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Development of Smart Healthcare Monitoring System Using IoT

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Abstract: *Using an ESP32 microcontroller, load cell sensors, and a GSM module for real-time saline tracking and alerts, our Internet of Things-enabled IV monitoring system improves patient safety. In order to handle intravenous therapy effectively, a web-based program facilitates remote monitoring, lowers risks, minimizes human error, and optimizes hospital efficiency. Intravenous (IV) fluid delivery necessitates constant monitoring to avoid issues such saline backflow, and patient safety in healthcare facilities is of utmost importance. We suggest an Internet of Things (IoT)-enabled alert system that incorporates smart sensors to monitor saline flow and identify anomalies instantly in order to improve patient care. The device, which is based on the ESP32 microcontroller, uses a GSM module to send SMS alerts to medical personnel and a load cell sensor to track fluid levels. Hospital procedures can be streamlined by using a web-based program to remotely monitor saline levels and flow rates. By lowering the dangers associated with saline, eliminating human error, and streamlining hospital operations, this innovation greatly enhances patient safety. In critical care, the automated alarm system improves response time, guaranteeing prompt intervention and effective fluid management. This system offers a scalable and efficient way to enhance intravenous therapy administration in clinical and hospital environments by utilizing IoT technologies.*

Keywords*:* Alert System; Internet of Things (IoT); Patient safety; Real-time monitoring; AVCOE, Department of Computer Engineering 2024-25 IV Saline Monitoring System

I. INTRODUCTION

Using IoT technology, this study creates an intelligent IV therapy monitoring system that automates the tracking of saline levels in IV drips. By combining sensors, a microcontroller, and a cloud-based platform, it ensures prompt action by sending real-time alerts to healthcare practitioners through online or mobile applications. By addressing the inefficiencies of manual monitoring, the system improves patient safety and lowers human error. Air embolisms and fluid overload are avoided by automating saline surveillance, which enhances patient outcomes overall. This and other IoT-driven healthcare technologies increase productivity and free up medical personnel to concentrate on important care duties. The goal of this project is to create a novel smart IV therapy monitoring system that uses Internet of Things (IoT) technology to automate the monitoring of saline levels in intravenous (IV) drip systems. To monitor saline levels in real time, the system combines sophisticated sensors, a microprocessor, and a cloud-based communication platform. When levels hit a critical threshold, alerts are delivered to healthcare providers using web or mobile applications, guaranteeing prompt intervention. The technology improves patient safety and expedites healthcare operations by automating this procedure, which eventually creates a more efficient and responsive medical environment [1].

The constraints of manual IV fluid monitoring, which is still widely used in many healthcare settings, make this research necessary. In high-stress situations where medical personnel are managing several patients at once, manual inspections might be ineffective and prone to human error. An automated system is necessary for precise and prompt saline level monitoring as patient numbers and healthcare demands rise. The pressing requirement for a dependable monitoring system that reduces the possibility of human error while freeing up medical staff to concentrate on providing direct patient care is addressed by this effort. The technology improves overall patient outcomes and operational efficiency in healthcare facilities by enhancing IV treatment management.

The main issue is that healthcare personnel primarily use manual checks for IV treatment monitoring. Routine chores may be neglected in hectic settings like hospitals and emergency rooms, which can result in serious problems like fluid overload, which can induce heart failure or pulmonary edema, or air embolisms, in which air enters the bloodstream. Both disorders can affect patient outcomes and provide serious health hazards. Traditional monitoring techniques are inadequate, which emphasizes how urgently a system that offers ongoing supervision devoid of human involvement is needed. This study model seeks to create a dependable system that improves patient safety and frees up medical staff to focus on critical care duties by automating saline level monitoring. This invention guarantees that human error will never jeopardize patient safety, fostering a higher standard of IV therapy management [3][4].

A network of linked devices that gather and exchange data in order to automate procedures and boost productivity is known as the Internet of Things (IoT). IoT encompasses more than just conventional computing devices; it also includes intelligent infrastructure like garbage disposal and traffic control systems. IoT-driven healthcare technologies, such as intelligent IV monitoring devices, improve patient care by guaranteeing timely notifications and real-time tracking. IoT applications will further transform industries and enhance daily life as it develops. [2] [5].

II. LITERATURE SURVEY

In order to prevent saline reversal occurrences and improve patient safety, Bhuvaneswary N et al. [1] present a novel Internet of Things-based system that uses cutting-edge sensors like load cells and ESP32 to monitor saline levels in real-time.

An IoT-based technique that monitors the saline levels in IV bottles and sends data to the cloud for real-time monitoring is presented by Pooja Pandit Landge et al. [2]. This ensures prompt notifications and increased healthcare efficiency.

An automated saline monitoring system is proposed by Jatin Parihar, Gouri Brahmankar, and Kriti Ojha et al. [3] to minimize manual checks by alerting medical personnel when fluid levels fall and avoiding refill delays.

A smart saline bottle system developed by Rajanayaki S. et al. [4] lowers the risk of consequences from unsupervised saline depletion by warning medical personnel when fluid levels go dangerously low.

In order to ensure prompt action and increase workflow efficiency, Sanjay B et al. [5] present an IoT-based monitoring system that tracks IV fluid levels and notifies healthcare providers.

In order to improve hospital care efficiency, Anusha Jagannathachari et al. [6] present a saline level indicator that measures fluid levels and sends out notifications to keep IVs from running empty.

In order to improve patient safety, D. Lee, S. Kim, H. Lee, et al. [7] suggest an Internet of Things-enabled system that uses smart sensors and alarms to monitor saline levels and flow rates.

In order to provide safer and more effective control of infusion therapy, S. Lee et al. [8] developed an algorithm to identify saline flow irregularities and initiate real-time alarms.

To avoid saline reversal and reduce the possibility of human error, H. Cho et al. [9] create a real-time monitoring system using flow sensors and clever algorithms.

The serious health hazards of undiagnosed saline reversal are highlighted by C. Brown, R. Smith, E. Wilson, et al. [10], who also provide an automatic detection technique that guarantees prompt medical intervention.

III. PROPOSED SYSTEM

Requirements:

Hardware:

i) ESP32

Equipped with Bluetooth and Wi-Fi, the ESP32 is a robust microcontroller. It functions as the system's core component, managing communication and processing of sensor data. It is perfect for Internet of Things applications because of its dual-core processor and numerous GPIO pins.

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ii) HX711:

A popular 24-bit precision analog-to-digital converter for load cells is the HX711. The load cell's low-voltage signal is amplified and transformed into digital data that a microcontroller can read. It guarantees precise weight measurements.

iii) GSM-Module

This component enables the system to communicate via mobile networks by sending and receiving messages. It is ideal for isolated locations because it functions without the use of Wi-Fi. When critical situations are identified, medical workers are notified by SMS as part of this study.

iv) LCD-Display

Real-time data, including saline levels and patient information, is shown on the LCD screen. It gives consumers an easy and efficient way to keep an eye on the state of the system without requiring an external device. Microcontroller interface is simple and straightforward to use.

v) Buzzer

The buzzer serves as a system of auditory alerts. When the saline level reaches a predetermined point, like 20%, it emits a sound to notify employees in the vicinity. Even in the event that SMS notifications are ignored, it guarantees prompt local awareness.

vi) Load-Cell

A load cell is a type of sensor that uses the strain that a load causes to determine weight. In this configuration, the amount of fluid left is estimated by detecting the weight of the saline bag. It is necessary for precise fluid level monitoring.

vii) Jumping-Cables

Various electronic components on the PCB or breadboard are connected via jumper wires. They offer a rapid and adaptable method for circuit configuration and modification during prototyping. Male-to-male, female-to-female, and male-to-female varieties are available.

viii) Push-Button

In order to initiate specific tasks or reset the system, the push button functions as a manual input device. It's straightforward but essential for starting processes or giving users control over embedded apps.

Technical:

i) Operating System

Linux and Windows Development and testing environments use both Linux and Windows. Linux delivers stability, security, and flexibility for server management and coding, while Windows offers a user-friendly interface and wide software compatibility.

ii) IDE

Multiple programming languages are supported by the lightweight yet potent source-code editor Visual Studio Code. It is perfect for web and embedded development because of its extensions, debugging tools, and Git integration.

iii) Programming Languages

PHP, JavaScript, HTML, CSS, and embedded C

The microcontroller is programmed for hardware-level functions using embedded C. PHP controls server-side logic and data handling, while HTML, CSS, and JavaScript handle the appearance and interactivity of the web interface.

iv) Domain

The web application is hosted on a bespoke domain, such as thesalineproject.info, which enables distant access to real-time patient data. Because it is available online, it increases the system's legitimacy and reach.

v) SQL,MySQL

MySQL is a well-known open-source database system, and SQL is the primary language for handling structured data. When combined, they effectively store, retrieve, and handle real-time saline data as well as patient records.

External Interface:

- User Interfaces: Healthcare personnel may easily view real-time saline level and flow data thanks to a custom web interface created using HTML, CSS, and JavaScript.
- Hardware Interfaces: The Arduino UNO collects and processes data for monitoring by connecting to sensors (flow and load cell).
- Software Interfaces: To control data logging and retrieval and enable reliable real-time monitoring, the PHP-based backend establishes a connection with the phpMyAdmin database.
- Communication Interfaces: To enable current monitoring on the web interface, ESP32 sends data to the server for display and storage in the phpMyAd min database.

Non-Functional:

Performance Requirements: In order to guarantee that medical personnel are promptly notified of any problems, the system must process and display saline levels and flow data with the least amount of delay possible.
Safety Conditions By identifying irregular flow patterns, the flow sensor lowers patient risks and stops backflow.
Need for Security To safeguard patient data and stop illegal access, the web application must be accessed securely.
Qualities of Software Reliability, minimal latency, and ease of use for medical personnel with little technical expertise are all requirements for the system.

Architecture:

The system architecture uses an ESP32 to track the flow of saline, sending information to a phpMyAdmin database via a PHP backend. While threshold-based alerts allow for prompt intervention, real-time data is shown via a custom web interface (HTML, CSS, JavaScript). This configuration facilitates effective saline level management and remote monitoring.[11]

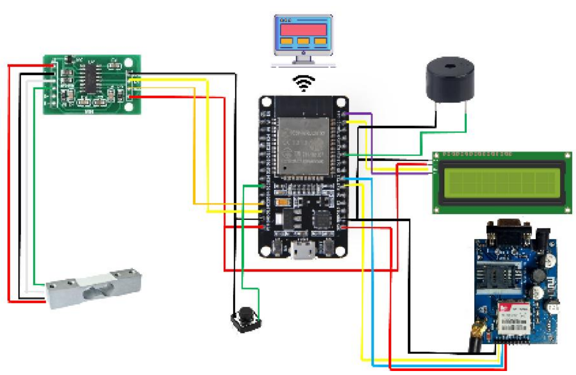

Fig. 1. Architecture of system

The system continuously monitors saline levels using load cell sensors, and the web interface shows the data in real time. Flow sensors that track the direction and constancy of saline flow can be detected using automated flow detection. If anomalies, such as backflow, are discovered, it sets off alerts to inform personnel. Medical personnel are kept

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informed in a timely manner via the system's use of a custom web application to deliver alarm notifications when low saline levels or irregularities in flow are noticed. Next, real-time saline level and flow data is presented to healthcare personnel in an easy-to-use format using a custom web interface created with HTML, CSS, and JavaScript. Subsequently, the ESP32 receives and processes data for monitoring via Hardware Interfaces Sensors (flow and load cell).

Interfaces for Software Consistent real-time monitoring is supported by the PHP-based backend's connection to the php MyAdmin database, which controls data logging and retrieval. Following these communication interfaces, ESP32 sends data to the server for storage and display in the php MyAdmin database, enabling real-time web interface monitoring. The system must then meet performance criteria by processing and displaying saline levels and flow data as quickly as possible, guaranteeing that medical personnel are aware of any problems as soon as they arise. Safety requirements: By identifying irregular flow patterns, the flow sensor lowers patient hazards and stops backflow. Security Conditions To safeguard patient data and stop illegal access, the web application must be accessed securely. Features of Software Quality Reliability, minimal latency, and ease of use for medical personnel with little technical expertise are all requirements for the system.

IV. RESULTS

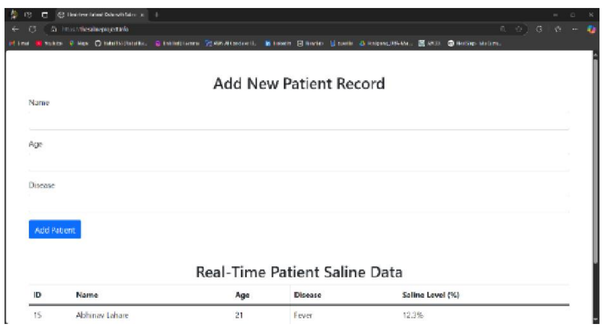

Fig. 2. Web Page

This project's web-based interface is intended to handle patient records and provide real-time saline level monitoring. Patient information, including name, age, and condition, can be entered by medical personnel and is safely saved in the system. To ensure current monitoring, the platform retrieves real-time saline level data straight from the ESP32 microcontroller. Our own domain, thesalineproject.info, which we registered for this project, hosts the web server where the data is seamlessly transferred. In clinical contexts, this integration facilitates faster response times and improves medical oversight.

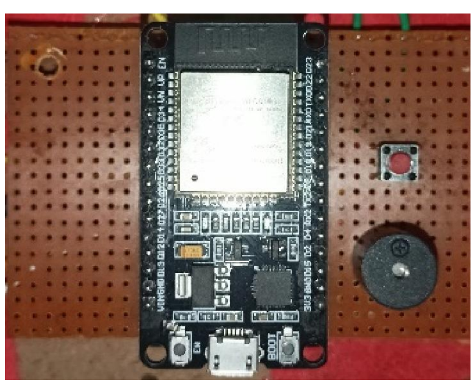

Fig. 3. ESP32 Microcontroller

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The buzzer in the configuration is set to sound when the saline level falls to 20%. This serves as an early warning system, giving medical personnel in the area an auditory notice before things get out of hand. The ESP32 microcontroller, which is linked to the buzzer, uses sensors to continuously check the saline level. To ensure prompt attention, the ESP32 sets off a loud siren when the threshold is achieved. This function helps avoid disruptions in patient care and is especially helpful in settings where continuous monitoring may not be feasible.

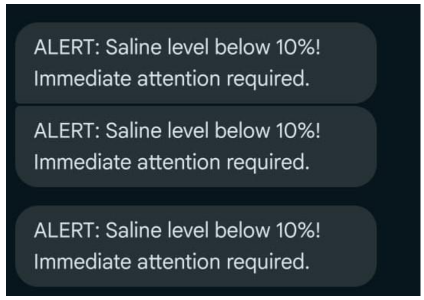

Fig. 3. Message Alert

This picture displays the outcome of our project, which uses a GSM module to deliver SMS notifications automatically. The device instantly sends the nurse a warning message that urgent action is necessary when the saline level reaches precisely 10%. This wireless connection is made possible by the GSM module and is independent of internet connectivity. This reduces the possibility of undetected saline exhaustion and improves patient safety by guaranteeing reliable and timely notifications.

V. DISCUSSION

By continuously measuring saline levels and identifying anomalies like depletion and reverse flow, the smart saline monitoring system enhances patient care. It lowers human error and increases hospital efficiency with real-time data processing and automatic alarms.

System Dependability and Efficiency:

Accurate fluid level tracking and anomaly detection are ensured by the ESP32 microcontroller and load cell. For prompt medical assistance, the GSM module enables instant alerts. For hospital employees, an LCD monitor provides immediate visibility.

Remote Monitoring and Data Management:

Medical practitioners can keep an eye on IV installations from a distance using a web-based platform. Real-time data storage and retrieval are supported via the PHP-based backend, which is connected to a phpMyAdmin database. Automated alerts assist in avoiding saline replenishment delays

Protection and Safety Considerations:

Authentication and encryption procedures guarantee the protection of patient data. By identifying anomalous flow conditions, the flow sensor avoids reverse flow and the dangers that come with it. Rapid notifications improve patient safety by facilitating prompt medical actions.

Scalability and Upcoming Improvements:

Multiple IV lines in different healthcare facilities can be monitored by scaling the system. AI-based predictive analysis, sophisticated wireless networking, mobile application integration, and dependable backup power solutions are a few possible enhancements.

VI. CONCLUSION

By minimizing fluid backflow and guaranteeing constant monitoring, the Internet of Things-based Automatic Saline Reversal Control System improves IV therapy safety. It incorporates sensors, such as a load cell for bottle weight, and processes data in real time using an ESP32 microprocessor. To ensure prompt response, medical staff receive notifications via SMS or phone calls using a GSM module when saline levels fall below a predetermined threshold.

Furthermore, a web application makes remote monitoring possible, giving medical professionals the ability to continuously check saline levels and flow rates. This technology enhances patient care, streamlines hospital operations, and lowers human error. It advances contemporary healthcare by offering a dependable, scalable, and effective solution for IV therapy administration through the use of IoT technologies. It reduces the possibility of issues brought on by postponed saline replacement. There is less need for continual manual supervision because the system runs on its own. Its modular design makes connection with current hospital systems and updates simple.

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