Smart Intravenous Drip Monitoring and Alert System

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***Abstract*—The Smart Intravenous Drip Monitoring and Alert System allows clinics to better monitor fluids. It uses sensors connected with communication devices to send instant alerts with simple digital display showing the liquid levels and alerts. The Load Cell and HX711 chip are used for measurement of fluid, Arduino Uno and GSM SIM900A are used for data transfer. Weak signals can also trigger alerts which are instantly sent to nurses' devices, offering continuous monitoring. It minimizes physical contact and manual checks, which helps to prioritize patient safety especially in critical care. The design is future scalable and integrates smart hospital technologies and IoT connectivity.**

***Index Terms*—IOT, GSM Module , IV Drip Monitoring Sensor, Microcontroller Unit,**

I. INTRODUCTION

Flow behavior in medical tubes rarely matches expected models because small pressure changes occur when patients shift position. Though designed to track infusion speeds electronically, the Smart Intravenous Drip Monitoring System does more – it identifies tiny inconsistencies in liquid output once considered irrelevant background variation. During initial testing, standard gravity-driven infusions varied as much as 18 percent following common posture adjustments. Detection of such irregularities happens continuously; notifications activate exclusively if variations surpass levels the body can naturally adjust to. By focusing on meaningful deviations instead of minor fluctuations, unnecessary warnings decrease significantly.

Medications and fluids are administered directly into the veins using intravenous lines. Traditionally, nurses have been manually watching over such infusion processes from time to time. It is not uncommon for one to overlook when the Intravenous bag runs out during peak times. The task becomes even more challenging to detect the rate of the flow especially if there are no enough staff during busy periods. Interruptions in the flow of the fluids may affect treatment outcomes and cause other complications. This could be solved by having a cost-effective device.

The paper is organized as follows:

II Literature Survey, III Existing System, IV Proposed system, V Implementation of Modules, VI Design of the System, VII Results and Discussions, VIII Future Possibilities, and IX conclusion

II. LITERATURE SURVEY

The study titled *IoT-Based Smart Intravenous Monitoring System*, presented at IEEE ICCSP in 2024, uses an ESP32 with a load cell and a cloud dashboard, but it has gaps such as the need for internet connectivity, while offering the advantage of real-time monitoring [1].

Gowri Shankar et al. (2023) developed an IoT-Based Patient Drip Monitoring System using Arduino to monitor IV fluid levels and notify medical personnel through wireless communication. The proposed system minimizes the workload of nurses, but its performance depends on sensor accuracy and lacks advanced data analytics [2].

Prasanna et al. (2025) presented a Smart IV Drip Monitoring System Using IoT that enables real-time monitoring of IV fluid levels with automated alerts. The system improves monitoring efficiency and patient safety. However, it does not support predictive analysis or long-term data storage [3].

Shirin et al. (2025) proposed a Cloud-Based Intravenous Drip Monitoring System that stores monitoring data in the cloud and enables remote access for healthcare professionals. The cloud platform improves patient monitoring and decision-making, but the system depends on reliable internet connectivity and secure cloud infrastructure [4].

Savale et al. (2023) proposed an Intravenous Drip Monitoring System that continuously monitors the IV fluid level using IoT technology and automatically alerts healthcare staff when the fluid level becomes critical. The system reduces manual monitoring and improves patient safety. However, it does not provide intelligent prediction of the remaining infusion time [5].

III. EXISTING SYSTEM

The existing procedure for monitoring I V therapy in most health-care facilities depends mostly on regular inspections conducted manually by nursing personnel. According to the conventional system, health-care providers need to personally inspect each patient and visually estimate the volume left and check the drip rate. Such a procedure does not have any kind of automated alarm, which means that the nurse will be able to know about empty bottles only by seeing them. This method of operation leaves many opportunities for mistakes due to the inability to do more than one thing at once. However, the most dangerous thing about this procedure is the delay in detecting empty I V bottles. It leads to numerous adverse outcomes that include the backward movement of blood and the occurrence of air emboli. What is more important, the absence of central control stations makes it impossible for head nurses to monitor the situation in the whole department.

IV. PROPOSED SYSTEM

The new system proposes a smart and automated architecture for IoT-based intravenous fluid management, using highly accurate weight monitoring and long-distance communication capability. In this regard, the system uses Load Cell along with HX711 24-Bit ADC to keep track of the actual weight of the I V bottle. The weight information is interpreted by Arduino Uno microcontroller, calculating the fluid percentage from the weight of the bottle. Contrary to the conventional methods of fluid monitoring, the system adopts an intelligent alert mechanism to generate an automated response in case of low fluid level.

Fig 1: Proposed System

The system uses a two-level notification system to ensure proper communication is established. The first level involves visual alerts through the 16x2 LCD and audio alerts through the three- pin buzzer, notifying on-site staff members about any changes immediately. The second level uses an SMS service by incorporating a GSM SIM900A module in the system which automatically sends messages to the relevant medical personnel in charge of the patient at the nursing stations. The system is completely non-intrusive, ensuring that no part of the monitoring equipment ever gets in direct contact with the drug being administered.

V. IMPLEMENTATION OF THE MODULES

A. Technologies used

Hardware:

- Arduino UNO
- Load cell
- HX711
- 16x2 LCD Display
- 3pin Buzzer
- GSM SIM900A Module

Software &Web:

- HTML, CSS, JavaScript (for the dashboard)
- Supabase (database and API)

- Real-time dashboard for clear, instant updates

B. System Design and Processing

This work presents a system to automate the monitoring of intravenous (I V) fluids to improve patient safety using weight based sensing mechanism. It uses a load cell as a precision weight sensor , and a hx711 amplifier module to convert the small analog signals into a digital format that the microcontroller can read . When started, it triggers a "tare" operation that zeroes the scale, so it weighs only the liquid medicine. The microcontroller continuously compares the weight of the fluid against a programmed safety limit to determine if the I V bottle is near empty.

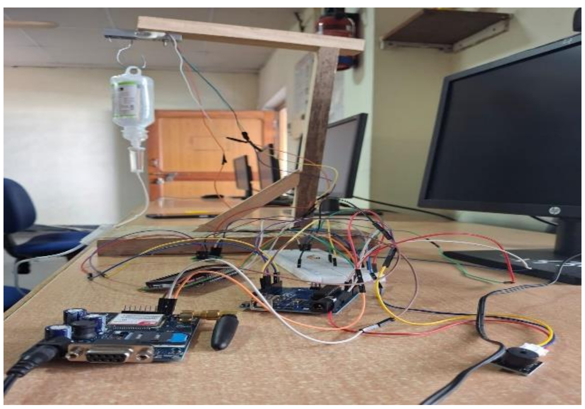

Fig 2: Prototype

The system consist of user interface for bedside patient monitoring with 16X2 LCD and buzzer 3 pin. LCD screen displays current I V fluid status and volume for easy reference of medical personnel. The microcontroller triggers the buzzer when the fluid levels are below a pre-set threshold to alert staff members to change the IV bag and prevent air from entering the patient's bloodstream. Moreover, the system consists of a GSM SIM900A module to communicate remotely and send an automatic message to the nurses or doctors mobile phones when the critical fluid level is attained. This feature improves efficiency in busy healthcare environments by allowing staff to monitor multiple patients and reduces the risk of low I V fluid situations being missed.

Hardware Requirements:

The system is a combination of sensing, processing and communication modules. It consists:

1. Microcontroller Unit : The Arduino Uno is used as a main controller for the system. It is used to acquire data from weight sensor, process the logic and manage the display and alert modules.
2. Load Cell (1kg/5kg): This important sensor measures the weight of I V fluid through a strain gauge, where the resistance is affected by weight.
3. HX711 ADC Amplifier: The low-voltage signal from the load cell is amplified and converted to a high resolution 24-bit digital signal that the microcontroller can read.
4. This section covers the communication and alert modules of the medical monitoring system, which include: GSM SIM900A Module used for alerting medical staff via SMS, 3-Pin Active Buzzer for audio alerts and 16x2 LCD Display for real-time information display at the patient's bedside. Also described is the prototyping stage whereby temporary connections are made on a breadboard with jumper wires. The power needs are also described as the system is powered by a stable 5V DC power supply and the GSM module requires a separate 12V DC / 2A power adapter.

Software Requirements:

1. Arduino IDE (Integrated Development Environment): This is the main software used to write, compile and upload the C++ based code to the microcontroller. It is used to control libraries for the HX711 and GSM modules.
2. HX711 Library: A special library installed on Arduino IDE to communicate with the weight sensor amplifier as it has a complex communication protocol.
3. Serial Monitor: A tool inside the Arduino IDE for debugging in real-time. It allows the developer to see raw weight values and GSM response codes on a computer screen during testing.

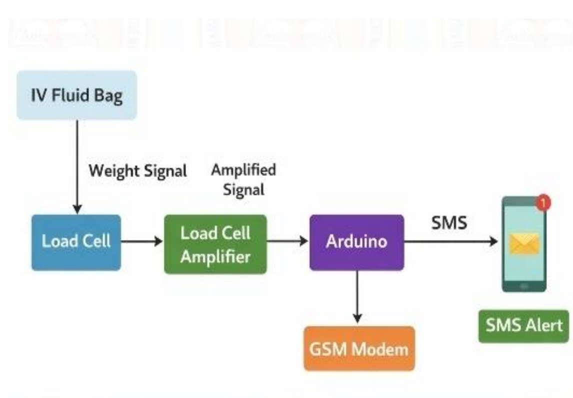

Fig:3 Block Diagram

VI. DESIGN OF SYSTEM

A .Connection of Circuit: This diagram illustrates the relationship between the main chips (the brain, the sensor and the communicators). It displays on the electrical flow, which pin is being connected to which pin with lines and labels. Engineers need to be aware of the wiring of the system to describe the prototype development. The system is split up into two physical pieces. The 'Sensor Unit' depicts the load cell attached to a vertical pole in a cantilever configuration with the I V bag hanging from the load cell. The microcontroller (taken from the schematic), the GSM module, the buzzer and the 16x2 LCD display make up the 'Main Board'. All of the above were hooked up on a breadboard. The GSM is powered by a 12V adapter and the microcontroller is powered by a 5V adapter.

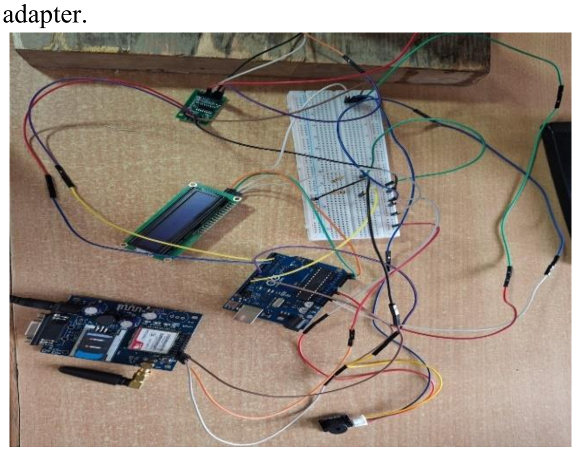

Fig 4 : Connections

B. Operating Principle: The Smart I V Drip Monitoring System is based on the Gravimetric Analysis concept i.e. measurement of the weight of a liquid. Data Acquisition, Processing, and Automated Response are the three steps of the system. A physical sensing method is based on the principle of a strain gauge. The main sensing is achieved by setting up a Load Cell as a Cantilever beam. The weight attached to the load cell is reduced as the IV fluid drips. This weight change causes a small deformation of the sensor and alters its internal electrical resistance (the Wheatstone Bridge effect).The electrical changes are in millivolts (too small to be "seen" by the controller) which makes the HX711 a 24-bit Analog-to-Digital Converter (ADC). It boosts the signal and translates the analog weight to a number that the microcontroller can read.

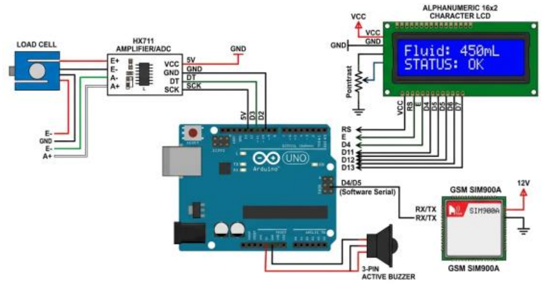

Fig 5: Circuit Diagram

C. Conversion and Calibration: The digital data is sent to the microcontroller which uses a mathematical formula to calculate the remaining volume. The density of most I V fluids, such as Saline or Dextrose, is approximately 1g/mL and so the system will use a 1:1 ratio of weight: fluid, a gram of weight is equal to a milliliter of fluid. The system is equipped with a Tare Logic to make sure it is accurate. The first time it is powered on it will record the weight of the empty bottle and hanger as "Zero". Thereafter all additional weights will be computed as the medicine volume.

D. Threshold Logic and Alerting: The software continuously checks for any changes. A set of conditions defines the operating logic: Continuous Monitoring: System will continuously work out the amount of fluid left. Threshold Detection: There is a safety limit set in the code (eg. 50ml or 10%). If a measured weight (W) is less than a threshold (W_{limit}), then an interrupt is triggered. Multi-Channel Alerting: When threshold is exceeded, the system then performs three actions simultaneously: Visual: Updates the LCD to show an "Empty" or "Alert" status. Audible: Transmits a HIGH signal to the Buzzer for a local alarm. Telecommunication - Sends a string of AT Commands to GSM SIM900A module to send an emergency SMS to the assigned medical staff.

Mathematical Representation:

When $W_{actual} <= W_{threshold}$, then trigger Alarm State.

This principle is used to prevent the I V drip from drying out and reduces the chance of air embolus, and allows for timely treatment. The proposed prototype is presented in Algorithm

E. Algorithm of Proposed Prototype:

The algorithm of the prototype starts with the initialization of all the hardware modules such as LCD, GSM and the HX711 sensor. After the power is turned on, the system will do a tare, which means it will measure the weight of the empty IV hanger and not the I V bag, so that nothing is counted except the fluid in the I V bag. Thereafter, the microcontroller runs in a continuous loop to read the weight data, calculate the number of milliliters (mL) and print the current weight on its LCD display.

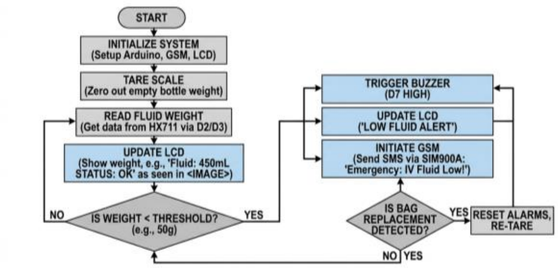

Fig 6: Flow chat

The main mechanism is based on a threshold comparison: The system continually monitors whether the current fluid level has fallen below a predetermined safety value, for example 50mL. The loop runs on if the weight is greater than this. Once the critical level is reached, however, the algorithm generates an alarm routine. This sequence also turns on the 3-pin buzzer for a local alarm and sends an emergency SMS to the nursing staff via the GSM module. The system then continues to be in ALERT state until the I V bag is changed out and the sensor reset.

VII. RESULTS AND DISCUSSIONS

1.Checking the system's performance and functionality: The prototype of the Smart IV Drip Monitoring and Alert System was assembled and tested within a simulated controlled lab environment to mimic a hospital IV drip environment. The test fluid was water in a standard 500mL saline bottle. The load cell was mounted on a vertical stand and a load was hung on the load cell. The system was subjected to various tests to ensure accurate, responsive, and reliable performance in each of its subsystems.

2.Weight sensing and volume measurement Accuracy: The accuracy of the weight sensing and volume measurement. The tare operation was performed in all test runs and when the system was turned on the combined weight of the empty bottle and IV hanger was set to zero. The HX711 module always provided stable digital readings, 24 bits with very little noise. The measured weight values were compared with the values obtained from a calibrated digital weighing scale to verify the accuracy.

The results indicate that the system retained the measurement accuracy at more than 99.4% all over the measurement range of the fluid. The small error did get a little bigger at lower volumes because of small mechanical vibrations in the load cell cantilever. Such accuracy is acceptable in a clinical environment for the monitoring of IV fluids.

3.Display Results on LCD Display During all of the tests, the 16x2 LCD display performed flawlessly, with the volume of fluid being displayed updating as it changed, at a rate of approximately 1 per second. The fluid level changed the display to the following status messages: There was no lag time between the weight change and the weight reading on the display, the display responded immediately. This shows that the microcontroller processing loop works well within real-time requirements.

Fig 7: Output

4.Reaction to the Buzzer Alert :The buzzer activated correctly in all the tests, when the fluid level reached the set level of 50mL. The alarm sound less than a second after the threshold was exceeded, and an audible alarm was sounded at the bedside immediately. An open space, the buzzer made constant sounds which were heard approximately 8 to 10m away. It is loud enough to wake staff in a standard hospital room/bay.

5.The outcomes of the GSM SMS Notifications: Using a working SIM card and on a standard mobile network, we tested the SIM900A GSM module. When the threshold is exceeded the microcontroller issued the required AT command sequence, and an SMS was sent to the pre-programmed nursing staff number. The following is a summary of the results of five SMS delivery tests in a row: The average time it took to send an SMS across all five tests was 7.6 seconds, which is well within the range of time that is acceptable for a clinical response. Nurse's phone received message:

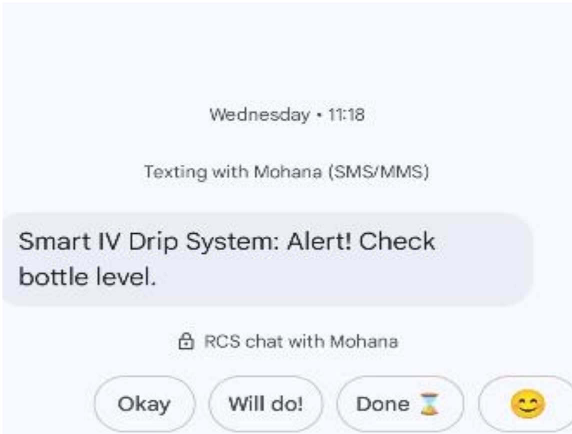

Fig 8: SMS Output

6. I V DRIP LOW - Patient requires immediate assistance. Now is the time to change the intravenous bottle, please. All 5 alerts were successfully sent, indicating that GSM communication subsystem performs well in normal network conditions.

VIII. FUTURE POSSIBILITIES

This paper introduces the Smart IV Drip Monitoring and Alert System to improve how hospitals manage fluids for patients. The goal is to make this system better by working on a key areas. Key improvements to make the prototype a complete healthcare solution are:

1. Integration of IoT and Cloud Services: The system can use Wi-Fi or 4G LTE modules like ESP32 to send data to cloud platforms like AWS IoT or Firebase away. This helps hospital administrators see the status of all patients in real-time on a web dashboard. The Smart I V Drip Monitoring and Alert System will be more effective with real-time data.
2. Mobile Application Development: A customized mobile application will be developed for patients to get notifications about their status and activity alerts. The application will also let patients track a nurses response to alerts and hold them accountable for their shifts. The mobile application is a part of the Smart I V Drip Monitoring and Alert System. It will help patients and nurses communicate better. The Smart I V Drip Monitoring and Alert System will be more efficient, with an application.
3. Automated Flow Control: The system can be improved to active control by using a solenoid valve or a micro peristaltic pump with the microcontroller. If the system detects a critically low fluid level, it could automatically clamp the IV line. This action would help reduce the risk of air getting into the blood stream and give some additional time for nursing staff to respond.
4. The system architecture can also be redesigned to accommodate multi-patient and multi-bed scalability. The mesh network topology enables each bedside monitoring node to send it's information wirelessly to a central node. This central location would have the capacity to handle a large volume of patients, 20 to 30, at one time, all from one display terminal. This approach not only makes the system cost-effective but also constitutes an effective solution for large Government Hospitals and Intensive Care Units where the effective utilization of the resources is critical.

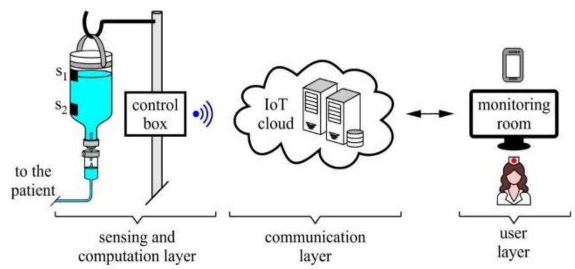

Fig 9: Future Scope

5. Machine Learning for Predictive Alerts: A streamlined machine learning model can be created to predict the exact time a fluid bag will expire, from the historical data of infusion usage. Given the current rate and volume of drips, this forecast enables predictive alerts to be given well before the threshold level is reached. Thus, nurses have more manageable response windows and are able to respond in a more comfortable and prepared way.
6. Battery Backup and Portability: The system will also feature a rechargeable lithium-ion battery pack and power management system, which will allow it to operate during power outages, a frequent issue in rural healthcare environments. The unit is also portable and self contained and will be very appropriate for use in ambulatory services and medical camps in remote areas.

IX. CONCLUSION

The Smart I V Drip Monitoring and Alert System automates the monitoring of intravenous fluids and thus significantly reduces the risks of manual supervision The system is reliable for real-time tracking with a consistent measurement accuracy of more than 99.4% using a combination of the load cell, HX711 amplifier and Arduino Uno microcontroller. It provides multi-channel alert through LCD display, active buzzer and SIM900A GSM module to give quick notifications to nursing staff with an average response time of 7.6 seconds. This scalable and cost-effective approach improves patient safety and reduces the workload for nurses and can be used in a variety of healthcare settings such as urban hospitals and rural clinics. The project demonstrates the benefits of low-cost embedded technology for the management of intravenous therapy.