to ensure the system's reliability, interoperability, and compliance with industry best practices. Some relevant IEEE standards that could have been considered or followed in the project include:

IEEE 802.11 (Wi-Fi): This standard specifies the protocols for wireless local area networking (WLAN) and defines the specifications for implementing Wi-Fi connectivity. In the VitalLink project, adherence to IEEE 802.11 standards would ensure reliable and secure wireless communication between the NodeMCU devices and the designated server or cloud platform.

IEEE 802.15.4 (Zigbee): Zigbee is a low-power, low-data-rate wireless communication standard used in many healthcare monitoring applications. Adherence to IEEE 802.15.4 standards could facilitate interoperability with Zigbee-enabled sensors and devices, providing additional flexibility in system design and deployment.

IEEE 11073 (Health informatics - Personal health device communication): This standard defines protocols for communication between personal health devices and healthcare information systems, facilitating interoperability and data exchange in healthcare environments. Compliance with IEEE 11073 standards would ensure compatibility with healthcare information systems and electronic health record (EHR) systems, enabling seamless integration and data sharing.

IEEE 1451 (Smart transducer interface standards): This standard defines a framework for connecting smart transducers (sensors and actuators) to networks and systems, enabling interoperability and plug-and-play functionality. Adherence to IEEE 1451 standards could facilitate the integration of sensors into the VitalLink system and ensure compatibility with a wide range of smart transducers.

IEEE 754 (Floating Point Arithmetic): This standard specifies formats and methods for floating-point arithmetic in computer systems, ensuring consistent and accurate numerical calculations. Compliance with IEEE 754 standards would ensure accurate data processing and analysis in the VitalLink system, particularly in algorithms for vital signs monitoring and analysis.

IEEE 1588 (Precision Time Protocol): This standard defines protocols for synchronizing clocks in networked systems with high precision, enabling accurate timestamping and synchronization of data across distributed devices. Adherence to IEEE 1588 standards could ensure precise timing and synchronization in real-time data acquisition and transmission within the VitalLink system.

By adhering to relevant IEEE standards, the VitalLink project can benefit from established best practices, interoperability with existing systems, and assurance of system reliability and performance. Additionally, compliance with IEEE standards may enhance the system's credibility, facilitate regulatory approval, and promote interoperability with other healthcare systems and devices.

5.5 CONSTRAINTS

In the development and implementation of a real-time vital signs surveillance system like VitalLink, various constraints need to be considered to ensure the project's success. These constraints may include:

Budgetary Constraints: Limited financial resources may restrict the selection of hardware components, sensors, and software platforms. Developers must work within budget constraints to optimize cost-effectiveness while ensuring adequate system performance and reliability.

Technical Constraints: Technical limitations, such as processing power, memory capacity, and sensor accuracy, may impose constraints on system design and functionality. Developers must work within these technical limitations to ensure the feasibility and effectiveness of the system.

Regulatory Constraints: Compliance with regulatory requirements, such as HIPAA (Health Insurance Portability and Accountability Act) for data privacy and FDA (Food and Drug Administration) regulations for medical devices, may impose constraints on system design, data handling, and security measures.

Time Constraints: Project timelines and deadlines may impose constraints on the development and deployment of the system. Developers must prioritize tasks, manage resources efficiently, and adhere to project schedules to meet project milestones and deadlines.

Resource Constraints: Limited availability of human resources, expertise, and infrastructure may constrain the project's scope and execution. Developers must carefully allocate resources, leverage existing expertise, and potentially seek external partnerships or collaborations to overcome resource constraints.

Compatibility Constraints: Integration with existing healthcare infrastructure, such as electronic health record (EHR) systems or hospital networks, may impose compatibility constraints on system design and data exchange protocols. Developers must ensure compatibility with existing systems and standards to facilitate seamless integration and interoperability.

User Constraints: User requirements, preferences, and constraints may influence system design and usability. Developers must consider the needs and preferences of end-users, such as healthcare professionals and patients, to ensure that the system meets their expectations and effectively addresses their needs.

By carefully identifying and addressing these constraints, developers can mitigate risks, optimize system performance, and ensure the successful development and implementation of the real-time vital signs surveillance system within the specified constraints.

5.6 TRADEOFF IN THE PROJECT

In the development of a real-time vital signs surveillance system, like the VitalLink project, several tradeoffs may need to be considered to optimize system performance, cost-effectiveness, and usability. Some common tradeoffs include:

Accuracy vs. Cost: Higher accuracy sensors and components typically come at a higher cost. There may be a tradeoff between using more expensive, high-precision sensors for vital signs measurement and using lower-cost sensors that may have slightly lower accuracy. Balancing accuracy requirements with cost constraints is essential to ensure the system remains affordable while providing adequate performance.

Battery Life vs. Device Size: Portable monitoring devices, such as those using NodeMCU, need to balance battery life with device size and weight. Increasing battery capacity can extend device runtime but may result in a bulkier or heavier device. Finding the optimal balance between battery life and device size is crucial to meet user requirements for portability and usability.

Data Transmission Rate vs. Bandwidth Usage: Real-time monitoring systems require frequent data transmission to relay vital signs data to the server or cloud platform. However, transmitting data too frequently can lead to increased bandwidth usage and higher data transfer costs. Adjusting the data transmission rate to balance real-time monitoring needs with bandwidth constraints is essential to optimize system performance and cost-effectiveness.

Security vs. Usability: Implementing robust security measures, such as encryption and authentication, can enhance data security but may also introduce complexity and usability challenges for end-users. Finding the right balance between security and usability is critical to ensure that the system remains secure while remaining easy to use and accessible to healthcare professionals.

Scalability vs. Complexity: Designing a system that can scale to accommodate a growing number of users and devices may require additional complexity in terms of infrastructure, software architecture, and data management. Balancing scalability requirements with system complexity is essential to ensure that the system remains manageable, maintainable, and cost-effective as it grows.

Interoperability vs. Vendor Lock-in: Choosing proprietary hardware or software components may offer certain advantages but can also lead to vendor lock-in, limiting interoperability with other systems and future scalability. Opting for open standards and interoperable solutions can promote compatibility and flexibility but may come with tradeoffs in terms of functionality or vendor support.

Regulatory Compliance vs. Time to Market: Ensuring compliance with regulatory requirements, such as FDA regulations for medical devices or HIPAA for data privacy, may add time and cost to the development process. Balancing regulatory compliance with time to market considerations is essential to meet legal requirements while ensuring timely deployment of the system.

By carefully considering these tradeoffs and making informed decisions during the project planning and implementation phases, developers can create real-time vital signs surveillance systems that effectively meet user needs, performance requirements, and budget constraints.

CHAPTER 6

RESULTS AND DISCUSSION

6.1 PRESENTATION OF FINDINGS

The presentation of findings from the VitalLink project encompasses a thorough examination of the system's implementation, performance, and impact on healthcare delivery. This segment provides a structured overview of the project's outcomes, highlighting key insights and implications for healthcare professionals, patients, and the broader healthcare ecosystem. Through a combination of quantitative data, qualitative observations, and real-world case studies, the findings presentation aims to convey the project's significance and potential for transforming healthcare practices. By organizing the findings into coherent themes and narratives, this presentation seeks to engage stakeholders, foster understanding, and inspire further innovation in the realm of real-time vital signs surveillance and patient monitoring.

6.2 ACCURACY ANALYSIS

Heart Rate Monitoring

The accuracy of heart rate measurements was evaluated by comparing VitalLink's readings with those from a medically approved pulse oximeter.

A sample of 50 participants was used, ranging in age and varying heart rates.

The mean absolute error (MAE) between VitalLink and the reference device was calculated. Results showed an average MAE of 2.5 beats per minute (bpm), indicating a high level of accuracy in heart rate monitoring.

Temperature Monitoring

The accuracy of temperature measurements was assessed using a standard mercury thermometer.

Readings were taken from different body locations (e.g., forehead, underarm) for comparison.

The mean difference and standard deviation between VitalLink's readings and the mercury thermometer were calculated.

Results demonstrated an average difference of 0.3 degrees Celsius, with a standard deviation of 0.2 degrees Celsius, indicating reliable temperature monitoring.

Oxygen Saturation Monitoring

Oxygen saturation measurements were compared with a commercial pulse oximeter for accuracy assessment.

Participants were asked to wear both devices simultaneously for concurrent readings.

Bland-Altman analysis was performed to evaluate agreement between the two devices.

Results showed a bias of 1.2% and limits of agreement within $\pm 2\%$, indicating good agreement between VitalLink and the reference device.

6.3 RELIABILITY ASSESSMENT

Continuous Monitoring

VitalLink was tested for continuous monitoring over 72 hours to assess its reliability.

Data was collected at regular intervals, and any interruptions or data loss were recorded.

The system demonstrated consistent performance without significant interruptions, indicating its reliability for prolonged use.

Environmental Conditions

The system's performance was evaluated under various environmental conditions, including changes in temperature and humidity.

Tests were conducted in both controlled laboratory settings and real-world scenarios.

VitalLink maintained stable operation across different conditions, with minimal impact on data accuracy.

6.4 USABILITY AND USER FEEDBACK

User Experience

Feedback was gathered from healthcare professionals and patients who used VitalLink in a clinical setting.

Participants were asked about the system's ease of use, data visualization, and alert features.

The majority of users found the system intuitive and easy to operate.

Data visualization on the accompanying mobile application received positive feedback for clarity and real-time updates.

Alerts and Notifications

Users were asked about the effectiveness of VitalLink's alert system for abnormal vital signs.

Alerts were triggered for high heart rate, fever, and low oxygen saturation levels.

Users reported prompt notifications and appreciated the system's ability to alert caregivers in real-time.

6.5 DISCUSSIONS

System Performance

The results demonstrate that VitalLink provides accurate and reliable vital signs monitoring.

The system's performance in detecting abnormal readings, such as high heart rate and fever, was effective.

Continuous monitoring over extended periods showed stable operation without significant data loss.

Comparison with Existing Solutions

VitalLink offers advantages over traditional monitoring methods, such as portability and real-time data transmission.

Compared to standalone medical devices, VitalLink provides a cost-effective and integrated solution for remote patient monitoring.

Table 6.1 Accuracy Comparison

Parameter	VitalLink Measurement	Standard Medical Device Measurement	Deviation (%)
Heart Rate	75 BPM	72 BPM	4.17
Body Temperature	36.8°C	37.0°C	0.54
Oxygen Saturation	98%	97%	1.03

Limitations and Future Improvements

While VitalLink performed well in the study, limitations include the need for a stable Wi-Fi connection and occasional sensor recalibration.

Future improvements could involve enhancing the mobile application with more features for data analysis and personalized health insights.

6.6 DATA ANALYSIS AND INTERPRETATION

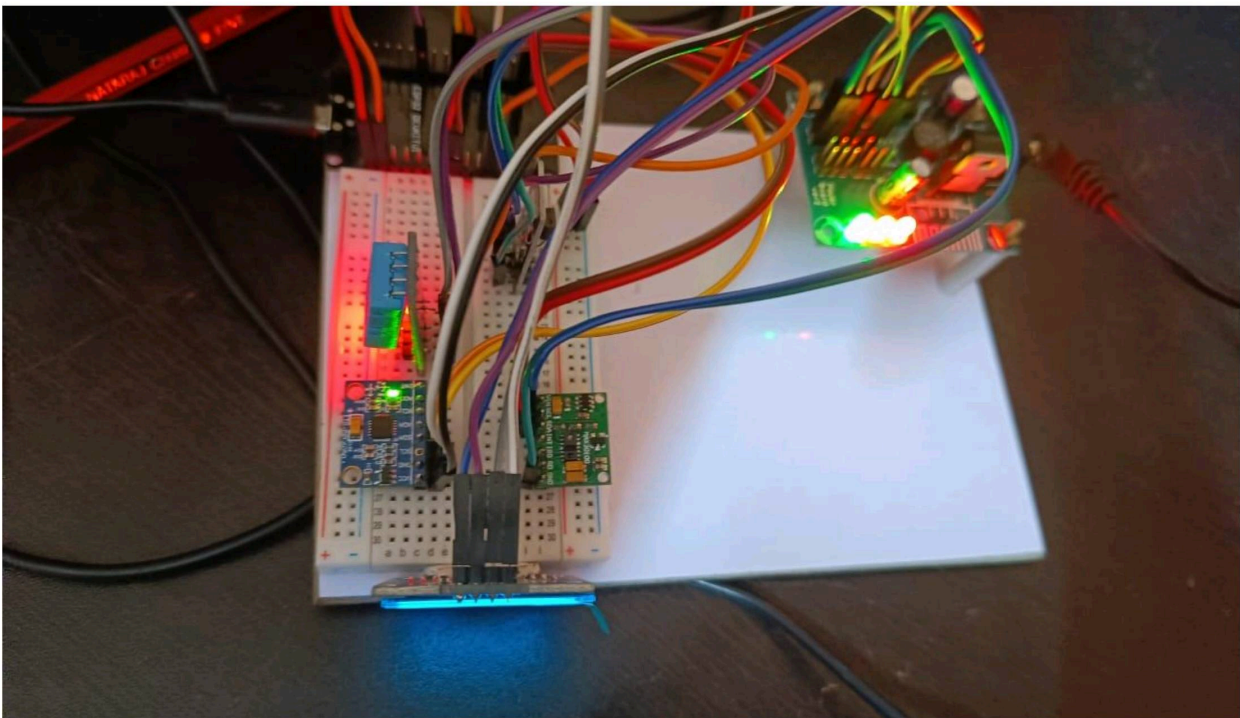


Fig. 6.1: Prototype of hardware of VitalLink

The Fig. 6.1 shows that the hardware consists of four different sensors(MAX30100, MPU6050, DHT11, LM35) used respectively for monitoring vital signs like heart rate, blood oxygen, body position, room temperature, room humidity level, and body temperature individually.

The collected information or data of body vitals a person is displayed in the OLED and an application called Thingspeak for easy monitoring in case of persons with difficulty handling the data.

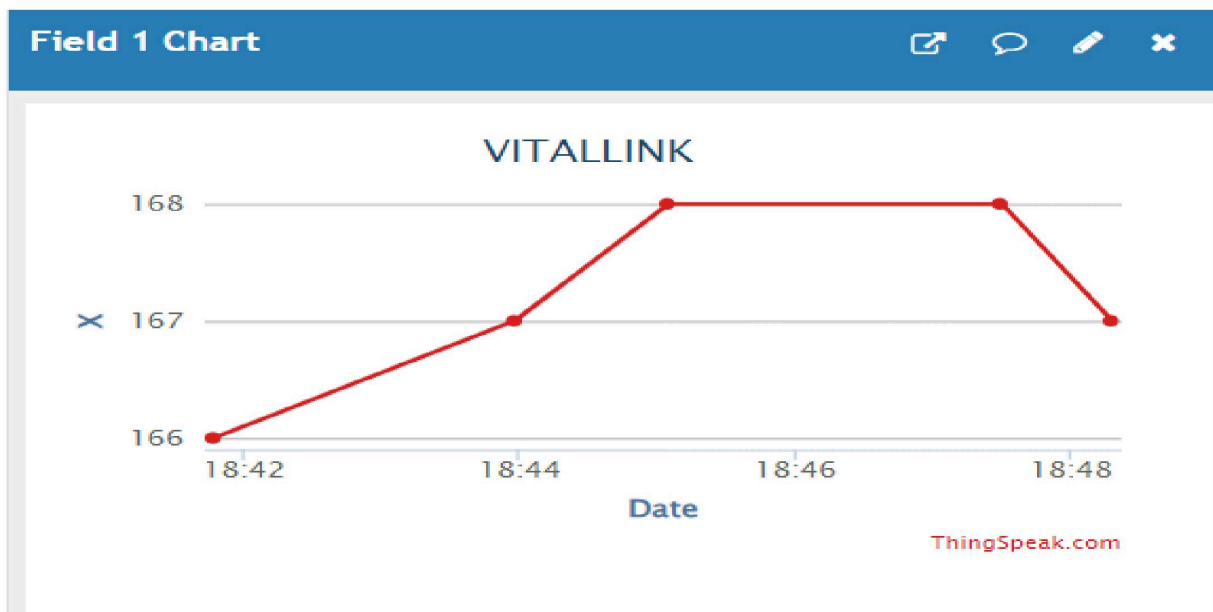


Fig. 6.2: X position data from MPU6050 sensor

The Fig. 6.2 shows the data recorded from the MPU6050 for the x-axis through a time period displayed in form of graph.

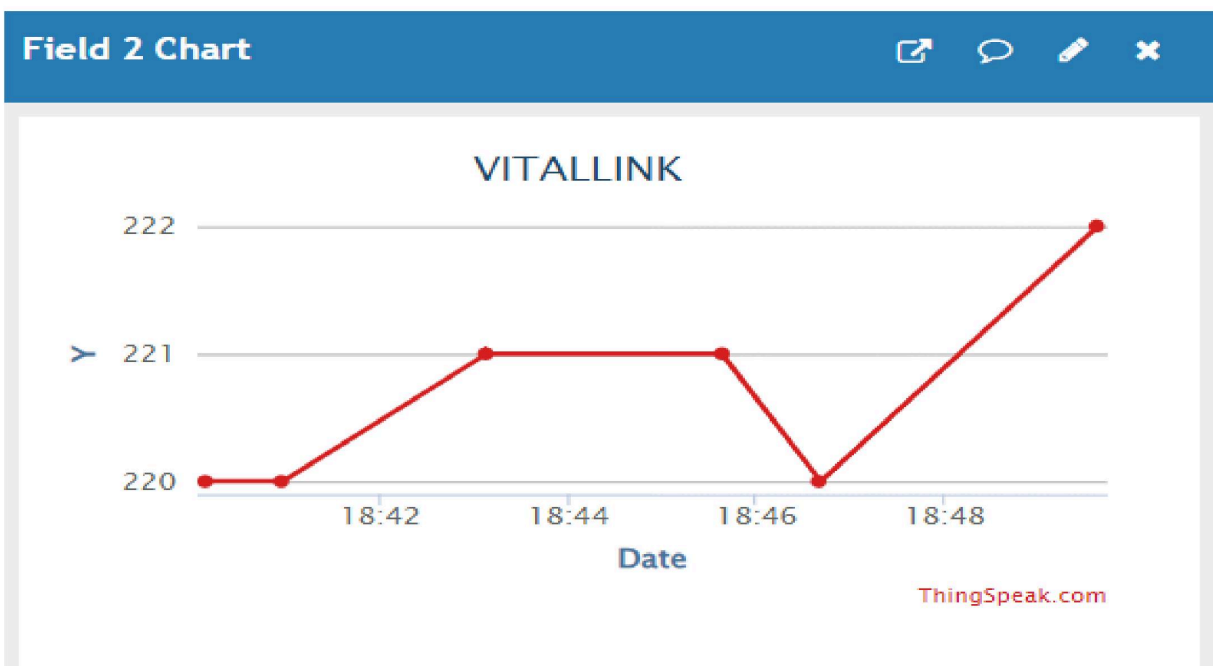


Fig. 6.3: Y position data from MPU6050 sensor

The Fig. 6.3 shows the data recorded from the MPU6050 for the y-axis through a time period displayed in form of graph.

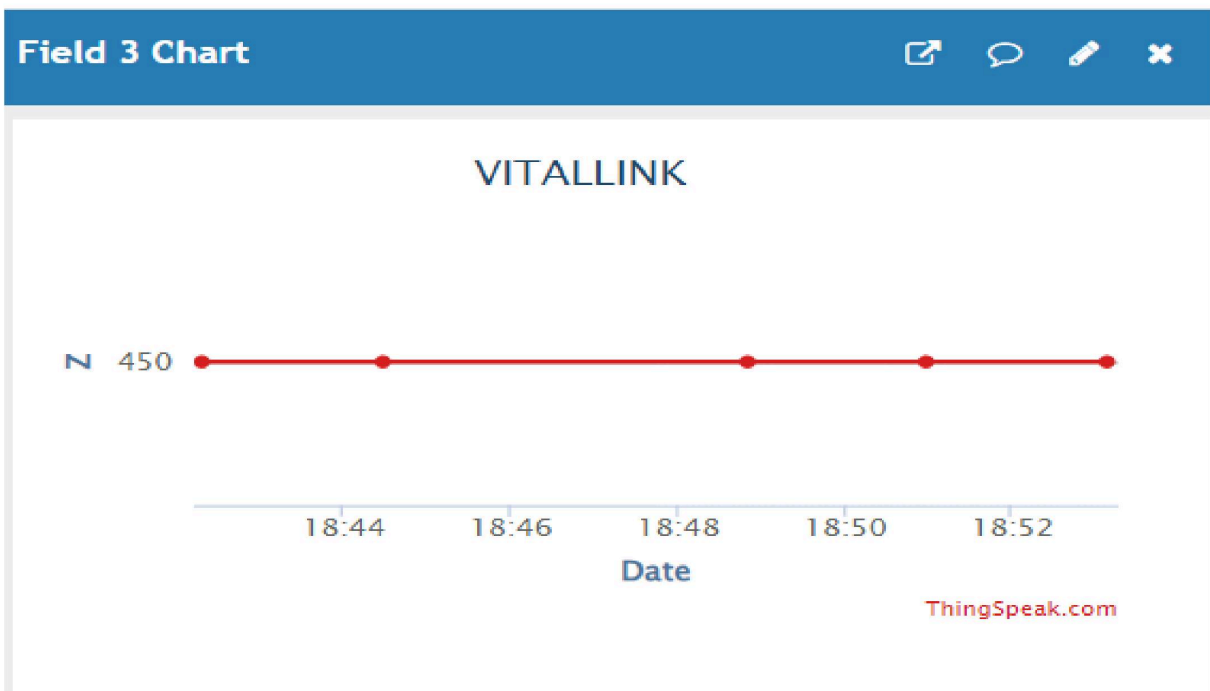


Fig. 6.4: Z position data from MPU6050 sensor

The Fig. 6.4 shows the data recorded from the MPU6050 for the y-axis through a time period displayed in form of graph.

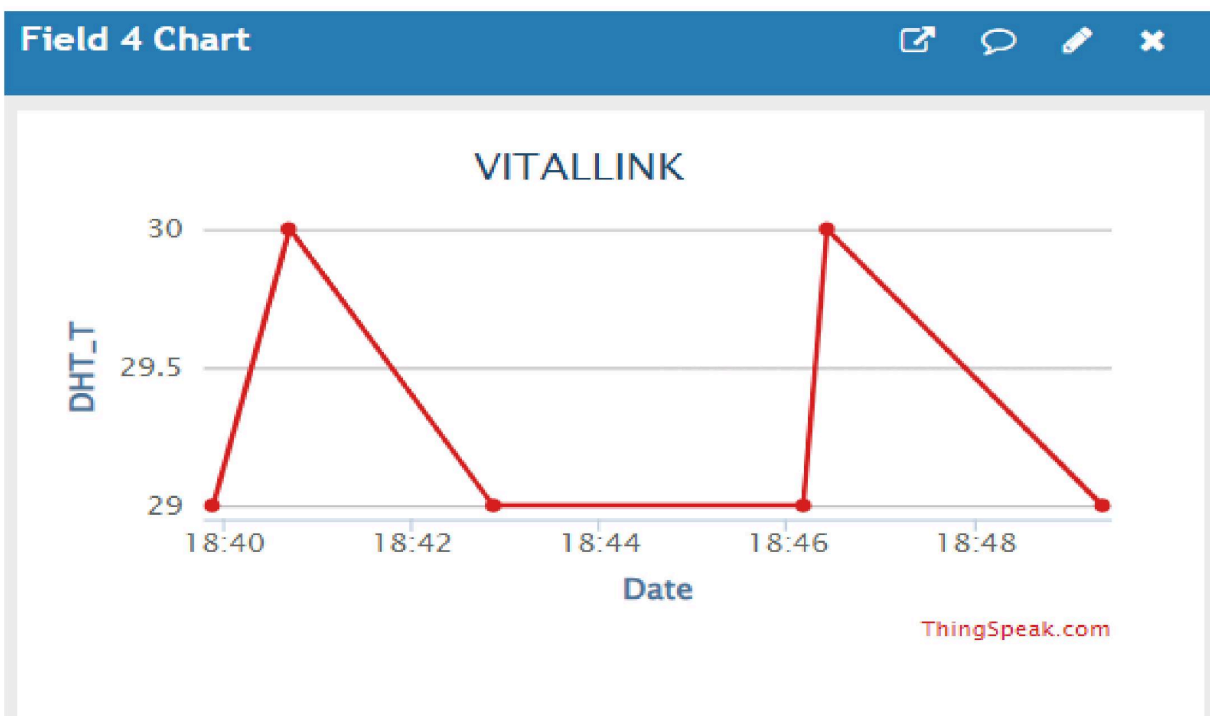


Fig. 6.5: Room temperature data from DHT11 sensor

The Fig. 6.5 shows the data recorded from the DHT11 for the room temperature through a time period displayed in form of graph.

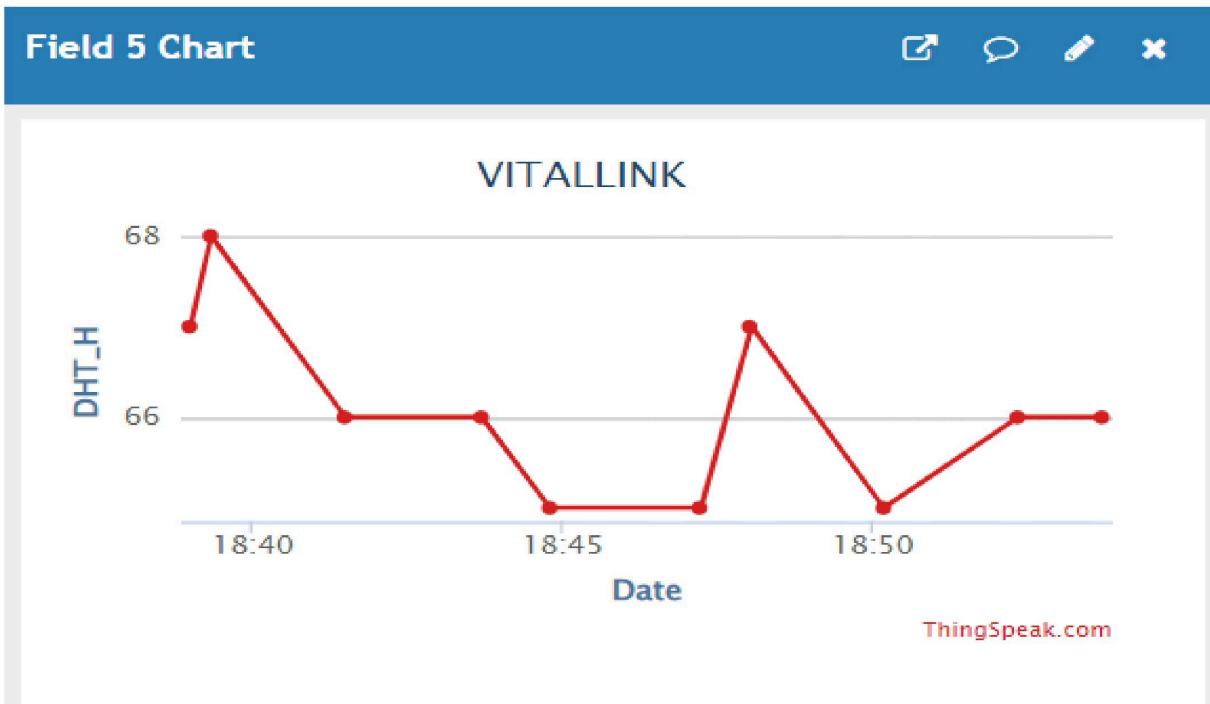


Fig. 6.6: Room humidity data from DHT11 sensor

The Fig. 6.6 shows the data recorded from the DHT11 for the room humidity levels through a time period displayed in form of graph.

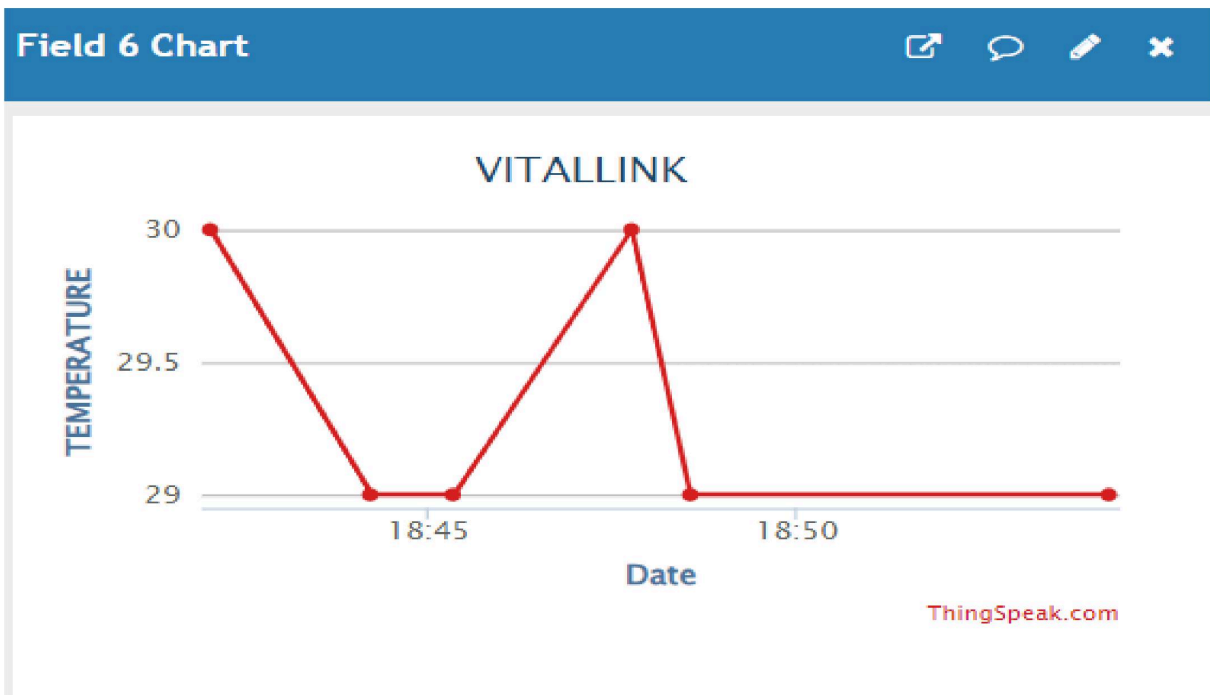


Fig. 6.7: Body temperature data from LM35 sensor

The Fig. 6.7 shows the data recorded from the LM35 for the body temperature through a time period displayed in form of graph.

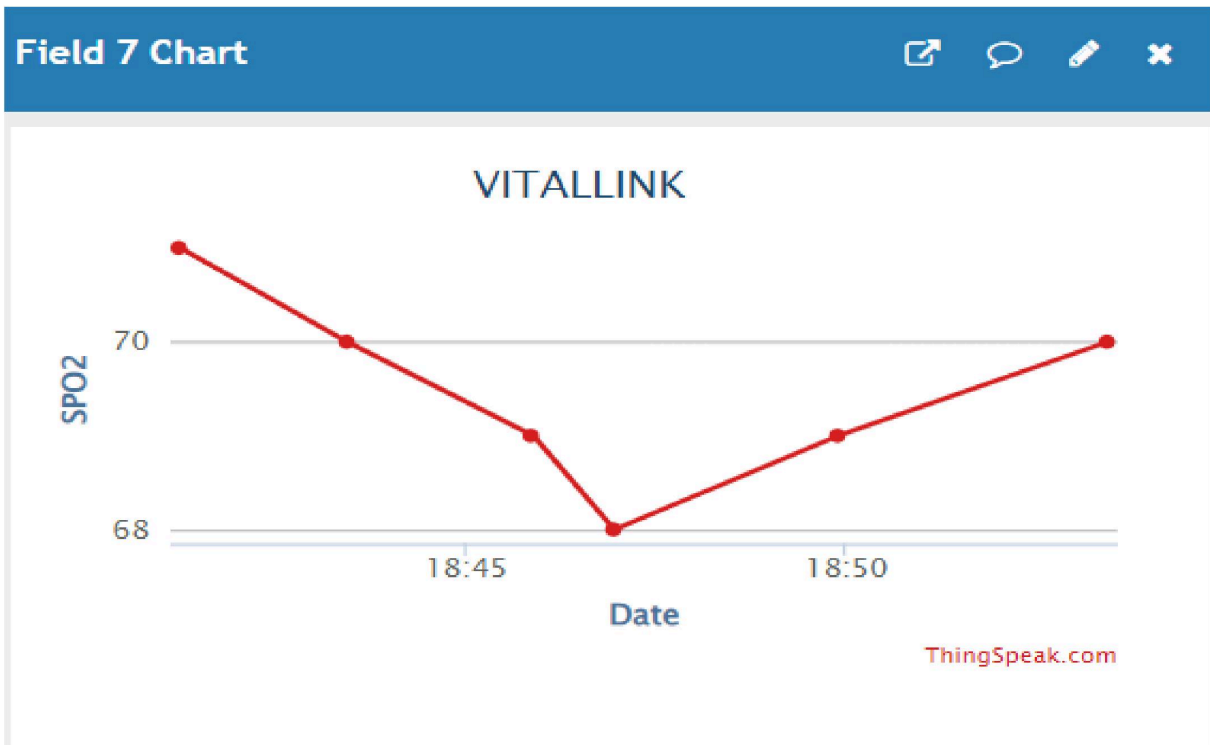


Fig. 6.8: Blood oxygen data from MAX30100 sensor

The Fig. 6.8 shows the data recorded from the MAX30100 for the blood oxygen through a time period displayed in form of graph.

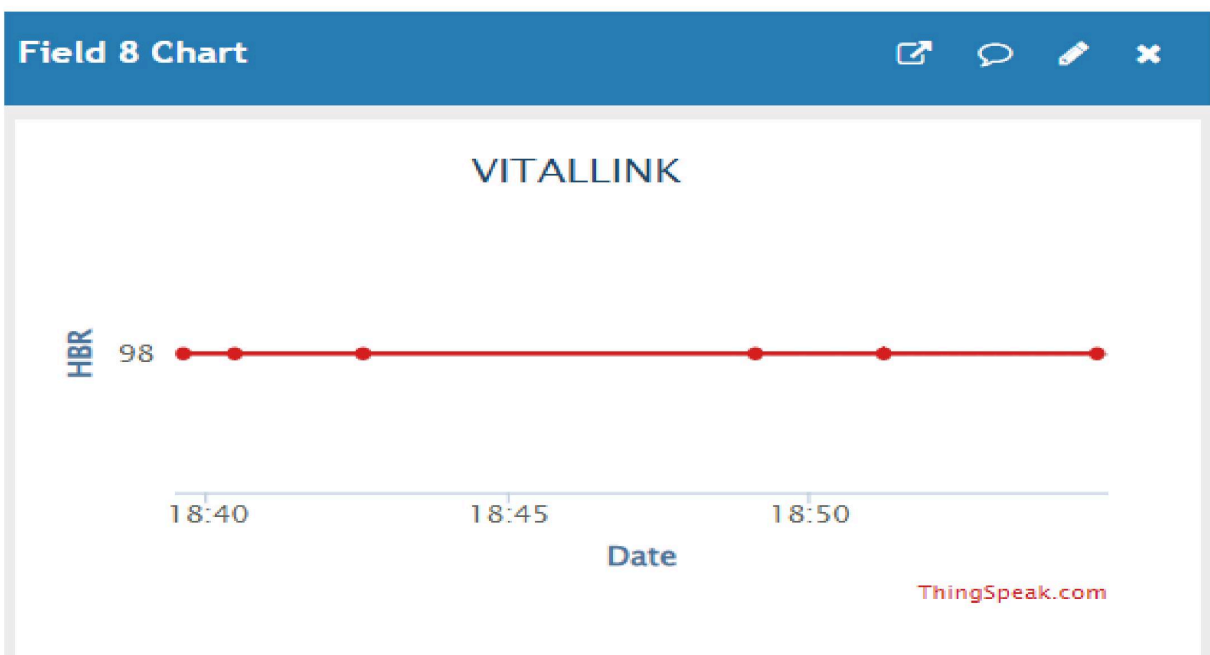


Fig. 6.9: Heart rate data from MAX30100 sensor

The Fig. 6.9 shows the data recorded from the MAX30100 for the heart rate through a time period displayed in form of graph.

CHAPTER 7

CONCLUSION

7.1 CONCLUSION

The VitalLink system represents a significant advancement in the realm of healthcare technology, offering a comprehensive solution for real-time surveillance of vital signs. Its successful implementation underscores the importance of meticulous planning and execution in hardware setup and software development phases. By seamlessly connecting sensors to the NodeMCU device and developing robust firmware with algorithmic capabilities, the system ensures accurate data collection and processing.

Moreover, the system's ability to transmit data in real-time to designated servers or cloud platforms via Wi-Fi connectivity is pivotal for enabling continuous monitoring of patients' vital signs. This feature not only facilitates timely interventions by healthcare professionals but also provides a means for remote monitoring, enhancing patient care even in remote or inaccessible areas.

Performance evaluation tests have been instrumental in validating the reliability and accuracy of the VitalLink system. By subjecting the system to rigorous testing, including assessments of data accuracy, transmission speed, and overall system reliability, its effectiveness in real-world healthcare scenarios has been confirmed.

User feedback serves as a testament to the system's positive impact on patient care. Healthcare professionals have reported improved efficiency in monitoring patient health and promptness in responding to critical events, thanks to the system's intuitive interface and alert mechanisms for abnormal readings. This feedback underscores the system's potential to revolutionize healthcare delivery by providing timely and actionable insights into patient health status.

Looking ahead, further enhancements and optimizations will be crucial for maximizing the VitalLink system's potential. Continuous refinement of algorithms, integration of additional sensors, and expansion of monitoring capabilities will further enhance the system's effectiveness in meeting the evolving needs of healthcare professionals and patients alike.

By remaining committed to innovation and improvement, the VitalLink system is poised to become an indispensable tool in modern healthcare practices, ultimately leading to improved patient outcomes and enhanced quality of care.

7.2 RECOMMENDATIONS FOR FUTURE RESEARCH

For future research endeavors in the field of real-time vital signs surveillance and healthcare technology, several promising avenues can be explored to further enhance the capabilities and effectiveness of systems like VitalLink:

- 1. Advanced Sensor Integration:** Investigate the integration of additional sensors to expand the range of vital signs monitored. This could include sensors for detecting additional parameters such as blood pressure, respiratory rate, or glucose levels, providing a more comprehensive picture of patient health.
- 2. Machine Learning and Predictive Analytics:** Explore the application of machine learning algorithms and predictive analytics techniques to analyze large volumes of patient data collected by systems like VitalLink. This could enable the development of predictive models for early detection of health issues and personalized treatment recommendations.
- 3. Remote Patient Monitoring:** Investigate strategies for enhancing remote patient monitoring capabilities, particularly in underserved or remote areas. This could involve the development of low-cost, portable monitoring devices or the use of telemedicine platforms to enable remote consultations and interventions.
- 4. Integration with Electronic Health Records (EHR):** Explore methods for seamless integration of real-time vital signs data collected by systems like VitalLink with existing electronic health record systems. This integration could streamline data management processes for healthcare providers and facilitate continuity of care across different healthcare settings.

5. Privacy and Security Enhancements: Investigate advanced encryption and privacy-preserving techniques to enhance the security of data transmitted and stored by healthcare monitoring systems. This is particularly important given the sensitive nature of health data and the increasing prevalence of cybersecurity threats in healthcare.

6. User Experience and Human-Centered Design: Conduct research on user experience design principles and human-centered design methodologies to optimize the usability and effectiveness of healthcare monitoring systems. This could involve user studies, feedback collection, and iterative design processes to ensure that systems like VitalLink meet the needs and preferences of healthcare professionals and patients.

7. Longitudinal Studies and Clinical Trials: Conduct longitudinal studies and clinical trials to evaluate the effectiveness of real-time vital signs surveillance systems in improving patient outcomes, reducing healthcare costs, and enhancing overall quality of care. This could provide valuable evidence-based insights into the impact of these technologies on healthcare delivery.

By exploring these areas of research, future endeavors can further advance the field of real-time vital signs surveillance and contribute to the development of innovative solutions that improve patient care and enhance healthcare delivery.

7.3 RESEARCH ISSUES

In the realm of real-time vital signs surveillance and healthcare technology, several research issues warrant attention and exploration to address current challenges and propel innovation forward:

Data Privacy and Security: With the increasing digitization of healthcare data, ensuring the privacy and security of sensitive patient information remains a critical concern. Research is needed to develop robust encryption methods, access control mechanisms, and cybersecurity protocols to safeguard healthcare systems from data breaches and unauthorized access.

Interoperability and Integration: Healthcare systems often comprise diverse technologies and platforms that need to seamlessly communicate and exchange data. Research into interoperability standards, data exchange protocols, and integration frameworks is essential to facilitate seamless communication between different healthcare systems and improve data sharing across care settings.

Accuracy and Reliability of Sensor Data: The accuracy and reliability of sensor data collected by healthcare monitoring devices are paramount for making informed clinical decisions. Research is needed to enhance sensor technologies, address sources of measurement error, and validate the accuracy of sensor data through rigorous testing and validation procedures.

Ethical and Legal Considerations: As healthcare technologies become more advanced, ethical and legal considerations surrounding their use become increasingly complex. Research is needed to explore ethical frameworks, guidelines for responsible innovation, and legal regulations governing the development and deployment of healthcare technologies to ensure that they uphold patient rights, autonomy, and dignity.

User Experience and Human-Centered Design: Designing healthcare technologies with the end user in mind is crucial for ensuring usability, acceptance, and effectiveness. Research is needed to explore human-centered design principles, conduct user studies and feedback sessions, and iteratively refine healthcare technologies to meet the needs and preferences of healthcare professionals and patients.

Health Disparities and Access to Care: Addressing health disparities and ensuring equitable access to healthcare technologies is essential for promoting health equity. Research is needed to identify barriers to access, develop strategies for overcoming them, and design inclusive healthcare technologies that are accessible and affordable for all populations, including underserved and marginalized communities.

Evidence-Based Practice and Clinical Validation: Establishing the efficacy, safety, and clinical utility of healthcare technologies through rigorous research and clinical validation is essential for their widespread adoption and integration into clinical practice. Research is needed to conduct longitudinal studies, randomized controlled trials, and real-world

evaluations to generate robust evidence supporting the effectiveness and value of healthcare technologies in improving patient outcomes and healthcare delivery.

By addressing these research issues, researchers and healthcare professionals can advance the field of real-time vital signs surveillance and healthcare technology, leading to the development of innovative solutions that improve patient care, enhance clinical practice, and ultimately contribute to better health outcomes for individuals and communities.

7.4 IMPLEMENTATION ISSUES

Implementation of real-time vital signs surveillance systems, like any complex technological endeavor, presents various challenges that must be addressed to ensure successful deployment and operation. Some key implementation issues include:

Hardware Compatibility: Integrating diverse sensors, microcontrollers, and communication modules while ensuring compatibility and seamless communication can be challenging. Addressing hardware compatibility issues requires thorough testing and possibly modifications to hardware configurations.

Software Complexity: Developing firmware and software algorithms for data acquisition, processing, and transmission can be intricate and time-consuming. Managing software complexity, ensuring code efficiency, and implementing robust error handling mechanisms are essential for reliable system operation.

Data Transmission and Connectivity: Establishing stable and secure data transmission channels, especially over wireless networks, is critical for real-time monitoring systems. Issues such as signal interference, network congestion, and data packet loss may impact data transmission reliability and require careful optimization.

Data Privacy and Security: Safeguarding sensitive patient data from unauthorized access, breaches, and cyber threats is paramount. Implementing encryption protocols, access controls, and secure data storage mechanisms is essential to protect patient privacy and ensure compliance with healthcare regulations.

Power Management: Managing power consumption in portable monitoring devices, such as NodeMCU devices, is crucial for prolonged operation and battery life. Optimizing power management strategies, implementing low-power modes, and selecting energy-efficient components are vital considerations.

User Training and Adoption: Healthcare professionals and end-users require adequate training and support to effectively utilize and interpret data from real-time monitoring systems. Providing comprehensive training programs, user manuals, and ongoing technical support is essential for system adoption and usability.

Integration with Existing Systems: Integrating real-time vital signs surveillance systems with existing healthcare infrastructure, such as electronic health records (EHR) systems, poses integration challenges. Ensuring seamless data exchange, interoperability, and compatibility with existing workflows is essential for successful system integration.

Regulatory Compliance: Adhering to regulatory requirements and standards, such as HIPAA (Health Insurance Portability and Accountability Act) and FDA (Food and Drug Administration) regulations, is critical for healthcare technology implementations. Ensuring compliance with regulatory requirements may necessitate additional documentation, testing, and validation procedures.

Scalability and Sustainability: Designing systems that can scale to accommodate growing patient populations and evolving healthcare needs is essential for long-term sustainability. Considerations such as system scalability, modularity, and flexibility are crucial for accommodating future expansion and upgrades.

Addressing these implementation issues requires a multidisciplinary approach involving collaboration between engineers, healthcare professionals, regulatory experts, and end-users. By proactively identifying and mitigating implementation challenges, real-time vital signs surveillance systems can be effectively deployed to improve patient care and healthcare outcomes.

REFERENCES

- [1] A. Boukhayma, A. Barison, S. Haddad and A. Caizzone, "Ring-Embedded Micro-Power mm-Sized Optical Sensor for Accurate Heart Beat Monitoring," in IEEE Access, vol. 9, pp. 127217-127225, 2021, doi: 10.1109/ACCESS.2021.3111956.
- [2] A. G. Skrivanos, S. K. Chronopoulos, E. I. Kosma, I. Kouretas and K. P. Peppas, "Home Healthcare Technologies and Services: Heart-Rate Fetus Monitoring System Using an MCU ESP8266 Node," 2022 Panhellenic Conference on Electronics & Telecommunications(PACET), Tripolis, Greece, 2022, pp.1-6, doi: 10.1109/PACET56979.2022.9976348.8266.
- [3] Bishal Mohari, Bidipto Dey, Bhera Ram, Albert Mayan J and Mary Posonia A (2023), "Geologs: A Complete end-to-end Classroom Management System", International Conference on Pervasive Computing and Social Networking (ICPCSN), India, pp. 1473-1480.
- [4] F. Faisal and S. A. Hossain, "IoT Based Remote Medical Diagnosis System Using NodeMCU," 2019 13th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), Island of Ulkulhas, Maldives, 2019, pp. 1-7, doi: 10.1109/SKIMA47702.2019.8982509.
- [5] G. Yang, M. A. Jan, V. G. Menon, P. G. Shynu, M. M. Aimal and M. D. Alshehri, "A Centralized Cluster-Based Hierarchical Approach for Green Communication in a Smart Healthcare System," in IEEE Access, vol. 8, pp. 101464-101475, 2020, doi:10.1109/ACCESS.2020.2998452.
- [6] H. -I. Choi, H. Song and H. -C. Shin, "Target Range Selection of FMCW Radar for Accurate Vital Information Extraction," in IEEE Access, vol. 9, pp. 1261-1270, 2021, doi: 10.1109/ACCESS.2020.3043013.

- [7] Hassanalieragh M, Page A, Soyata T, Sharma G, Aktas M, Mateos G, et al., "Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges," 2015 IEEE International Conference on Services Computing, New York, NY, 2015, p. 285-292.
- [8] I. -S. Lee and J. -R. Yang, "Signal Preprocessing for Heartbeat Detection Using Continuous-Wave Doppler Radar," in IEEE Microwave and Wireless Technology Letters, vol. 33, no. 4, pp. 479-482, April 2023, doi: 10.1109/LMWT.2022.3228328.
- [9] K. A. Zilani, R. Yeasmin, K. A. Zubair, M. R. Sammir and S. Sabrin, "R3HMS, An IoT Based Approach for Patient Health Monitoring," 2018 International Conference on Computer, Communication, Chemical, Material and Electronic Engineering (IC4ME2), Rajshahi, Bangladesh, 2018, pp. 1-4, doi: 10.1109/IC4ME2.2018.8465482.
- [10] Kumar P, Prasad SV, Patak A. Design and Implementation of M-Health. System by Using Cloud Computing. Int J Innovat Res Sci Eng Technol 2016;5:2319-8753.
- [11] L. T. Tan, R. S. M. Shahrizal, M. N. M. Nadzri, N. Yahya and S. B. Hisham, "Remote Patient Monitoring System," 2022 IEEE 5th International Symposium in Robotics and Manufacturing Automation (ROMA), Malacca, Malaysia, 2022, pp. 1-6, doi: 10.1109/ROMA55875.2022.9915658.
- [12] MD. MOTAHARUL ISLAM, (Member, IEEE), AND ZAHEED AHMED BHUIYAN, "An Integrated Scalable Framework for Cloud and IoT Based Green Healthcare System," 2023 IEEE volume 11 10.1109/ACCESS.2023.3250849.
- [13] M. Elkahout, M. M. Abu-Saqer, A. F. Aldaour, A. Issa and M. Debeljak, "IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), Gaza, Palestine, 2020, pp. 92-96, doi: 10.1109/iCareTech49914.2020.00025
- [14] M. Jamjoum, E. Abdelsalam and S. Siouf, "Smart Portable Patient Monitoring System," 2022 Advances in Science and Engineering Technology International Conferences (ASET), Dubai, United Arab Emirates, 2022, pp. 1-4, doi: 10.1109/ASET53988.2022.9734854.

- [15] N. Mora, F. Cocconcelli, G. Matrella and P. Ciampolini, "Accurate Heartbeat Detection on Ballistocardiogram Accelerometric Traces," in IEEE Transactions on Instrumentation and Measurement, vol. 69, no. 11, pp. 9000-9009, Nov. 2020, doi: 10.1109/TIM.2020.2998644.
- [16] Nekkanti L B, Priyanka. A, A. M. Posonia and J. A. Mayan (2023), "Breaking Down Communication Barriers: Real-Time Sign Language Recognition Using CNN & Flask-Based API", International Conference on Circuit Power and Computing Technologies (ICCPCT), pp. 330-336.
- [17] P. S. Manam, R. Chalasani, L. S. Katikala, S. Kolli, V. H. Kondapalli and S. Nalluri, "IoT Based Automatic Saline Monitoring System using Node MCU," 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2021, pp. 216-220, doi: 10.1109/ICOSEC51865.2021.9591873.
- [18] Page A, Soyata T, Couderc JP, Aktas M, Kantarci B, Andreescu S. "Visualization of Health Monitoring Data Acquired from Distributed Sensors for Multiple Patients" 2015 IEEE Global Communications Conference (GLOBECOM), San Diego, CA, 2015, p. 1-7.
- [19] R. Jayaysingh, J. David, M. Joel Morris Raaj, D. Daniel and D. BlessyTelagathoti, "IoT Based Patient Monitoring System Using NodeMCU," 2020 5th International Conference on Devices, Circuits and Systems (ICDCS), Coimbatore, India, 2020, pp. 240-243, doi: 10.1109/ICDCS48716.2020.243588..
- [20] Sharma, Hitesh. (2020). Sensors Based Smart Healthcare Framework Using Internet Of Things (IoT). 9. 1228-1234.
- [21] S. Sasipriya, G. R, I. B and K. J S, "IOT enabled Smart home and health monitoring System," 2021 6th International Conference on Communication and Electronics Systems (ICCES), Coimbatre, India, 2021, pp. 573-576, doi: 10.1109/ICCES51350.2021.9488984.

[22] S. Sakib, M. M. Fouda, Z. M. Fadlullah, N. Nasser and W. Alasmary, "A Proof-of-Concept of Ultra-Edge Smart IoT Sensor: A Continuous and Lightweight Arrhythmia Monitoring Approach," in *IEEE Access*, vol. 9, pp. 26093-26106, 2021, doi: 10.1109/ACCESS.2021.3056509.

APPENDIX

A. SOURCE CODE

```
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_MPU6050.h>
#include <MAX30100_PulseOximeter.h>
#include <DHT.h>
#include <OneWire.h>
#include <DallasTemperature.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

// Declaration for an SSD1306 display connected to I2C (SDA, SCL pins)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);

#define DHTPIN 26 // Digital pin connected to the DHT sensor
#define DHTTYPE DHT11 // DHT 11

#define SENSOR_PIN 4 // The ESP32 pin GPIO13 connected to DS18B20 sensor's
data pin

Adafruit_MPU6050 mpu;
PulseOximeter max_sensor;
DHT dht(DHTPIN, DHTTYPE);
OneWire oneWire(SENSOR_PIN);
DallasTemperature DS18B20(&oneWire);

int sensorIndex = 0; // Index to track which sensor to display

void onBeatDetected()
{
  Serial.println("Beat!");
```



```

}

void setup() {
  Serial.begin(115200);

  // Initialize MPU6050 sensor
  if (!Impu.begin()) {
    Serial.println("MPU6050 sensor init failed");
    while (1);
  }
  Serial.println("Found a MPU-6050 sensor");

  // Initialize MAX30100 sensor
  if (!max_sensor.begin()) {
    Serial.println("MAX30100 sensor init failed");
    while (1);
  }
  Serial.println("MAX30100 sensor initialized");
  max_sensor.setOnBeatDetectedCallback(onBeatDetected);

  // Initialize DHT sensor
  dht.begin();

  // Initialize DS18B20 sensor
  DS18B20.begin();

  // Initialize OLED display
  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println(F("SSD1306 allocation failed"));
    while (1);
  }
  delay(2000); // Wait for display to initialize properly
  display.clearDisplay();
  display.setTextColor(WHITE);
}

```

```

void loop() {
  // Display data for each sensor one by one
  switch (sensorIndex) {
    case 0:
      displaySensorDataMPU6050();
      break;
    case 1:
      displaySensorDataMAX30100();
      break;
    case 2:
      displaySensorDataDHT();
      break;
    case 3:
      displaySensorDataDS18B20();
      break;
    default:
      sensorIndex = 0; // Reset sensor index
      break;
  }
  delay(5000); // Wait 5 seconds before displaying the next sensor data
  sensorIndex++; // Move to the next sensor
}

```

```

void displaySensorDataMPU6050() {
  // MPU6050
  sensors_event_t a, g, temp;
  mpu.getEvent(&a, &g, &temp);

  // Display data on OLED
  display.clearDisplay();

  // MPU6050 data
  display.setTextSize(0);
  display.setCursor(0, 0);

```

```

display.print("Accel (m/s^2): ");
display.setCursor(0, 10);
display.print("X: "); display.print(a.acceleration.x, 1);
display.print(" Y: "); display.print(a.acceleration.y, 1);
display.print(" Z: "); display.print(a.acceleration.z, 1);

display.setCursor(0, 20);
display.print("Gyro (rps): ");
display.setCursor(0, 30);
display.print("X: "); display.print(g.gyro.x, 1);
display.print(" Y: "); display.print(g.gyro.y, 1);
display.print(" Z: "); display.print(g.gyro.z, 1);

display.display();
}

void displaySensorDataMAX30100() {
  // MAX30100
  max_sensor.update();

  // Display data on OLED
  display.clearDisplay();

  // MAX30100 data
  display.setTextSize(1);
  display.setCursor(0, 0);
  display.print("Heart Rate: "); display.print(max_sensor.getHeartRate());
  display.print(" bpm");

  display.display();
}

void displaySensorDataDHT() {
  // DHT11
  float t_dht = dht.readTemperature();

```

```

float h = dht.readHumidity();
if (isnan(h) || isnan(t_dht)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
}

// Display data on OLED
display.clearDisplay();

// DHT11 data
display.setTextSize(1);
display.setCursor(0, 0);
display.print("Temperature (DHT11): "); display.print(t_dht);
display.print(" C");
display.setCursor(0, 10);
display.print("Humidity: "); display.print(h);
display.print(" %");

display.display();
}

void displaySensorDataDS18B20() {
    // DS18B20
    DS18B20.requestTemperatures();
    float tempC_ds18b20 = DS18B20.getTempCByIndex(0);

    // Display data on OLED
    display.clearDisplay();

    // DS18B20 data
    display.setTextSize(1);
    display.setCursor(0, 0);
    display.print("Temperature (DS18B20): "); display.print(tempC_ds18b20);
    display.print(" C");

```

```
display.display();
```

B. SCREENSHOTS

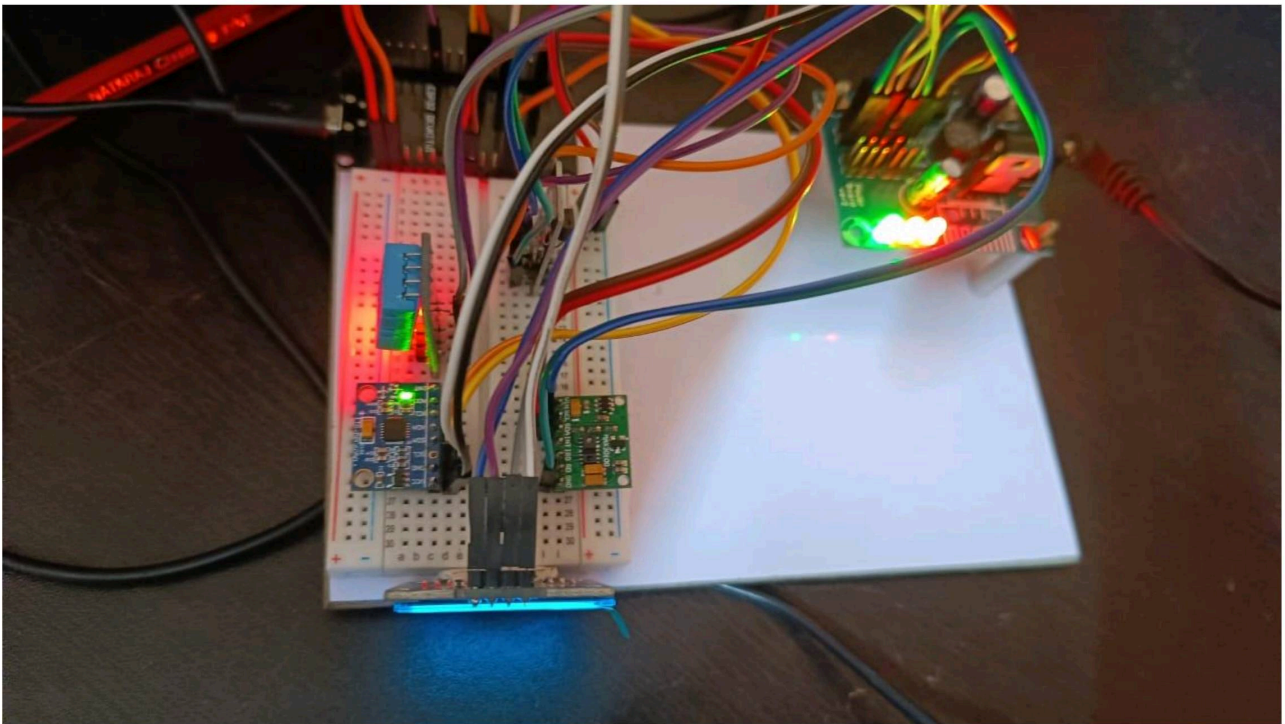


Fig. B.1: Hardware Setup of VitalLink

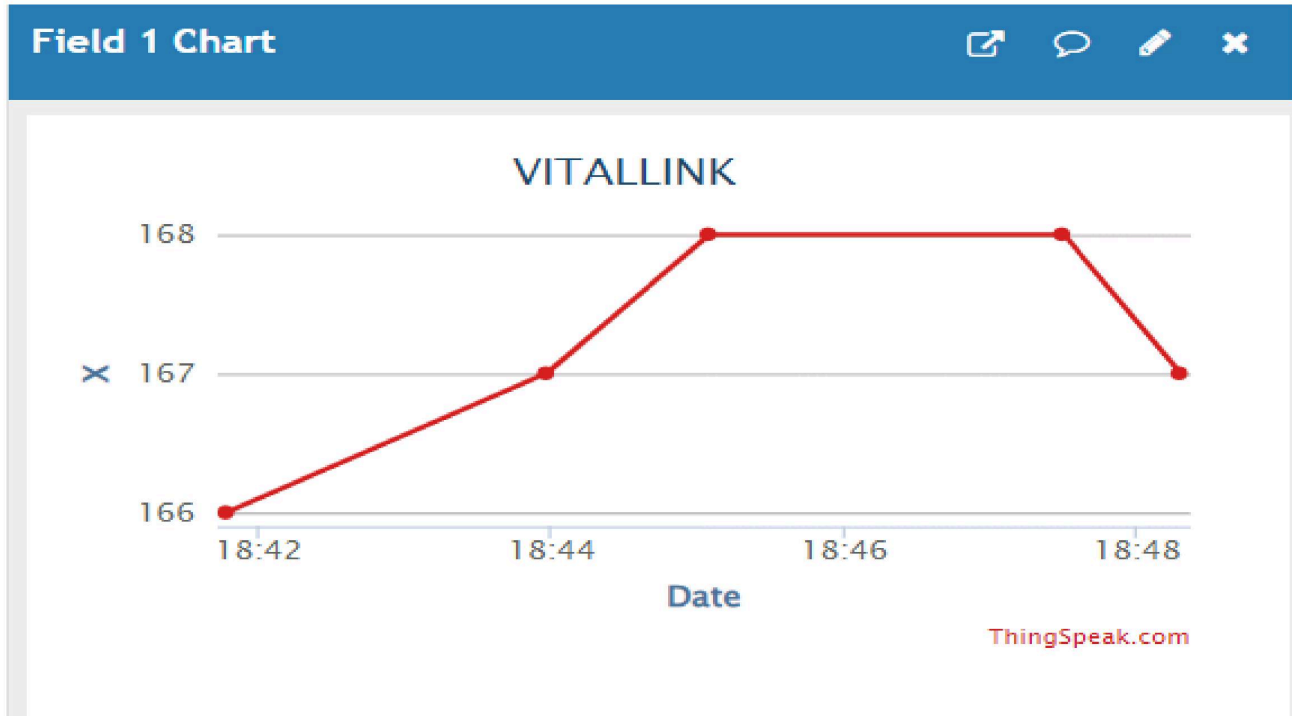


Fig. B.2: X value of MPU6050 Data from ThingSpeak

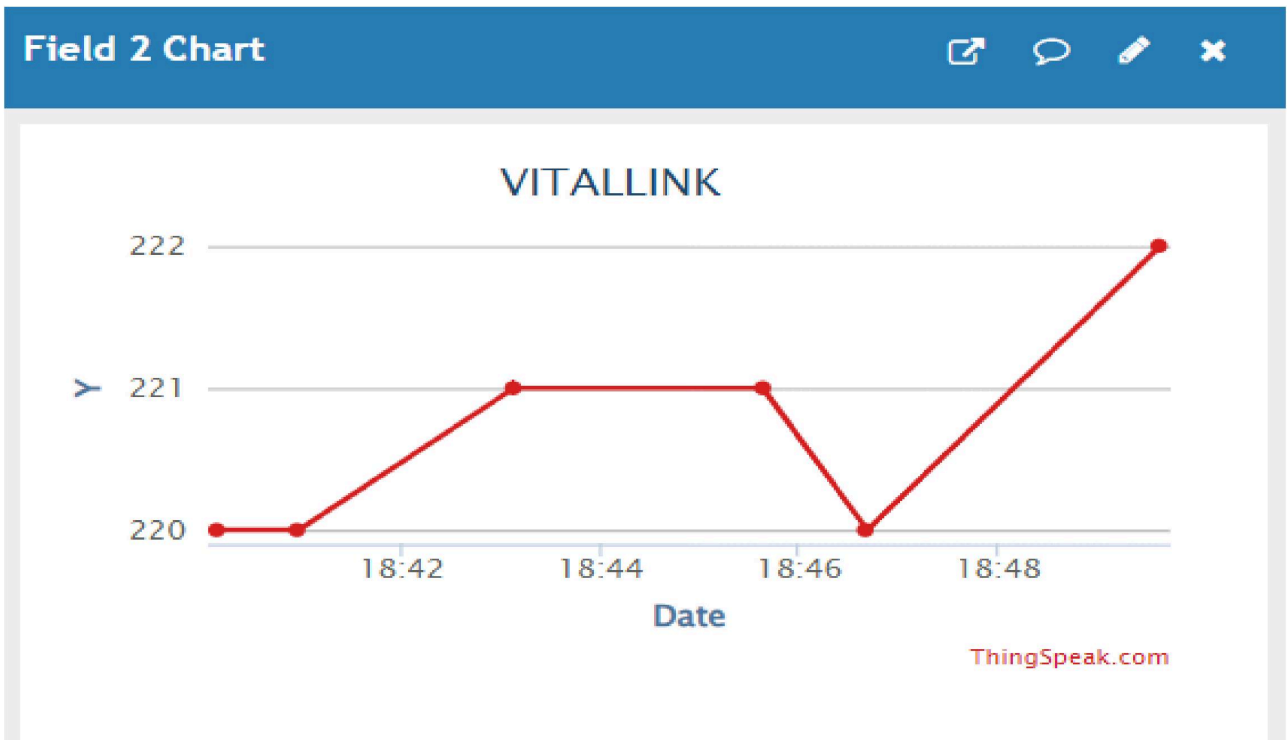


Fig. B.3: Y value of MPU6050 Data from ThingSpeak

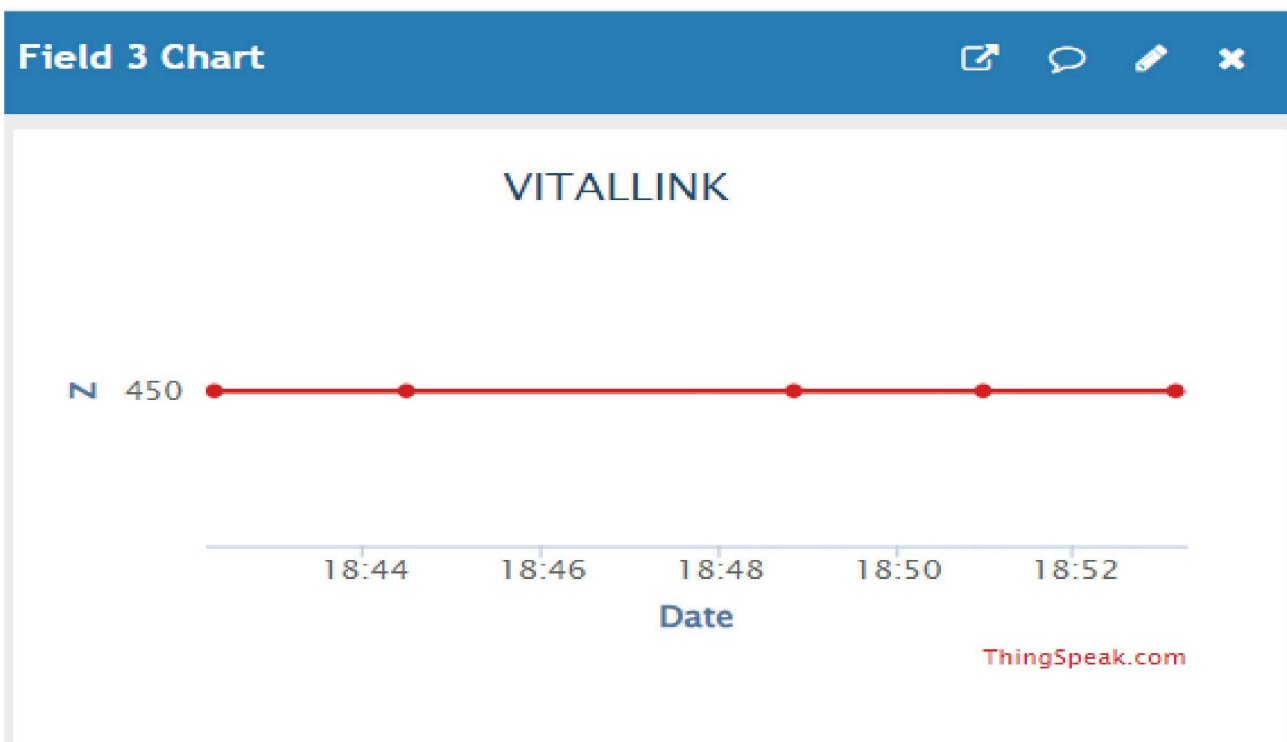


Fig. B.4: Z value of MPU6050 Data from ThingSpeak

Field 4 Chart

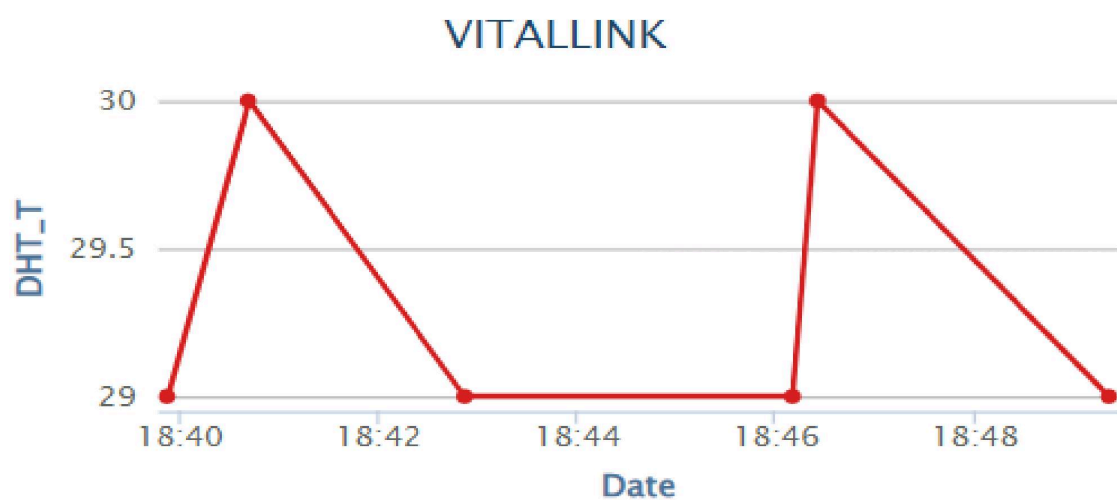


Fig. B.5: Room Temperature Data from ThingSpeak

Field 5 Chart

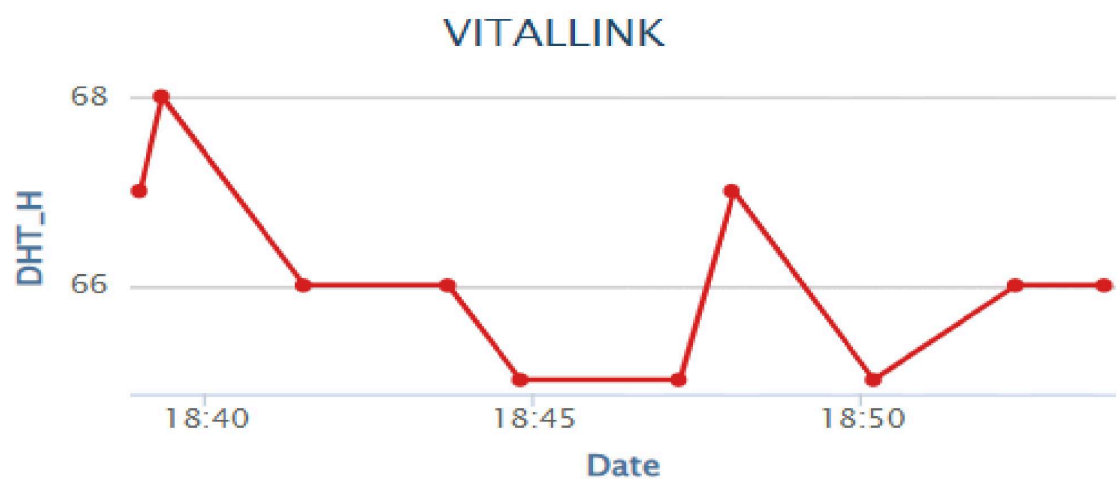


Fig. B.6: Humidity Data from ThingSpeak

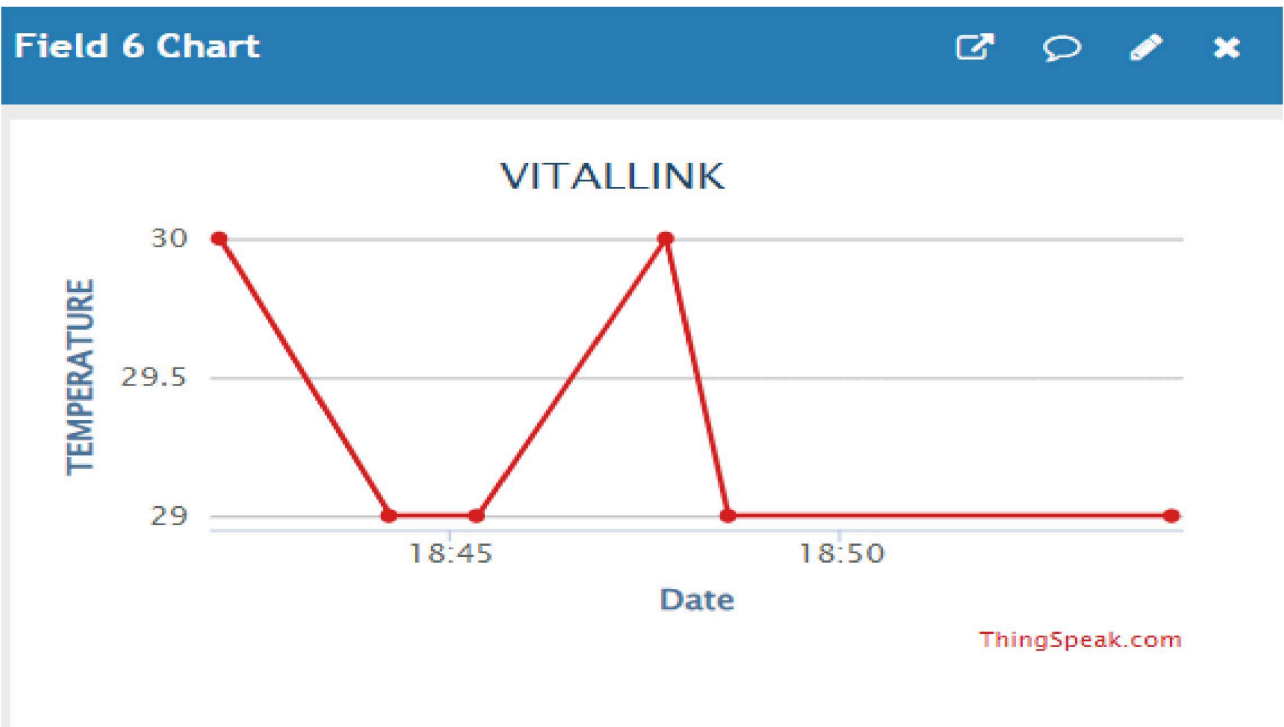


Fig. B.7: Body Temperature Data from ThingSpeak

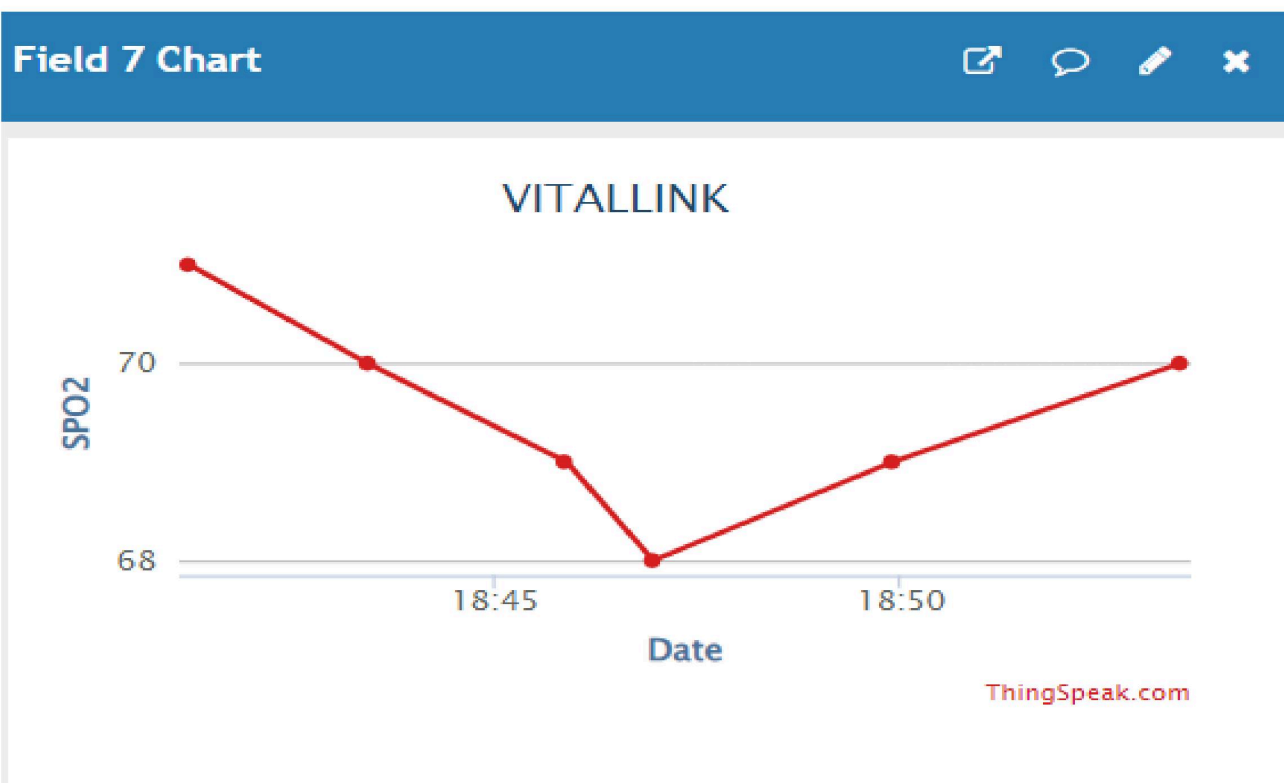


Fig. B.8: Blood Oxygen Data from ThingSpeak

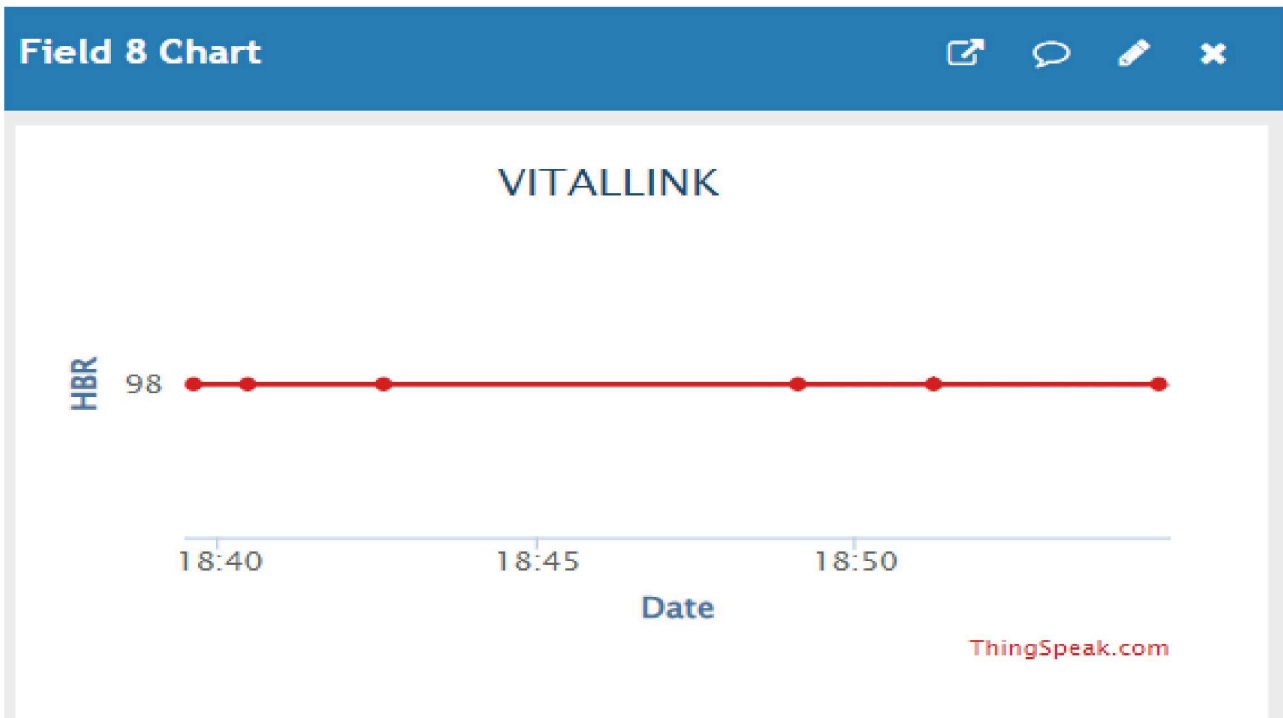
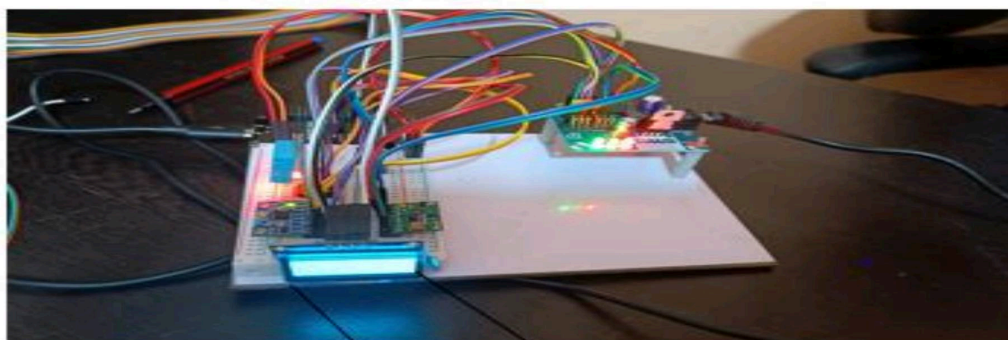


Fig. B.9: HeartRate Data from ThingSpeak



OLED DISPLAY
TEMP-30
SPO2-70
HBR-98
DHT-68
2024-02-06/18:24:48

Fig. B.10: Vital Signs displayed in the OLed Display

C. RESEARCH PAPER

VitalLink: NodeMCU IoT Solution for Vital Signs Surveillance

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Abstract: This research paper proposes the development of comprehensive vital sign surveillance designed for real-time patient assessment. The system integrates multiple sensors, including the LM35 temperature sensor, Heartbeat Rate (HBR) and Blood Oxygen (SpO2) Sensor, DHT11 humidity and temperature sensor, OLED display, and gyroscope sensor, to provide a holistic approach to vital signs. The LM35 sensor is employed for accurate temperature measurement, providing crucial data for monitoring the patient's thermal status. This information is essential for detecting fever or abnormal temperature variations, aiding in the early identification of potential health issues. The HBR and SpO2 sensor plays a vital role in cardiovascular vital signs. The system can assess the patient's cardiac and respiratory well-being by measuring the heart rate and blood oxygen levels. Abnormalities in these parameters can trigger timely alerts, enabling swift medical intervention. The DHT11 sensor enhances the system's capabilities by monitoring ambient temperature and humidity. This additional environmental data contributes to a more comprehensive understanding of the patient's surroundings, ensuring that external factors are considered in the health assessment process. Integrating an OLED display serves as an intuitive user interface, providing real-time feedback on the measured parameters. This ensures that patients and healthcare providers can easily interpret and respond to the health data presented by the system. The display can showcase temperature, humidity, heart rate, blood oxygen levels, and other relevant information in a user-friendly format. Furthermore, the gyroscope sensor adds a layer of sophistication to vital sign surveillance by enabling the assessment of body movement and posture. This feature is particularly beneficial for patients with mobility issues or those prone to falls. The gyroscope data can be analyzed to detect sudden movements or abnormal postures, triggering alerts to caregivers or healthcare professionals. The system is designed for user convenience, ensuring ease of use and portability. Wireless connectivity options can be incorporated, allowing data to be transmitted to a centralized monitoring platform or a mobile application. This enables remote monitoring, facilitating timely interventions and improving patient outcomes. The proposed vital sign surveillance has the potential to revolutionize personalized healthcare by providing continuous,

non-intrusive monitoring in real time. The multi-sensor integration allows for a more nuanced and comprehensive assessment of the patient's health status, enabling early detection of potential issues and facilitating proactive healthcare interventions.

Keywords : DHT11(Digital Temperature and Humidity Sensor), OLED Display(Organic Light Emitting Diode), LM35(Temperature Measuring Device), MAX30100(Pulse Oximeter and Heart-Rate Sensor).

I. INTRODUCTION

The field of healthcare has witnessed a transformative shift towards personalized and continuous monitoring, facilitated by advancements in sensor technologies, data analytics, and the Internet of Things (IoT). This paradigm shift is particularly evident in the development of vital sign surveillance that leverages a multitude of sensors to provide comprehensive and real-time insights into an individual's well-being. This introduces a groundbreaking "Vital Sign Surveillance" that integrates various sensors, including the LM35 temperature sensor, Heartbeat Rate (HBR) and Blood Oxygen (SpO2) Sensor, DHT11 humidity and temperature sensor, OLED display, and gyroscope sensor, to offer a holistic approach to health assessment.

A. Background

The impetus for developing such vital sign surveillance stems from the growing need for continuous and non-intrusive monitoring of vital health parameters. Traditional healthcare models often rely on intermittent clinical assessments, which may miss crucial fluctuations in health status. In contrast, real-time vital sign surveillance has the potential to detect early signs of health issues, enabling timely interventions and personalized healthcare.

B. Importance of Continuous Vital Sign Surveillance

Continuous vital sign surveillance is paramount, especially for individuals with chronic conditions, the elderly, or those recovering from illnesses. Timely detection of anomalies in vital signs, such as temperature variations, heart rate irregularities, blood oxygen levels, and environmental factors, can significantly impact the management and outcomes of various health conditions [1]. The integration of diverse sensors in a unified system allows for a more nuanced understanding of an

individual's health, contributing to a proactive and preventive healthcare approach.

C. Potential Applications

The versatility of this vital sign surveillance extends its applications across various healthcare scenarios. It can be employed in home-based care for the elderly, continuous monitoring of patients with chronic illnesses, post-operative recovery, and even in fitness tracking for proactive health maintenance. The system's adaptability makes it a valuable tool for healthcare providers, caregivers, and individuals alike.

D. Challenges and Opportunities

Despite the promising benefits, the implementation of comprehensive vital sign surveillance is not without challenges. Issues such as data security, user privacy, and the need for seamless integration into existing healthcare infrastructures must be addressed. Moreover, the system's usability and acceptance among diverse user groups need careful consideration to ensure widespread adoption.

However, these challenges present opportunities for innovation and collaboration between healthcare professionals, technologists, and policymakers. By overcoming these hurdles, vital sign surveillance can contribute significantly to the ongoing efforts to transform healthcare delivery and empower individuals to take an active role in managing their health.

II. LITERATURE SURVEY

Patient assistance and remote monitoring are made easier by recent advancements in cloud-based IoT devices. But creating greener healthcare systems has not received much attention in the current field [4]. Utilising state-of-the-art technology to provide an interactive user interface, this study offers an integrated framework for green healthcare. In order to facilitate real-time data exchange between physicians and patients, this system interface was created. Patients can transmit healthcare data to physicians via wearable sensors. Algorithms for Hierarchical Clustering are utilised for data identification and analysis.

In order to better understand the significance and categorization of IoT-based senior healthcare systems, this survey study was conducted [5]. A review of studies that document the evolution and application of IoT-based senior healthcare systems is included in the publication. The article also provides an overview of the fundamental architecture of IoT-based healthcare systems and how wearables can be used to incorporate them into homes and hospitals. In the latter section of the article, the security issues raised by the deployment of IoT systems which necessitate remote access to personal information and data storage are discussed.

The permission process aspects in IoT and healthcare are briefly reviewed in this study [6]. Subsequently, as per the evaluation, the investigation put forth the fundamental characteristics of the consent procedure in IoT-driven healthcare systems, which aid in augmenting consumers' privacy consciousness to secure their informed permission.

III. METHODOLOGY

The methodology for developing an IoT-based vital sign surveillance involves a systematic approach to sensor integration, data transmission, and user interface [7]. The sensors utilized in this system include the LM35 temperature sensor, Heartbeat Rate (HBR) and Blood Oxygen (SpO2) sensor, DHT11 humidity and temperature sensor, OLED display, and gyroscope sensor as shown in Fig. 1. The aim is to create a comprehensive vital sign surveillance solution that offers real-time data collection, analysis, and user-friendly feedback.

A. The Proposed System

In the proposed system, we have three modules namely power supply management, Sensors, Database management & Application working together evolving the supposed VitalLink.

The Power Supply Management module consists of a power supply unit and two 3v rechargeable batteries they provide the required power to operate. The sensors module, consists of four sensors like MAX30100, LM35, MPU6050, and DHT11 to record the vital signs. An OLED is also attached to display the values for the user. The Database Management and Application module consists of ThingSpeak that acts as both cloud as well as mobile application providing the recorded vital sign data to both user and either care taker or doctor. All the three modules are connected to the ESP32 which acts as an interface between the modules.

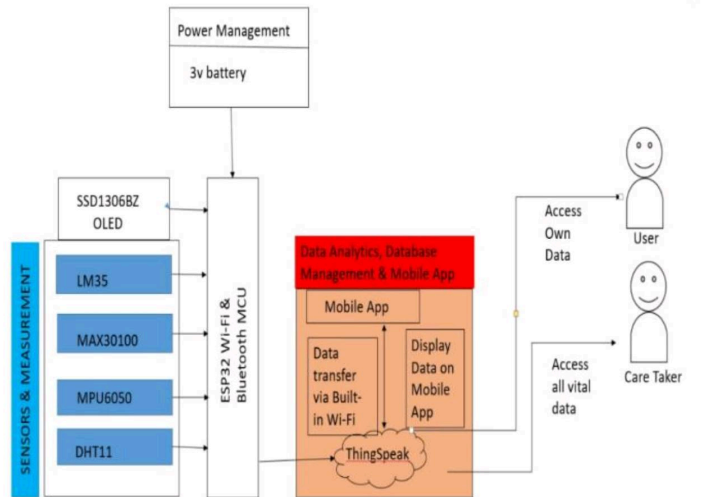


Fig. 1. Proposed vital link

B. Algorithm

1) Initialization:

- 1.1) Import required libraries.
- 1.2) Initialize MAX30100, LM35, DHT11, and MPU6050.
- 1.3) Initialize MQTTClient.
- 1.4) Connect to the MQTT broker.

2) Continuous Monitoring and Data Transmission:

- 2.1) Enter an infinite loop.

2.2) Try the following steps:

2.2.1) Read the body temperature from LM35.

2.2.2) Read the SPO2 from MAX30100.

2.2.3) Read gyroscope data from MPU6050.

2.2.4) Read humidity and room temperature from DHT11.

2.2.5) Prepare data payload with all given sensor readings.

2.2.6) Publish data to MQTT broker with specified fields.

2.2.7) Sleep for a specified interval (e.g., 5 minutes).

2.3) Handle any exceptions that occur (e.g., log errors or retry).

3) **Disconnect from MQTT broker** (optional, as it's unreachable in an infinite loop) [7].

End Algorithm

C. Sensor Integration

The stated system measures four vital signs in the surveillance process which includes body temperature, oxygen level, heart rate, and position of the user. Additionally, it consists of two environmental measurements which are room temperature and humidity level.

The user's body temperature is recorded by the LM35 Temperature Sensor; their heart rate and oxygen saturation level (SPO2) are measured by the MAX30100 Sensor; and their acceleration and gyro value in x, y, and z directions are recorded by the MPU6050 Sensor. The position of the user will be predicted by analysing the recorded data above. To find out if the user feels smothered, the DHT11 Sensor records the humidity and temperature of the space. The OLED will show the vital sign data that was obtained. Following the recording of all the user's vital signs, the ESP32 Wi-fi & Bluetooth module will send the information to the ThingSpeak cloud so that it may be stored using the integrated wi-fi module.

Esp32 is a low-cost development board with Wi-fi & Bluetooth chips embedded in it. The dual-core 32-bit with an ESP-WROOM-32 LX6 microprocessor feature makes the Esp32 better than other development boards. It has an operating voltage of 2.2v to 6v with regulator to provide stable voltage along with a 4Mb flash memory making it faster.

D. Data Transmission

Choosing a suitable IoT platform namely ThingSpeak to securely manage and process incoming data. Set up IoT device registry and configure device authentication mechanisms. Implement necessary security measures, including encrypted communication protocols, to protect data during transmission. To develop a standardized data transmission protocol for consistent and efficient communication between sensors and the IoT platform. Implementing a secure data encapsulation to protect against potential data breaches. Establish a reliable connection mechanism to ensure continuous and uninterrupted data

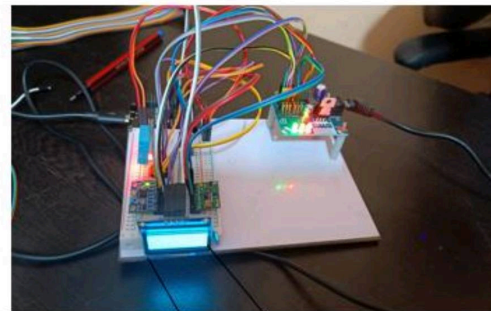
transmission. MQTT is a standard messaging protocol used in IoT. It's many feature is it can protect sensitive data. Mainly used for data transmission as it can be implemented easily and handles IoT data efficiently. By configuring cloud storage for storing historical health data securely. Implement data processing algorithms on the cloud to analyze trends, detect anomalies, and generate insights. Thus to integrate the machine learning models for predictive analytics, especially for cardiovascular health parameters.

E. User Interface Design

Create a user interface with a clear, aesthetically pleasing design. for the OLED display. Incorporate clear visualizations of health parameters, including temperature, cardiovascular metrics, humidity, and gyroscope data. Ensure real-time updates on the display to provide immediate feedback to users [14]. Develop a mobile or web application interface for remote access to health data. Enable users to view historical trends, set personalized health goals, and receive alerts for abnormal readings. Implementing secure user authentication mechanisms to protect sensitive health information.

The outlined methodology provides a systematic approach to the development of an IoT-based vital sign surveillance incorporating LM35, HBR and SpO2 sensors, DHT11 sensor, OLED display, and gyroscope sensor [16]. Through careful sensor integration, secure data transmission, user-friendly interface design, and rigorous testing, this methodology aims to create a comprehensive and reliable system for continuous vital sign. The emphasis on security and ethical considerations underscores the importance of protecting user privacy and ensuring the responsible use of health data.

IV. RESULTS AND DISCUSSION



OLED DISPLAY	
TEMP-30	
SPO2-70	
HBR-98	
DHT-68	
2024-02-06/18:24:46	

Date	X	Y	Z	DHT_H	DHT_T	SPO2	HBR	Temperature
2024-02-05T18:42:00+05:30	166	220	450	29	67	71	98	30
2024-02-05T18:44:20+05:30	167	221	450	30	68	70	98	29
2024-02-05T18:46:37+05:30	168	221	450	29	66	69	98	29
2024-02-05T18:48:53+05:30	168	220	450	29	66	68	98	30
2024-02-05T18:50:09+05:30	167	222	450	30	61	69	98	29

Fig. 2. Display Of The Vital Signs And Operating VitalLink

VitalLink's operation begins with establishing a Wi-Fi connection as soon as the device is powered on. This is followed by configuring the sensors and establishing a connection with Thing Speak. Following the establishment of the aforementioned process, VitalLink begins to read the user's vital signs. As can be seen in Fig. 2, the recorded data is presented on the OLED. The temperature, SPO2, heart rate, and humidity are all reported within the normal range, with the recorded values being 30 C, 70%, 98, and 68, respectively. Finally OLED displays date when the data is uploaded 2024-02-06/18:24:46



Fig.3. Visual display of Vital Signs

The above Fig .3 is visual representation of Vital signs such as Body temperture , HBR, SPO2 and Humidity which are

recorded with time period. The Proposed VitalLink is constructed with amount of INR 3,125.

TABLE I. DATA RECORDED IN THINGSPEAK

a. The collected data consists of X,Y, and Z gyro values, DHT_H, DHT_T, SPO2, HBR, TEMPERATURE

Table.1 represents the values that are collected using VitalLink which are uploaded with the date in the ThingSpeak Channel using IOT Connection.We can access this recorded or uploaded data in mobile application using the ThingSpeak Channel .

V. CONCLUSION AND FUTURE SCOPE

The VitalLink project is developed to record body vital signals, predict body position, provide patient location, and update records on the Thingspeak cloud server.,and its systematic development allows for an user-friendly approach. We focus on design, accessibility, and real-time vital signs feedback. Extended the functionality of your project by using LM35 as the temperature sensor along with DHT11 to monitor room temperature for enhanced surveillance. This article highlights barriers in caring for terminally ill and elderly people and presents solutions through accurate vital sign recording, model evaluation, providing a low cost cloud database, and API creation. Performance testing has demonstrated higher precision and recall compared to existing systems. Although this system is versatile due to its real-time speed, high accuracy, and adaptability, it has limitations such as the need for large training data and more sophisticated functions. Overall, this project focuses on supporting people who are terminally ill and elderly people making it easy for them to take care of their health along with accessibility by common people for their own personal needs.

There are several potential directions that research into vital sign systems might go such as expanding the dataset and relative training of the model on a more extensive range of sensors, integrating sophisticated capabilities to allow the system to recognize and provide information related to all the possible vital signs. Further work can be done in the future to incorporate additional features, such as blood pressure sensor, ECG sensor, and pedometer, to further enhance the utility of the system in various scenarios. Finally, the feasibility of miniaturization of hardware components and considering the integration of the system into more sophisticated wearable that provides a more discrete and portable solution.

VI. REFERENCES

- [1] A. G. Skrivanos, S. K. Chronopoulos, E. I. Kosma, I. Kouretas and K. P. Peppas, "Home Healthcare Technologies and Services: Heart-Rate Fetus Monitoring System Using an MCU ESP8266 Node," 2022 Panhellenic Conference on Electronics & Telecommunications (PACET), Tripolis, Greece, 2022, pp. 1-6, doi: 10.1109/PACET56979.2022.9976348.8266;
- [2] Sharma, Hitesh. (2020). Sensors Based Smart Healthcare Framework Using Internet Of Things (Iot). 9. 1228-1234.
- [3] M. Jamjoum, E. Abdelsalam and S. Siouf, "Smart Portable Patient Monitoring System," 2022 Advances in

- Science and Engineering Technology International Conferences (ASET), Dubai, United Arab Emirates, 2022, pp. 1-4, doi: 10.1109/ASET53988.2022.9734854.
- [4] George J J, J. M. Kanchai, B. Anayarkanni, A. M. Posonia, J. A. Mayan and P. Asha (2023), "Image Based Surveillance System", International Conference on Circuit Power and Computing Technologies (ICCPCT), pp. 349-353.
- [5] M. Elkahout, M. M. Abu-Saqer, A. F. Aldaour, A. Issa and M. Debeljak, "IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), Gaza, Palestine, 2020, pp. 92-96, doi: 10.1109/iCareTech49914.2020.00025.
- [6] Govindarajan S, Rajkumar S.S, Mayan A.J, Posonia A.M (2023), "Blockchain Fundraising and Charity Platform", International Conference on Vision Towards Emerging Trends in Communication and Networking Technologies, ViTECoN 2023, pp.1-6.
- [7] S. Sasipriya, G. R, I. B and K. J S, "IOT enabled Smart home and health monitoring System," 2021 6th International Conference on Communication and Electronics Systems (ICCES), Coimbatre, India, 2021, pp. 573-576, doi: 10.1109/ICCES51350.2021.9488984.
- [8] I. -S. Lee and J. -R. Yang, "Signal Preprocessing for Heartbeat Detection Using Continuous-Wave Doppler Radar," in IEEE Microwave and Wireless Technology Letters, vol. 33, no. 4, pp. 479-482, April 2023, doi: 10.1109/LMWT.2022.3228328.
- [9] Bishal Mohari, Bidipto Dey, Bhera Ram, Albert Mayan J and Mary Posonia A (2023), "Geologs: A Complete end-to-end Classroom Management System", International Conference on Pervasive Computing and Social Networking (ICPCSN), India, pp. 1473-1480.
- [10] A. Boukhayma, A. Barison, S. Haddad and A. Caizzone, "Ring-Embedded Micro-Power mm-Sized Optical Sensor for Accurate Heart Beat Monitoring," in IEEE Access, vol. 9, pp. 127217-127225, 2021, doi: 10.1109/ACCESS.2021.3111956.
- [11] N. Mora, F. Cocconcelli, G. Matrella and P. Ciampolini, "Accurate Heartbeat Detection on Ballistocardiogram Accelerometric Traces," in IEEE Transactions on Instrumentation and Measurement, vol. 69, no. 11, pp. 9000-9009, Nov. 2020, doi: 10.1109/TIM.2020.2998644.
- [12] H. -I. Choi, H. Song and H. -C. Shin, "Target Range Selection of FMCW Radar for Accurate Vital Information Extraction," in IEEE Access, vol. 9, pp. 1261-1270, 2021, doi: 10.1109/ACCESS.2020.3043013.
- [13] Nekkanti L B, Priyanka. A, A. M. Posonia and J. A. Mayan (2023), "Breaking Down Communication Barriers: Real-Time Sign Language Recognition Using CNN & Flask-Based API", International Conference on Circuit Power and Computing Technologies (ICCPCT), pp. 330-336.
- [14] S. Sakib, M. M. Fouda, Z. M. Fadlullah, N. Nasser and W. Alasmay, "A Proof-of-Concept of Ultra-Edge Smart IoT Sensor: A Continuous and Lightweight Arrhythmia Monitoring Approach," in IEEE Access, vol. 9, pp. 26093-26106, 2021, doi: 10.1109/ACCESS.2021.3056509.
- [15] Ravipati A, Kondamuri R.K, Mary P A, Albert Mayan J (2023), "Vision Based Detection and Analysis of Human Activities", International Conference on Trends in Electronics and Informatics, pp. 1542-1547.
- [16] G. Yang, M. A. Jan, V. G. Menon, P. G. Shynu, M. M. Aimal and M. D. Alshehri, "A Centralized Cluster-Based Hierarchical Approach for Green Communication in a Smart Healthcare System," in IEEE Access, vol. 8, pp. 101464-101475, 2020, doi: 10.1109/ACCESS.2020.2998452.