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IV Fluid Bag Monitoring, Alert, and Control System Using ESP32 and IoT

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Abstract

This paper introduces an innovative IV Fluid Bag Monitoring, Alert and Control System Using ESP32 and IoT designed to address critical challenges in traditional IV therapy. The system uses an ESP32 microcontroller to monitor the weight of an intravenous (IV) fluid bag in real time via a load cell and HX711 amplifier module. A 16x2 LCD display provides continuous visual feedback of the IV bag's status, while a Blynk-based mobile application ensures remote monitoring capabilities for healthcare providers. When the fluid level drops below a critical threshold, the system triggers visual and audio alerts, sends notifications to the medical staff, and automatically stops IV flow using a solenoid valve to prevent air embolism and other complications. This cost-effective and scalable solution aims to improve efficiency in clinical settings by minimizing human error and enabling timely medical interventions.

Keywords: IV Bag (Saline Bag), Load Sensor, IOT, Arduino IDE, ESP32, Relay, Solenoid Valve, 16X2 LCD Display, Blynk Mobile app

1. INTRODUCTION

Intravenous (IV) therapy is one of the most common and essential procedures in hospitals and healthcare facilities. It involves the administration of fluids, medications, or nutrients directly into a patient's vein. While widely used, IV therapy requires close monitoring to ensure that the fluid levels are maintained within safe limits. Failure to monitor IV bags properly can result in serious consequences, including air embolism, patient dehydration, or medication overdose, especially when the bag runs dry without being noticed.

Traditionally, nurses or medical staff manually check IV fluid levels, which can be inefficient and prone to human error—particularly in busy or understaffed medical environments. This limitation calls for an automated and reliable solution to monitor IV fluid levels continuously and alert caregivers when attention is required.

With the aim to improve hospital workflow and patient safety, this project presents a Smart IV Fluid Bag Monitoring, Alert, and Control System. The system makes use of a 16x2 LCD to show fluid level data in real time, an ESP32 microcontroller for processing and connectivity, and a load cell sensor to determine the weight of the IV fluid bag. The system also connects to the Blynk IoT platform, allowing for remote monitoring and mobile alerts in the event that fluid levels drop below a predetermined threshold. A control mechanism that uses a motor or valve to automatically stop the fluid flow when critical levels are reached is included to further improve safety.

By combining low-cost hardware components with modern IoT and automation technologies, the proposed system offers a scalable and efficient solution to an important healthcare challenge. This project not only reduces the risk of medical errors but also allows healthcare providers to focus more on patient care rather than routine monitoring tasks.

Contributions of the paper are as follows:

1. A Health Monitoring system is developed using IoT and an embedded system.

This paper has been organized into Six sections – introduction, related works, methodology, related works, results&discussion, conclusion and references.

2. LITERATURE SURVEY

Author [1] Design of Automatic Infusion Monitoring System Based on Arduino by A.S. Fauziyyah et al. (2020): This study presents the design and implementation of an automatic infusion monitoring system using Arduino as the core controller. The primary aim was to automate the process of monitoring IV fluid levels and provide alerts to medical personnel when the fluid reaches a critical level.

Author [2] Smart Infusion and Web-Based Monitoring Infusion Fluids in Isolation Room Based on Fuzzy Logic by M. Yamin et al. (2021): This paper presents the design and implementation of a smart infusion monitoring system that operates within isolation rooms, a need that became critical during the COVID-19 pandemic. The key objective was to develop a non-contact, intelligent system that can monitor IV fluid levels remotely and reduce physical interaction between medical personnel and infected patients.

Author[3] DripOMeter: An Open-Source Opto-Electronic System for Intravenous (IV) Infusion Monitoring by Venkatesh et al. (2022): The study introduces the DripOMeter, an open-source, cost-effective opto-electronic device designed to monitor intravenous (IV) infusion therapy. The primary goal is to enhance patient safety by providing accurate, real-time monitoring of IV drip rates, particularly in low-resource settings where advanced medical equipment may be scarce.

Author [4] Monitoring of Clinical Signs of Intravenous Infusion Patients with ZigBee Wireless Technology by Zhu, X. et al. (2022): This paper presents a wireless monitoring system designed to enhance the safety and efficiency of intravenous (IV) infusion therapy using ZigBee wireless technology. The goal is to overcome the limitations of manual monitoring methods, which are often error-prone and inefficient, especially in high-demand clinical settings.

Author [5] Design and Realization of Intelligent Infusion Monitoring System by Bai, K. et al. (2023): The paper presents the development and implementation of an intelligent infusion monitoring system aimed at enhancing the safety and efficiency of intravenous (IV) therapy in clinical environments. Recognizing the limitations of traditional manual monitoring, the authors propose a system that leverages sensors, microcontrollers, and artificial intelligence to provide real-time monitoring and intelligent alerting.

Author [6] Deep Learning-Based Computer Vision for Real-Time Intravenous Drip Infusion Monitoring by Giaquinto, N. et al. (2020): This paper presents a deep learning-based computer vision system designed for real-time monitoring of intravenous (IV) drip infusion. The primary motivation is to automate and improve the reliability of drip rate monitoring, which is traditionally performed manually by healthcare professionals.

Author [7] Smart Intravenous Drip Monitoring System Based on IoT by Nandhini et al. (2024): This study introduces an IoT-enabled system that automates the monitoring of glucose levels in IV therapy. Utilizing a load cell amplifier, the system measures the weight of the glucose bottle to determine fluid levels. When the fluid drops below a predefined threshold, a GSM modem sends SMS and call notifications to medical staff, ensuring timely intervention and reducing the need for manual checks.

Author [8] IoT-Based Intravenous (IV) Therapy Monitoring System for Elderly Care by Irianto & Firdaus (2024): This research focuses on developing an IoT-based IV therapy monitoring system tailored for elderly patients. The system provides real-time monitoring of intravenous volume and issues alarms in case of fluid delivery issues or failures, enhancing patient safety and reducing the burden on healthcare providers.

Author [9] Novel Implementation of IoT-Based Non-Invasive Sensor System for Real-Time Monitoring of Intravenous Fluid Level for Assistive E-Healthcare by Ray et al. (2019): This study proposes a non-invasive IoT-based sensor system for real-time monitoring of IV fluid levels. The system aims to enhance patient safety by providing continuous monitoring without direct contact, utilizing sensors to detect fluid levels and alerting healthcare providers as necessary.

Author [10] IoT-Based IV Drip Monitoring and Control System with Compact Medical Stretcher by Krishna Priya et al. (2022): The authors developed an IoT-based IV drip monitoring and control system integrated with a compact medical stretcher. This system allows for real-time monitoring and control of IV fluid administration, improving patient mobility and comfort during treatment.

Author [11] IoT-Based IV Bag Monitoring System for Patient Safety and Security by Gupta & Singla (2021): This paper discusses the implementation of an IoT-based IV bag monitoring system designed to enhance patient safety and security. The system continuously monitors the IV bag's status and alerts healthcare providers to prevent potential complications arising from unnoticed depletion.

Author [12] Design and Implementation of an IoT-Based IV Bag Monitoring System Using Arduino and ESP8266 by Abdelaziz & Al-Jarrah (2020): The study presents the design and implementation of an IoT-based IV bag monitoring system utilizing Arduino and ESP8266 microcontrollers. The system aims to provide real-time monitoring and alerts for IV fluid levels, thereby reducing manual checks and improving efficiency.

Author [13] An IoT-Based IV Bag Monitoring System with Backflow Prevention by Al-Haddad et al. (2020): This research introduces an IoT-based IV bag monitoring system equipped with backflow prevention mechanisms. The system ensures continuous monitoring of IV fluid levels and incorporates features to prevent backflow, enhancing patient safety during intravenous therapy.

Author [14] Design and Implementation of an IoT-Based IV Bag Monitoring System with Backflow Prevention Using Arduino Uno and ESP32 by Azeez & Olanrewaju (2021): The authors designed and implemented an IoT-based IV bag monitoring system with backflow prevention, employing Arduino Uno and ESP32 microcontrollers. The system provides real-time monitoring and alerts, aiming to improve patient care by preventing complications associated with IV therapy.

Author [15] Design and Implementation of an IoT-Based IV Bag Monitoring System for Remote Patient Care Kumar & Singh (2022): This paper presents the design and implementation of an IoT-based IV bag monitoring system intended for remote patient care. The system enables healthcare providers to monitor IV fluid levels remotely, facilitating timely interventions and reducing the need for constant physical supervision.

Book [16] The 8051 Microcontroller and Embedded Systems Using Assembly and C by Publisher: Pearson Education This book is a foundational text for learning embedded systems programming using the 8051 microcontrollers. It covers both assembly and C programming for hardware control. Topics include I/O port programming, timers, serial communication, and interfacing techniques. It is highly regarded for building a strong theoretical and practical understanding of microcontroller-based systems, which is transferable to modern microcontrollers like the ESP32.

Book [17] Programming the ESP32: Getting Started with the Espressif IoT Development Framework (ESP-IDF) by Publisher: Elektor International Media.

3.PROPOSED METHODOLOGY

A. Block diagram

Our project uses the following components: 1. ESP32. 2. The load cell. 3. HX711 Amplifier for load cell 4. LCD screen. Module 5. Circuit Board for PCBs. 6. Relay. 7. Solenoid valve. 18. Buzzer and LED light 9. Blynk IOT app. 10. Arduino IDE. The block diagram consists of the following hardware components: ESP32, load cell, PCB circuit board, LCD display, relay, solenoid valve, buzzer, and LED light are the hardware elements that make up the block diagram. Blynk and Arduino IDE are the software components used in this project. First, a 5V DC power adapter is used to supply power to the ESP32, and a USB port is used to connect it to a PC or laptop. Following activation, the ESP Module connects to a registered wireless network (Wi-Fi). Once the connection is established, the ESP requests that the user place a weight on the load cell, which is shown via the LCD display that is attached to the ESP processor.

The weight of an object or bag is calibrated once it is placed on the load cell, and it is shown on the LCD and uploaded to the cloud, where it is visible on the Blynk IoT Platform. The Blynk app allows for real-time tracking of the bag's weight. A notification to refill or replace the bag is sent to the user through the Telegram app if the weight or liquid level of the bag falls below a predetermined threshold. Additionally, once the weight drops below the threshold value, the solenoid valve automatically stops the IV flow.

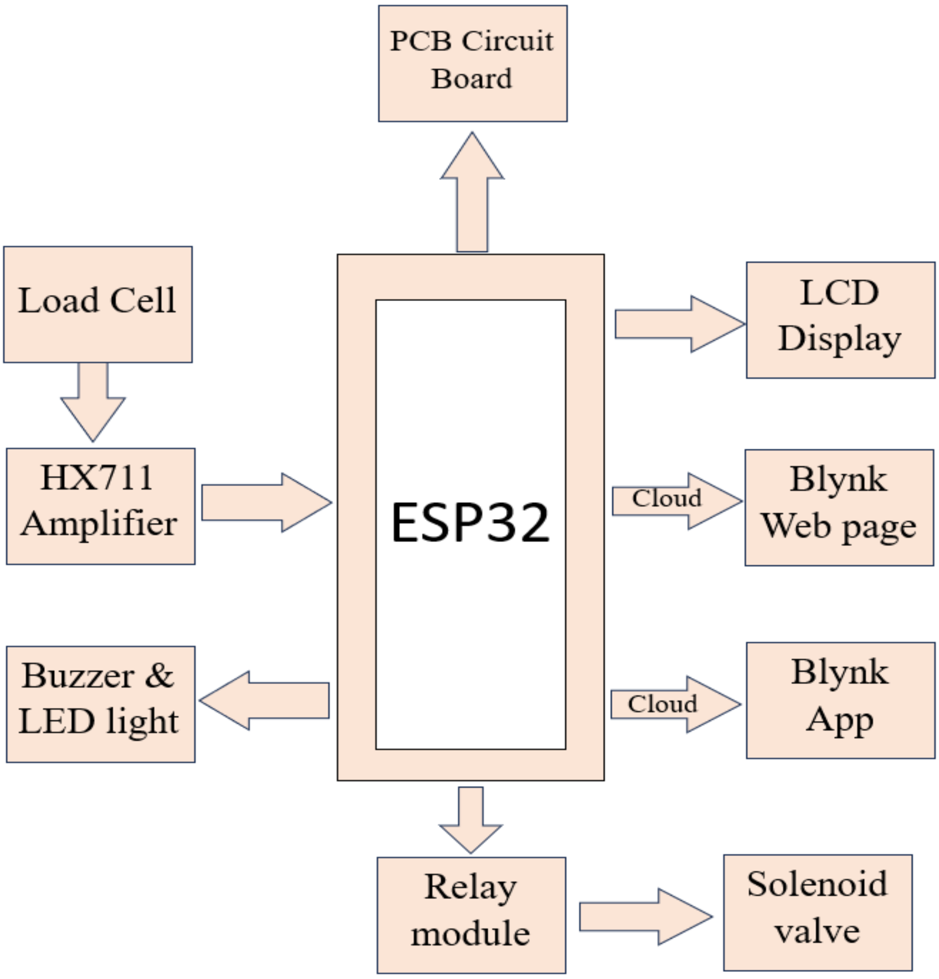

Fig. 1. Block diagram of the proposed system

B. Certain components

1) ESP32

ESP32 is a powerful, low-cost system-on-chip (SoC) microcontroller that combines Wi-Fi and Bluetooth capabilities. It is designed and manufactured Department of Electronics and Communication Engineering 7 by Espressif Systems, a Chinese company known for creating cutting edge IoT solutions. The ESP32 is the successor to the ESP8266, offering improved performance and added features.

2) Load Cell

A load cell is a device used to measure force or weight. It converts the physical force applied to it into an electrical signal that can be measured and analyzed. Load cells are commonly used in industrial and commercial applications to measure the weight of materials or products during manufacturing, shipping, and other processes.

3) HX711

The HX711 is a precision 24-bit analog-to-digital converter (ADC) specifically designed for weighing scale applications. It is widely used with load cells to measure weight or force, such as fluid levels in IV bags or pressure in medical systems. The HX711 amplifies the small voltage signal from the load cell and converts it into a digital signal readable by a microcontroller like the ESP32 or Arduino.

4) LCD Display

A 16x2 LCD display with I2C module is a widely used output device in embedded systems to show text data such as sensor readings, status messages, or alerts. The I2C module attached to the LCD allows communication using only two data lines (SDA and SCL) instead of the usual 6+ GPIO pins required for standard LCDs.

5) PCB Circuit Board

A printed circuit board (PCB) is an essential component in the design and manufacture of electronic devices. It is a flat board made of a non-conductive material, such as fiberglass, with conductive pathways etched onto its surface to connect various electronic components. PCBs are widely used in electronic devices, ranging from small consumer electronics to large industrialsystems.

6) 5V Relay Module

A 5V relay module is an electromechanical switch used in embedded systems to control high voltage or high current devices (e.g., motors, pumps, solenoid valves) using a low-power microcontroller like an ESP32 or Arduino. It acts as an electrical isolation switch, allowing the microcontroller to safely operate external AC/DC devices.

7) Solenoid Valve

A solenoid valve is an electromechanical device used to control the flow of liquids or gases. It works by using an electromagnetic solenoid coil to open or close an internal valve, allowing or stopping the flow based on an electrical signal. In embedded and automation projects, solenoid valves are ideal for automatically controlling fluid flow, such as in IV fluid systems, irrigation, water dispensers, or industrial fluid lines.

8) Blynk IOT (web dashboards)

Blynk is a powerful and user-friendly Internet of Things (IoT) platform that allows you to build, monitor, and control hardware projects remotely via smartphones or web dashboards. It supports microcontrollers like ESP32, ESP8266, Arduino, and others.

9) Blynk (App)

The Blynk Mobile App is a key component of the Blynk IoT Platform that allows users to create custom dashboards on their smartphones to monitor and control IoT devices like the ESP32. It provides a simple drag-and-drop interface where users can add widgets to interact with hardware remotely. Available for Android and iOS, the app connects to devices over the internet via the Blynk Cloud, enabling real-time interaction with sensors, actuators, and systems without needing to write complex frontend code.

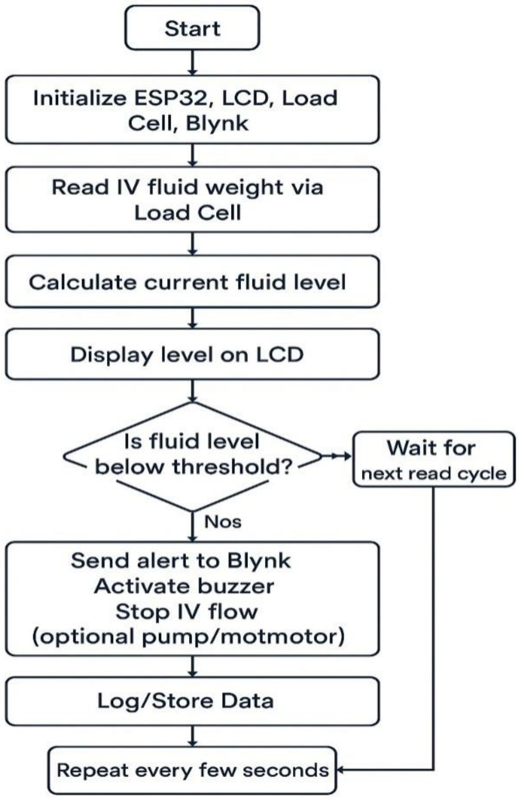

Fig. 2. Proposed Flow of Execution

4. RESULTS AND DISCISSION

The Working of the system is divided into different steps of discussion and results to get a clear picture and understand the functioning of the project. In the following steps different operations and results are shown where the flow chart of the project is satisfied.

Fig. 3. Title is displayed.

- As the system is turned on the Title of the Project is displayed on the LED Display.

Fig. 4. Message displayed on Wi-fi Connection.

- The System is automatically connected to a saved Wi-Fi Network named "paranthaman." Once connected to the Wi-Fi a message is displayed on the LED.

Each image is an output image of the project which represents several stages of execution of the system.

Fig. 5. Title is displayed.

- Several Messages and alerts throughout the process of the project are shown on the LED.

Fig. 6. Asks the user to place a bottle/bag.

- Once the system is successfully connected to the Wi Fi the system asks the user to place a saline bottle/bag to measure the weight of the bag.
- The Weight of the Bag is calibrated by using the Load Cell. Weight up to 500gms can be measured using the Load Cell.
- Once the weight of the bottle is measured it is both displayed on the LED Display and simultaneously updated on the Blynk app which can be seen in Fig.7&8.

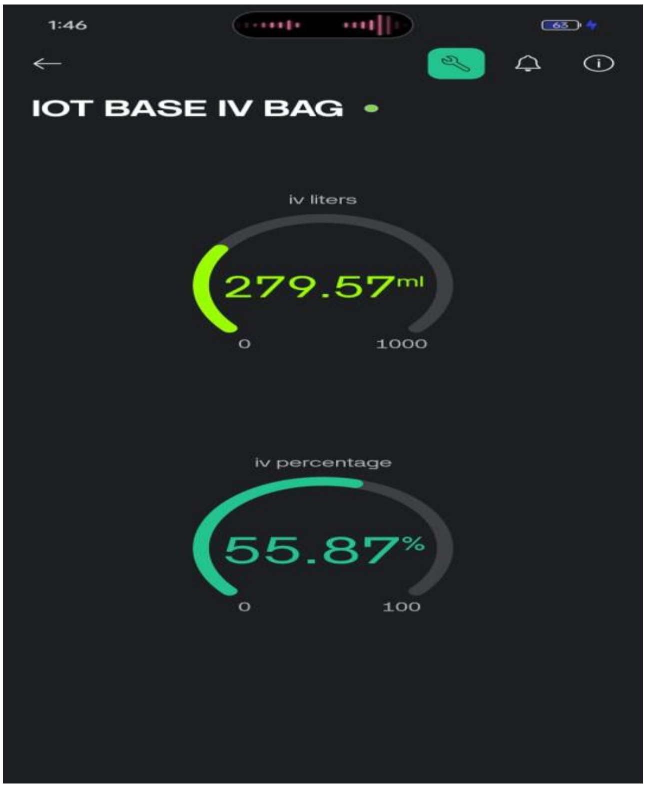

Fig. 7. Measured Weight is shown on the Blynk app.

- Once the data is sent to the Blynk app the weight of the measured bag is displayed on the Mobile as shown in the above figure.

Fig. 8. Figure.8: Weight displayed on LED.

- The Measured weight of the bottle is shown on the LED Display.
- A Bottle of 222gms is placed on the system. Any weight up to 500gms can be measured by the system using the Load Cell.
- The Calibrated Weight of the bottle is sent as data via the cloud to the Blynk app or Email.

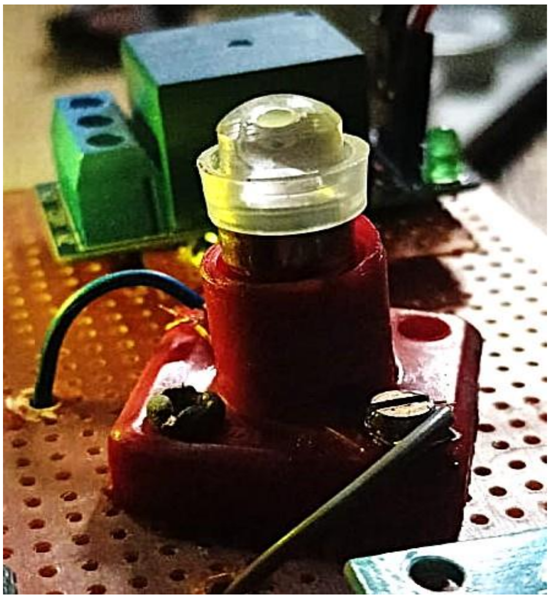

Fig. 9. LED light Indicator

- An LED light is used as an indicator in the system to signify a reduction in IV bag weight. It is controlled through the ESP32 microcontroller and is triggered when the detected weight falls below the threshold level (<50 grams). The LED remains off when the fluid bag weight is sufficient. In the example above, the IV bag weighs 221 grams, so the LED light remains off, indicating a normal condition.

Fig. 10. Weight displayed on Blynk app.

- As the weight is changed, the weight of the bag is simultaneously updated on the Blynk app which is shown in the above figure.

Fig. 11. Another Weight is Placed on the System

- The Previous Bag which weighed 221 gms is removed, and another bag is placed on the system whose weight is calibrated as shown in the above diagram.

Fig. 12. Lamp Indicator turn on.

- Since the new weight placed(38gms) falls below the threshold level(<50gms or <12%) the indicator glows. The Indication is also to replace/refill the bottle/bag placed.

Fig. 13. Solenoid Valve Used for Automated IV Fluid Flow Control

- It is connected to a microcontroller that receives data from sensors monitoring the fluid level. When the fluid level becomes too low (<50gms or <12%), the microcontroller sends a signal to close the valve, stopping the flow and preventing risks like air embolism.

5. CONCLUSION

The IV Fluid Bag Monitoring, Alert, and Control System has been successfully designed and implemented to address a critical need in healthcare settings—preventing complications caused by the depletion of intravenous fluids. By continuously monitoring the fluid level in the IV bag and providing real-time alerts, the system enhances patient safety and reduces the burden on medical staff.

Utilizing components such as the ESP32 microcontroller, load cell sensor, LCD display, and Blynk-based mobile notifications, the system provides a reliable and automated solution. The addition of control functionality, including the ability to stop fluid flow when levels are critically low, further improves the efficiency and responsiveness of the system.

Throughout the testing phase, the system demonstrated consistent performance, accurate weight-based fluid detection, and timely alerts. Its modular design also allows for future scalability and integration into broader hospital management systems.

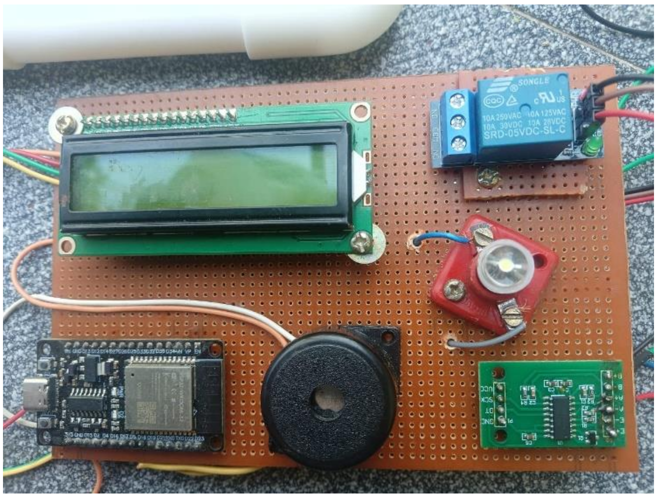

Fig. 2. Proposed Flow of Execution

In conclusion, this project not only meets its objectives but also lays the groundwork for future enhancements such as wireless sensor integration, battery backup for mobility, and data logging for patient records. With further refinement, the system holds the potential to become a standard tool in modern healthcare facilities.

6. REFERENCES

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