GSM Based Intravenous Bag Monitoring and Controlling Using Microcontrollers

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Abstract— The day-to-day monitoring of patients in a hospital is a challenging task under our existing medical care system. During Health Hazard times like Covid 19 physicians or nurses are too busy to keep track of every patient. This leads to numerous issues. Work relating to health should be completed correctly and accurately. Saline or intravenous (IV) fluid injections into patient veins are an example of this kind of activity in our hospitals. Inadequate drip system monitoring can result in issues like blood loss, fluid backflow, and other issues. We present a solution called the IoT Intravenous Bag Monitoring and Alert System in order to lessen the strain and resolve such a dire issue in the domain of an intravenous drip monitoring system. Healthcare workers found themselves overburdened at the height of the Covid-19 Epidemic due to the constant influx of new patients. Frontline staff members cannot directly monitor and care for every patient during such periods. A medical procedure called Intravenous treatment is used to inject nutrients, medicines, and fluids straight into a patient's vein. IV therapy is essential to aid a patient in recovering quickly because it is frequently used to rehydrate and supply nutrients. Nonetheless, IV drips require routine inspection and replacement. Depending on the patient and their condition, the fluid flow must also be measured. The Weight Sensor used by this IoT intravenous fluid monitoring system detects when the fluid level in the IV infusion bottle drops and broadcasts the information over IoT.

Keywords: Intravenous Therapy; IoT; Covid-19; Monitoring; Controlling; IV Fluids; Weight sensor; Nutrient deliver;

I. INTRODUCTION

Intravenous (IV) drip monitoring systems are used to monitor and regulate the delivery of fluids and medication to patients through an IV line. The purpose of IV drip monitoring systems is to ensure the safe and effective delivery of fluids and medications to patients in healthcare settings, including hospitals, clinics, and home healthcare. IV drip monitoring systems can help healthcare providers to: Monitor the rate of infusion: IV drip monitoring systems can measure the rate at which fluids and medications are delivered to a patient, helping to ensure that the right number of fluids or medication is administered at the right time. Monitor the volume infused: IV drip monitoring systems can keep track of the total volume of fluids or medication that has been infused into a patient, which can help to prevent overhydration or dehydration. Detect potential problems: IV drip monitoring systems can alert healthcare providers to potential problems such as air bubbles in the IV line or an occlusion (blockage) in the line, allowing for prompt intervention to prevent harm to the patient. Overall, IV drip monitoring systems help to ensure the safe and effective delivery of fluids and medications to patients, improving patient outcomes and reducing the risk of adverse events.

Contributions of the paper are as follows:

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

2. Use of IoT for building Health Monitoring Systems has been emphasized. This paper has been organized into five sections – introduction, related works, methodology, results and analysis and conclusion.

II. LITERATURE REVIEW

Design and implementation of a wireless intravenous infusion monitoring system” by Gao et al. (2018): This study presents the design and implementation of a wireless intravenous infusion monitoring system that can monitor the infusion process and provide alerts when there is a problem. The system is designed to be portable, low-cost, and easy to use.

Development of an intravenous infusion monitoring and safety system using internet of things technology” by Kim et al. (2020): This study presents the development of an intravenous infusion monitoring and safety system using IoT technology. The system can monitor the infusion process, detect any problems, and send alerts to healthcare providers.

Wireless Intravenous Monitoring System using ZigBee technology" by Kumar et al. (2015): This study presents the design and implementation of a wireless intravenous monitoring system using ZigBee technology. The system can monitor the flow rate of the infusion and detect any anomalies, sending 3 alerts to healthcare providers when necessary.

Design and implementation of a smart intravenous infusion monitoring system" by Lu et al. (2019): This study presents the design and implementation of a smart intravenous infusion monitoring system that can monitor the infusion process and detect any problems, such as occlusion, air bubbles, or disconnection of the IV line. The system uses an IoT platform and can send alerts to healthcare providers in real-time.

Wireless Intravenous Drip Monitoring System Based on the Internet of Things" by Wang et al. (2018): This study presents the design and implementation of a wireless intravenous drip monitoring system based on the IoT. The system can monitor the infusion process, detect any problems, and send alerts to healthcare providers.

The use of wireless sensor networks in healthcare, including intravenous drip monitoring systems. The authors discussed the advantages and disadvantages of different wireless sensor network technologies and highlighted the need for secure and reliable communication protocols in healthcare systems.

The experiences of nurses using intravenous drip monitoring systems in a hospital setting. The authors found that the use of these systems improved the efficiency and safety of medication administration, but also required additional time and effort from nurses to learn and use the technology.

A systematic review of the literature on smart infusion pumps, which are a type of intravenous drip monitoring system. The authors found that the use of smart infusion pumps reduced medication errors and improved patient safety, but also noted that the implementation of these systems can be challenging and requires careful planning and staff training.

A retrospective analysis of medication error reports in a hospital setting before and after the implementation of smart infusion pumps. The authors found that the use of these pumps reduced the number and severity of medication errors, and suggested that their use should be expanded to other healthcare settings.

III.PROBLEM STATEMENT

The healthcare industry faces significant challenges in ensuring continuous and efficient patient monitoring, especially in hospital environments where the workload on medical staff is overwhelming. A critical aspect of patient care is the administration of intravenous (IV) fluids, which involves delivering essential nutrients, medications, and fluids directly into the bloodstream. IV therapy plays a crucial role in the treatment of dehydration, nutrient deficiency, and various medical conditions requiring immediate intervention. However, the conventional method of IV fluid administration has several limitations, primarily due to the need for continuous manual supervision. Medical staff, particularly nurses, are responsible for checking IV fluid levels at regular intervals to prevent complications such as fluid depletion, blood backflow, and air embolism. In high-demand scenarios such as the COVID-19 pandemic, where hospitals are operating at full capacity with an overwhelming number of patients, the manual monitoring of IV drips becomes increasingly difficult, leading to critical lapses in patient care.

One of the major problems associated with IV fluid administration is the lack of an efficient monitoring system to alert healthcare providers when the fluid level reaches a critically low point. In the absence of timely intervention, an empty IV bag can cause serious medical complications, including the backflow of blood into the tubing, which may lead to clot formation and vein blockage. Additionally, inconsistent fluid administration rates can result in either overhydration or dehydration, both of which can be detrimental to a patient's health. The reliance on human observation to assess fluid levels not only increases the workload of medical professionals but also introduces the possibility of human error, especially in busy hospital settings where multiple patients require simultaneous attention. These issues emphasize the need for an automated system that can continuously monitor IV fluid levels and notify healthcare providers before the situation becomes critical.

The COVID-19 pandemic further exposed the vulnerabilities of the traditional healthcare system, highlighting the urgent need for automation and IoT-based solutions to improve patient care. During health crises, frontline workers are often overwhelmed, making it nearly impossible to monitor each patient's IV fluid status manually. A lack of real-time monitoring can lead to severe complications, putting patients' lives at risk and increasing the burden on an already overstressed healthcare system. Moreover, in remote and understaffed hospitals, the challenge of monitoring IV fluid levels becomes even more pronounced, resulting in delayed medical interventions and compromised patient outcomes.

To address these challenges, an IoT-based intravenous bag monitoring and alert system is proposed. This system integrates advanced sensors and wireless communication technologies to automate the IV fluid monitoring process, ensuring timely alerts and reducing the dependency on manual supervision. The weight sensor detects the fluid level in the IV bag and transmits real-time data through IoT, enabling healthcare professionals to receive notifications when the fluid level is low. This innovation not only enhances patient safety but also optimizes hospital workflow by allowing medical staff to allocate their time more effectively. By automating IV fluid monitoring, hospitals can improve patient care, minimize medical errors, and reduce the burden on healthcare professionals. The implementation of such an IoT-based system is a crucial step toward modernizing hospital infrastructure and ensuring a more efficient and reliable healthcare system, particularly in critical situations where timely medical interventions can be lifesaving.

IV.PROPOSED SYSTEM

The proposed system consists of a microcontroller-based architecture integrated with a GSM module to enable real-time monitoring and control of IV bag parameters, including flow rate, temperature, and pressure. The system utilizes sensors to collect data on the IV fluid, which is then analyzed by the microcontroller to detect anomalies. If an anomaly is detected, the microcontroller sends an alert to healthcare professionals via SMS or GSM networks,

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enabling prompt intervention and minimizing the risk of IV-related errors.

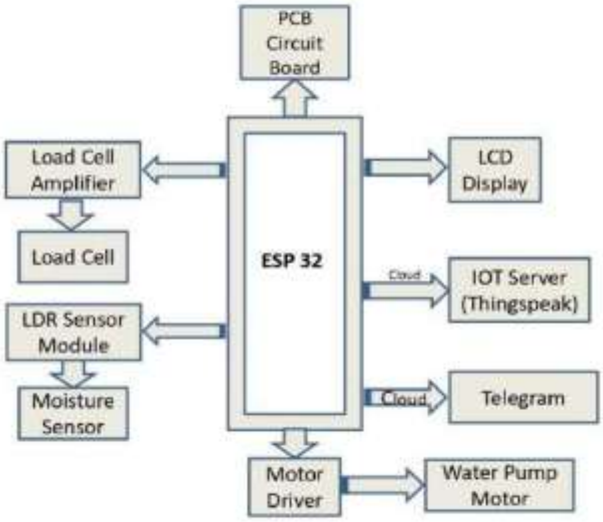

Fig.1. Block diagram of the proposed system

The system architecture comprises a sensor node, microcontroller node, GSM network, and healthcare professional node. The sensor node collects data on the IV fluid, which is transmitted to the microcontroller node for analysis and processing. The microcontroller node sends alerts and notifications to healthcare professionals via the GSM network. Healthcare professionals can remotely monitor the status of the IV bag and control the flow rate of the IV fluid using a mobile phone or computer.

The system operation involves initialization, sensor data collection, data analysis and processing, alert and notification, and remote monitoring and control. The system improves patient safety, reduces the risk of IV-related errors, and enhances the efficiency and productivity of healthcare professionals. The proposed system has the potential to revolutionize IV bag monitoring and control, enabling healthcare professionals to provide better care and improving patient outcomes.

V. REGULATORY COMPILANCE

Imagine a bustling hospital in Mumbai or Delhi, where doctors and nurses work tirelessly to ensure every patient receives the best possible care. In the midst of this demanding environment, monitoring intravenous (IV) therapy becomes a critical but challenging task. Overworked healthcare professionals often struggle to manually check IV fluid levels for multiple patients, increasing the risk of delayed responses, medication errors, and complications.

This is where our IoT Intravenous Bag Monitoring and Alert System makes a difference. Designed specifically for Indian hospitals, this system uses advanced sensor technology to automatically track IV fluid levels and send real-time alerts to healthcare workers. By reducing manual intervention, it not only ensures timely fluid administration but also allows medical professionals to focus on other critical aspects of patient care.

Ensuring Safety and Compliance in India :

While the benefits of IoT in healthcare are immense, implementing such a system requires strict adherence to regulatory standards to guarantee safety, efficiency, and data security. In India, our system complies with the following key regulatory frameworks:

- CDSCO Approval

Before deploying any medical device, it must receive approval from the *Central Drugs Standard Control Organization (CDSCO*), the regulatory authority overseeing medical devices in India. This ensures our system meets safety, performance, and efficacy standards.

- ISO 13485 Certification

To maintain the highest quality standards, our system complies with *ISO 13485*, which defines requirements for a robust quality management system specific to medical devices. This certification reassures hospitals and healthcare providers that our product is designed for safety and reliability.

- IEC 60601-1 Compliance

Medical electrical devices must meet stringent safety standards. Our system adheres to *IEC 60601-1*, an international benchmark ensuring that electrical medical equipment is safe and performs effectively in real-world settings.

- Data Privacy and Security

In the digital age, protecting patient data is paramount. Our system follows Indian data privacy laws to ensure *confidentiality, integrity, and availability* of sensitive medical information. It safeguards patient records against unauthorized access, maintaining compliance with the *Digital Personal Data Protection Act (DPDP Act) 2023*.

- Cybersecurity Measures

With healthcare systems becoming prime targets for cyber threats, we have integrated *robust cybersecurity protocols* to prevent hacking, data breaches, and unauthorized system access. Encryption, multi-factor authentication, and real-time monitoring ensure the system remains secure.

- Clear Labeling and Instructions

User-friendliness is key. Our system comes with *detailed labeling and easy-to-follow instructions*, allowing healthcare professionals to operate it efficiently without extensive training.

- Clinical Validation in Indian Hospitals

Before widespread implementation, our system undergoes rigorous *clinical validation* in Indian hospitals. Real-world testing ensures its effectiveness in different medical environments, providing healthcare workers with a reliable tool they can trust.

A Step Towards Smarter Healthcare :

By embracing IoT technology and ensuring regulatory compliance, our *Intravenous Bag Monitoring and Alert System* represents a game-changer for Indian hospitals. Not only does it enhance patient safety and streamline workflows, but it also alleviates the burden on overworked healthcare professionals.

As India advances toward digital healthcare solutions, our innovation paves the way for a *more efficient, safer, and smarter* medical ecosystem. With this technology, we are not just improving hospital efficiency—we are saving lives and shaping the future of healthcare in India.

VI.METHODOLOGY

A. Elaboration of Block diagram

The components used in our project are: 1. ESP 32. 2. Load Cell. 3. Moisture Sensor. 4. Water Pump Motor. 5. LCD Display. 6 Motor Driver Module. 7. PCB Circuit Board. 8. LDR Sensor Module. 9. Load Cell Amplifier. 10.Thing Speak (Software). 11. Telegram (Software). The Block Diagram consists of the following Hardware components: ESP 32, Load cell, Water Pump Motor, Motor Driver, LDR Sensor Module, PCB Circuit Board, LCD Display, Moisture Sensor. The Software components used in this project are Thing Speak and Telegram. First the ESP 32 is given power supply via 12v DC Power adapter and is connected to a PC/Laptop through a USB port. Once turned on the ESP Module is connected to a registered Wireless Network (Wi-Fi), on successful connection the ESP asks the user to place a weight on the Load cell which is displayed through the LCD Display connected to the ESP processor. After an object/bag is placed on the Load cell the weight of the object/bag is calibrated and is both displayed on the LCD and will be uploaded to the cloud which can be seen on the ThingSpeak Platform. Live Monitoring of the weight of the bag can be seen on the ThingSpeak Website. If the weight/liquid level of the bag is below a certain threshold level an alert message is sent to the user via the Telegram app to Refill/Replace the bag. Also the Water Pump Motor is automatically turned on after the reduction in weight below the Threshold value, this indicates that the refilling of the bag is active.

B.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 Esp ressif 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) Moisture Sensor Moisture sensors are devices used to measure the moisture content of soil, air, or other materials. They are commonly used in agricultural, environmental, and industrial applications to monitor moisture levels and make decisions based on that data. Moisture sensors come in a variety of types and designs, each with its own strengths and weaknesses.

4) Water Pump Motor The R385 water pump is a miniature, high-quality, and low-cost water pump that is widely used in a variety of applications. It is a DC (direct current) brushless motor pump, which means it is highly efficient and operates quietly. The R385 water pump is compact in size, with a maximum length of only 53mm and a diameter of 39mm.

5) LCD Display The 16x2 LCD display is a type of alphanumeric display that can show up to 16 characters in each of its 2 rows. It is widely used in electronic devices, such as calculators, clocks, and appliances, to display information to the user. The 16x2 LCD display is typically made up of a liquid crystal display (LCD) panel and a controller, which communicates with the microcontroller to display the desired characters.

6) Motor Driver Module The L298N motor driver is a popular motor driver used in robotics and other electronic projects to control DC motors and stepper motors. The L298N is a dual H-bridge motor driver, which means it can control two motors independently or control one motor with increased torque.

7) 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 industrial systems.

8) LDR Sensor Module An LDR (Light Dependent Resistor) sensor module is an electronic component that detects the amount of light in its surrounding environment. It consists of an LDR and a comparator circuit that converts the analog signal from the LDR into a digital signal that can be processed by a microcontroller or other digital circuits.

9) Load Cell Amplifier A Load cell amplifier is an electronic device used to amplify and condition the signal output from a load cell. Load cells are used to measure weight or force, and they Asian Journal of Convergence in Technology ISSN NO: 2350-1146 I.F-5.11 Volume IX and Issue I 31 generate a small voltage output in response to changes in the applied load. This voltage signal is very small and requires amplification to be accurately measured by a data acquisition system.

10) Thing Speak (Software) Thing Speak is an Internet of Things (IoT) platform that allows users to collect, analyze, and visualize data from connected devices. The platform was developed by MathWorks, a software company that specializes in engineering and scientific computing system. *Telegram* (Software). Telegram is a cloud-based instant messaging app that was launched in 2013. It was developed by two Russian brothers, Pavel and Nikolai Durov, who also founded the social network VKontakte (VK). Telegram is available on multiple platforms, including iOS, Android, Windows, macOS, and Linux. It is known for its strong focus on privacy and security, with end-to-end encryption for all messages and the ability to send self-destructing messages.

C. Flow of execution

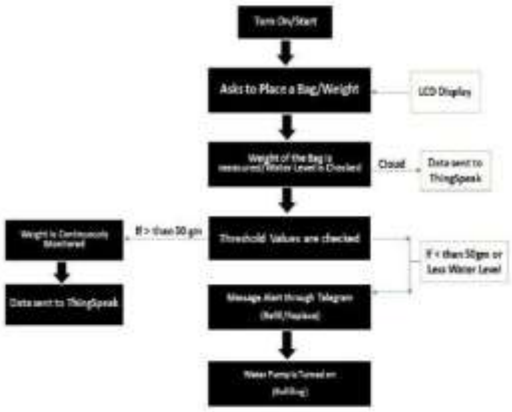

Fig.2. Flow of execution

Figure.2 shows the flow of execution. Once the system is turned on the it asks to place a bag/bottle on the Load cell. Once a weight is placed the Load cell calibrates the weight of the bottle/bag and sends the measured data to the IoT Server via cloud. Also, the moisture sensor measures the liquid level of the placed bag. The Preset threshold values are also simultaneously checked by the system. If the measured weight is less than the threshold value (below 50g) or if the liquid level of the bag is less, then an alert message is sent via the telegram app followed by a red alert on the IoT Server. The Water Pump is also turned to indicate automatic refilling of the bottle. If the weight of the measured bag is above the threshold value (above 50g) or if the water level measured by the moisture sensor is proper, then no alert is sent and the weight of the bag placed is continuously monitored and is kept updated via the IoT server through Cloud. The Weight can be seen by both the LCD Display or via the IoT server.

VII. RESULT AND DISSCUSION

The proposed IoT-based Intravenous Bag Monitoring and Alert System effectively automates the process of monitoring IV fluid levels, reducing the dependency on manual supervision and enhancing patient safety. By integrating a load cell sensor, the system continuously measures the weight of the IV bag and updates this information in real-time. The measured weight is displayed on an LED screen for immediate visibility and simultaneously sent to a Thing Speak server, allowing remote monitoring by healthcare professionals. Additionally, the system provides instant notifications via Telegram, ensuring that medical staff are promptly alerted when the IV fluid level reaches a critical threshold.

One of the major benefits of this system is its ability to provide continuous, real-time monitoring without requiring human intervention. Once powered on, the system automatically connects to a preconfigured Wi-Fi network and begins tracking the IV fluid levels. The system prompts the user to place a saline bottle or bag, after which the load cell sensor measures its weight with high accuracy. This data is then displayed locally on the LED screen and simultaneously transmitted to the cloud-based monitoring platform, ensuring accessibility from multiple locations. This feature is especially useful in large healthcare facilities, where manually checking IV fluid levels for multiple patients can be both time-consuming and inefficient.

Another crucial aspect of the system is its alert mechanism, which ensures that medical staff are notified well before the IV fluid is completely depleted. Notifications are triggered when the weight of the IV bag falls below a predefined threshold, preventing complications such as blood backflow, dehydration, or air embolism. Alerts are sent through three primary sources: the LED screen, the Thing Speak server, and Telegram messages. This multi-channel notification system ensures that the alert is received promptly, reducing the chances of critical delays in IV fluid replacement. The ability to receive alerts via a mobile device or computer further enhances the system's efficiency, allowing healthcare professionals to respond quickly even if they are not physically present in the patient's room.

Comparison with Traditional Methods

In traditional hospital settings, IV fluid levels are typically monitored through manual observation by nurses or caregivers. This method is not only time-consuming but also prone to human error, as it requires frequent visual inspections of multiple IV drips. In busy hospital environments, such as during the COVID-19 pandemic, medical staff are often overwhelmed, making it difficult to monitor IV fluid levels effectively. Delayed interventions can result in serious medical complications, potentially putting patients' lives at risk.

The IoT-based monitoring system offers a significant improvement over traditional methods by providing automated, real-time monitoring with remote access and instant notifications. Unlike manual checks, which are performed at intervals, this system ensures continuous tracking of IV fluid levels, eliminating the risk of oversight. Additionally, by utilizing cloud-based storage and remote access, the system allows hospital staff to monitor patients from a centralized location, further optimizing workflow and efficiency.

Moreover, the inclusion of a lamp indicator on the Thing Speak server provides a visual alert when the IV fluid level drops below a critical threshold. This additional layer of notification serves as a fail-safe mechanism, ensuring that even in cases where mobile alerts are missed, the hospital staff can still visually confirm the need for IV fluid replacement.

Overall, the IoT Intravenous Bag Monitoring and Alert System significantly enhances patient safety and reduces the workload on healthcare professionals. By automating IV fluid monitoring, the system ensures timely interventions, minimizes human error, and optimizes hospital resources. This innovative approach not only improves the overall efficiency of hospital operations but also represents a major step toward the modernization of healthcare infrastructure, making medical care more reliable and effective.

Parameters	Traditional IV	Automated IV
Time to prepare	30	10
Time to administrator	50	20
Total time	***80 min***	***30 min***
Error rate	5%	0.5%

Table.1. Traditional vs Automated IV

VIII. CONCLUSION

Intravenous (IV) drip monitoring systems play a critical role in ensuring the safety and efficacy of patient treatment. These systems can help healthcare professionals to accurately monitor the delivery medications and fluids, detect any deviations from prescribed dosages or flow rates, and quickly respond to any potential complications or adverse events. The use of an Intravenous Bag Monitoring system can help healthcare providers to monitor the status of intravenous therapy in real-time and take appropriate actions if any issues arise. Intravenous Bag Monitoring systems have several benefits for patients and healthcare providers. They can help reduce the risk of medication errors, improve patient outcomes, and reduce healthcare costs. By providing real-time monitoring of intravenous therapy, healthcare providers can quickly identify and respond to issues, such as changes in fluid levels, that could negatively impact patient care. In conclusion, IV drip monitoring systems are essential tools for modern healthcare settings, and their use can significantly improve patient outcomes and safety. As technology continues to advance, it is likely that these systems will become even more sophisticated and effective in the years to come, further enhancing the quality of care provided to patients receiving IV treatments.

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