



Smart IV Blockage Detection and Nurse Alert System

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DOI : <https://doi.org/10.55248/gengpi.07.1026.3270>

ABSTRACT :

Intravenous (IV) therapy is widely used in hospitals to deliver fluids and medicines, yet the infusion is still monitored mainly by manual observation of the IV bag and the drip chamber. Stoppage of flow caused by a blocked tube or catheter, or an IV bag that runs empty, may go unnoticed when a nurse is attending several patients. This paper presents a Smart IV Blockage Detection and Nurse Alert System built around an ESP32 microcontroller. A load cell with an HX711 amplifier measures the weight of the IV bag to estimate the remaining fluid level, while a YFS201 flow sensor generates pulses that indicate whether fluid is flowing through the IV line. The ESP32 compares these readings with predefined thresholds, declares a blockage when no flow pulses are detected for a defined period, and closes a relay-driven solenoid valve when the fluid level falls to the level set by the user. Local indication is provided through an LCD, green and red LEDs and a buzzer, while data and alerts are sent over Wi-Fi to the Blynk IoT platform so that nursing staff can monitor the infusion remotely. The prototype shows a simple, low-cost and practical approach for reducing the delay in identifying IV flow stoppage and for improving the safety of IV fluid administration.

Keywords: IV fluid monitoring; blockage detection; ESP32; load cell; flow sensor; Blynk; Internet of Things; nurse alert

Introduction

Intravenous (IV) therapy is one of the most common procedures in hospitals and clinics and is used to deliver fluids and medicines directly into a patient's bloodstream. During an infusion, the fluid level in the bag and the drip flow have to be observed continuously. In current practice, nurses and healthcare staff check the IV bag and the drip chamber manually at regular intervals. This becomes difficult when several patients need to be monitored at the same time, and it depends on the availability and attentiveness of the staff.

If the IV bag becomes critically low, or if the flow becomes too slow or stops because of a blockage in the IV tube or catheter, delayed detection may interrupt the continuity of treatment. An automated system that continuously measures the remaining fluid and the flow, recognises abnormal conditions and immediately alerts the nursing staff is therefore desirable.

This paper presents a Smart IV Blockage Detection and Nurse Alert System based on an ESP32 microcontroller. A load cell with an HX711 amplifier measures the weight of the IV bag to estimate the remaining fluid, and a YFS201 flow sensor detects whether fluid is flowing through the IV line. The ESP32 processes both signals, identifies low-level and blockage conditions, drives the local indicators (LCD, LEDs and buzzer), controls a solenoid valve through a relay, and uses its built-in Wi-Fi to send data and alerts to the Blynk IoT platform for remote monitoring by authorized healthcare personnel. The main objectives of the work are:

- to monitor the IV fluid level and flow continuously and in real time;
- to detect low fluid level and flow stoppage (blockage) automatically using sensors and the ESP32;
- to provide local indication through an LCD, LEDs and a buzzer and to send alerts to nursing staff over Wi-Fi; and
- to reduce continuous manual monitoring and the workload of healthcare staff, and thereby improve the safety and efficiency of IV fluid administration.

The system is intended for hospitals, clinics and other healthcare environments. It can later be extended with mobile applications, cloud data storage, multiple-bed monitoring and additional sensors.

Literature survey

Several researchers have investigated sensor-based and IoT-enabled monitoring of IV infusion. Kumar et al. [1] reported an IoT-enabled IV infusion rate monitoring and control device designed for precision care and portability, and a remote monitoring system based on optical sensors was proposed in [2] to prevent medical accidents during fluid treatment. Venkatesh et al. [3] described DripOMeter, an open-source opto-electronic system for IV infusion monitoring. IoT-based drip monitoring combined with reverse blood flow prevention was presented in [4].

Weight-based monitoring has also been widely used. Nandhini et al. [5] developed an IoT-based IV drip monitoring system in which a load cell and amplifier determine the weight of a glucose bottle and a GSM modem sends SMS and call notifications to medical staff when the fluid reaches a minimum threshold. Afrianda et al. [6] implemented an IoT-based infusion monitoring system using a wireless sensor network, and Koh and Chai [7] proposed a self-calibrating weighing sensor with peristaltic pump control for closed-loop infusion monitoring. IoT-based IV bag monitoring and alerting, with SMS and real-time alerts, was further reported in [8]–[10].

A common observation is that many reported systems concentrate either on measuring the remaining fluid or on detecting the drip rate, and alerts are often limited to the fluid-level threshold. The present work combines weight-based level sensing with flow-pulse-based blockage detection in a single low-cost ESP32 platform, adds local and Wi-Fi alerts for the nurse, and allows the infusion to be started, stopped and limited to a set level remotely.

System analysis

1.1. Existing system

In the existing IV administration practice, the IV fluid level and the drip rate are monitored manually by nurses or healthcare staff. The IV bag is inspected visually at regular intervals, and the drip chamber is observed to confirm that the fluid flows at the required rate. Conventional practice does not provide continuous automated measurement of the remaining fluid, so the nurse has to estimate it by sight, and any change in drip rate or interruption of flow has to be identified through regular observation. Some modern systems use individual sensors such as load cells, optical/IR sensors or IoT modules, but many of them address only fluid-level measurement or only drip-rate monitoring rather than combining both in one system.

1.2. Limitations of the existing system

- Frequent manual monitoring by healthcare personnel is required.
- The workload of nurses increases, especially when many patients are treated at the same time.
- The fluid level is commonly estimated by visual observation only.
- Abnormal drip rates or flow stoppage may not be detected immediately, which can delay intervention.
- There is no continuous real-time monitoring, and basic systems may not give remote notifications.
- Separate methods may be required for fluid quantity and flow rate.
- Lack of integrated IoT connectivity limits remote access to IV status information.

Proposed system

1.3. System overview

The proposed system continuously monitors the remaining quantity and the flow of the IV fluid during treatment. A load cell with an HX711 amplifier measures the weight of the IV bag, from which the remaining fluid level is obtained. A flow sensor installed in the IV line produces pulses whenever fluid flows, which allows flow interruption (blockage) to be identified. An ESP32 microcontroller acts as the main control unit: it reads both sensors, compares the readings with predefined threshold values and decides the status of the infusion. The status is displayed on a 16×2 LCD, a green LED indicates normal operation and a red LED with a buzzer indicates an abnormal condition. A relay-driven solenoid valve starts or stops the fluid flow. Through its built-in Wi-Fi, the ESP32 transmits the level and alerts to the Blynk cloud, from where the nurse station or authorized healthcare personnel can monitor the infusion on a smartphone and acknowledge or stop the process.

1.4. Advantages of the proposed system

- Real-time, continuous monitoring of the IV fluid level and flow during treatment.
- Weight-based (load cell and HX711) measurement of the remaining fluid.
- Flow-pulse-based detection of flow interruption (blockage).
- Fewer repeated visual checks of the IV bag and drip chamber by the nurse.
- Immediate local indication by LCD, LEDs and buzzer, and remote alerts over Wi-Fi.
- Simple, low-cost design built from commonly available components.

1.5. Block diagram

The block diagram of the proposed system is shown in Fig. 1. The IV bag hangs on the load cell, and the IV tube passes through the flow sensor. The load cell signal (through the HX711) and the flow sensor signal are given to the ESP32, which drives the LCD, the LED indicators, the buzzer and the Wi-Fi link to the cloud server and the nurse station. A reset button is provided to silence and acknowledge an alert after the nurse has attended to the patient.

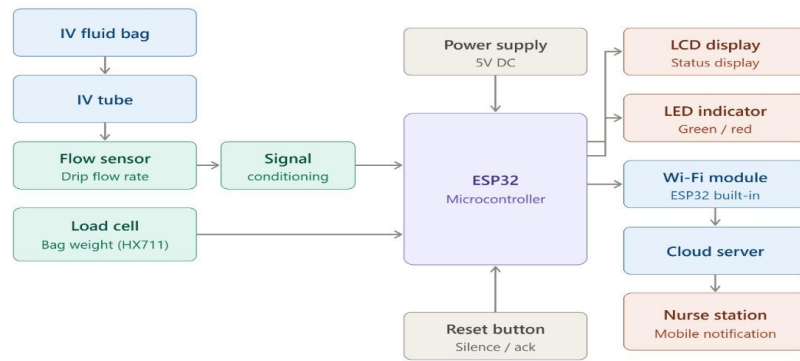


Fig. 1 - Block diagram of the Smart IV Blockage Detection and Nurse Alert System.

1.6. Working principle

The user first sets the minimum fluid level (10–100 %) with the slider in the Blynk application and starts the process with the Start/Stop button. If the measured level is already at or below the set level, the process does not start and the low-level alert is raised. Otherwise the solenoid valve is opened and the ESP32 checks the system every second. The weight W of the bag is read through the HX711 and converted into the fluid level L as a percentage of the full-bag weight W_{full} :

$$L (\%) = (W / W_{full}) \times 100 \quad (1)$$

The pulses of the flow sensor are counted in an interrupt routine and read once per second. The pulse frequency f (Hz) is related to the flow rate Q by the usual relation for this type of sensor:

$$Q (L/min) = f (Hz) / 7.5 \quad (2)$$

If at least one pulse is received in a second, flow is considered present. If no pulse is received for a defined blockage time after an initial start-up grace period, the ESP32 declares a blockage, turns on the red LED and the buzzer, shows the alert on the LCD and updates the blockage indicator in Blynk. When the fluid level falls to the set level, the valve is closed, the alarm is raised and the level-finished indicator blinks in Blynk. The alarm is cleared automatically when a new bag with a level higher than the set level by a margin is hung, or manually when the Stop button is pressed. Monitoring then continues until the treatment is completed or the system is switched off.

Experimental setup

1.7. Prototype implementation

The hardware prototype is shown in Fig. 2. The ESP32 controller, 16x2 LCD, sensor-interface modules and the power regulation section are assembled on a wooden base board. The flow sensor is connected in the fluid line, and the load cell is fixed on a metal stand from which the IV bag is hung. The buzzer and the LED indicators are connected to the ESP32 output pins, and the sensors are connected to the controller with wires.

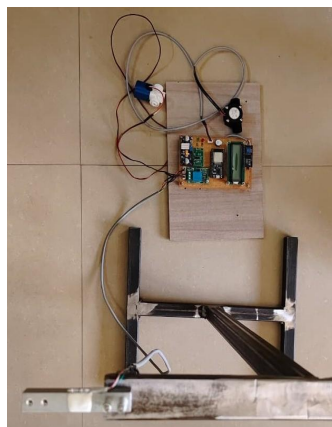


Fig. 2 - Hardware prototype of the system.

1.8. Output response representation

Fig. 3 shows the response of the system for a test cycle. In Fig. 3(a) the fluid weight measured by the load cell falls steadily as the fluid is consumed, and Fig. 3(b) shows the flow rate given by the flow sensor. When the line becomes blocked, the flow rate falls to zero and the weight stops decreasing. As soon as the flow rate stays below the low-flow threshold, the ESP32 turns on the red LED and the buzzer and sends the alert through Wi-Fi. When the flow is restored and the alert is acknowledged, normal monitoring continues. Later, when the remaining fluid falls below the low-level threshold, a low-fluid alert is generated.

The graph confirms that the two sensor readings together distinguish a blocked line (zero flow with constant weight) from the normal condition (steady flow with decreasing weight). The thresholds used in Fig. 3 (100 mL and 5 mL/min) are illustrative values.

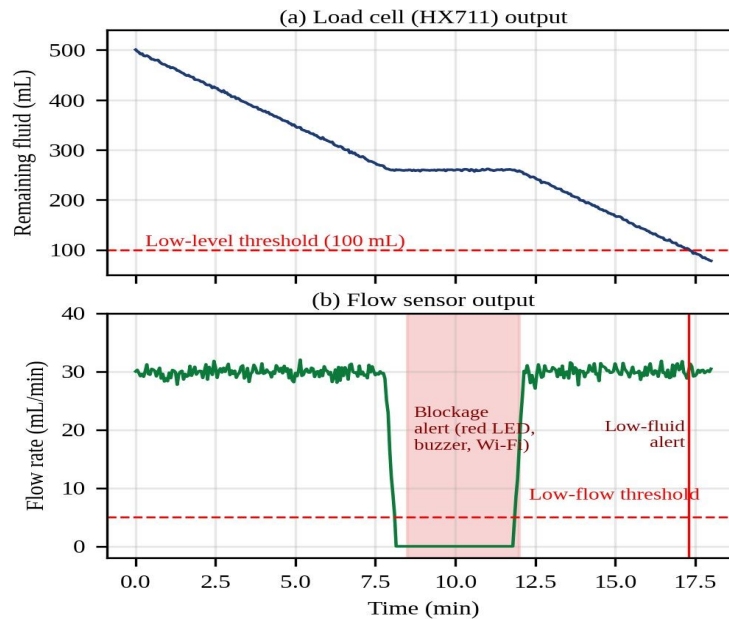


Fig. 3 - Fluid weight and flow rate response with alert points.

Results and discussion

The prototype of the Smart IV Blockage Detection and Nurse Alert System was assembled with the load cell and HX711, flow sensor, ESP32, LCD, LED indicators, buzzer, relay with solenoid valve and the Blynk application (Fig. 2). During testing, the load cell detected the change in the weight of the IV bag as the fluid was gradually consumed, and the HX711 provided the signal in a form that the ESP32 could process, so that the remaining fluid was estimated in real time. The flow sensor monitored the movement of the fluid through the IV line, and the ESP32 processed its pulses to decide whether flow was present.

When the fluid level was above the set level and flow pulses were present, the system indicated a normal condition. When the flow stopped, the system identified it as a blockage, and when the fluid reached the set level the valve was closed and the level-finished alert was generated. The LCD displayed the level, set level, valve state, flow and status, the green LED was on during normal operation, and the red LED and buzzer were activated during abnormal conditions. The response of the system for the different conditions is summarised in Table 1.

Table 1 - Response of the system to different infusion conditions.

Condition	Detection	Local indication	Remote indication (Blynk)
Normal infusion	Level above set level; flow pulses present	Green LED on; LCD status NORMAL	Level shown on V2; alert LEDs off
Blockage	Valve on, no flow pulse for more than 5 s after start-up	Red LED and buzzer on; LCD alert page BLOCKAGE	Blockage indicator (V3) on
Level low / finished	Level at or below set level	Valve closed; red LED and buzzer on; LCD alert LEVEL LOW-STOP	Level-finished indicator (V4) blinks; start switch returns to OFF
Stop / acknowledge	Stop button pressed	Alarms cleared; valve closed	Indicators off

Fig. 4 shows the Blynk dashboard of the prototype. In Fig. 4(a) the fluid level has reached the set level and the level-finished indicator is active, and in Fig. 4(b) the blockage indicator is active. The ESP32's Wi-Fi connection therefore allows the nurse to receive the status without continuously observing the IV setup, and the stop function of the application lets the alert be acknowledged after the necessary action has been taken.

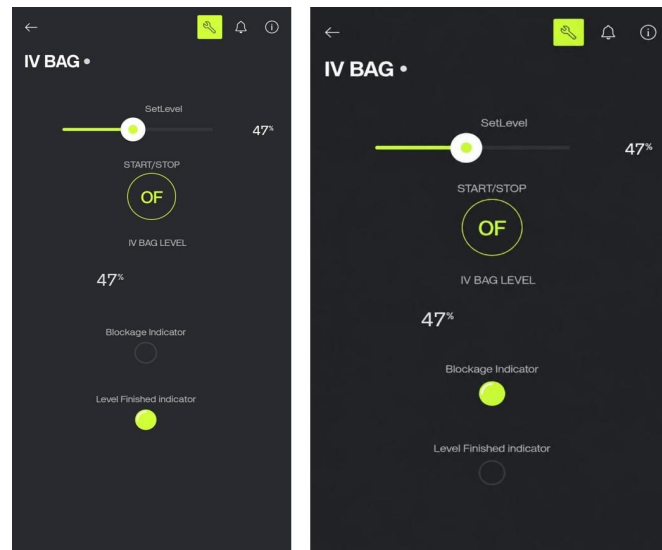


Fig. 4 - Blynk dashboard: (a) level-finished indicator active; (b) blockage indicator active.

The results show that the proposed system can reduce the need for continuous manual observation and can shorten the time to identify a flow stoppage or an empty bag. The measurement of the YFS201 sensor is not precise and is used only for flow detection, and a detailed accuracy study of the weight and flow measurements as well as safety validation under clinical conditions are still required before practical medical use.

Conclusion

A Smart IV Blockage Detection and Nurse Alert System based on the ESP32 has been developed to monitor the IV fluid quantity and flow during medical treatment. The load cell with HX711 measures the remaining fluid, the flow sensor detects flow interruption, and the ESP32 determines the infusion status, controls the solenoid valve and generates alerts. The LCD, LED indicators and buzzer give immediate local information, and the Wi-Fi link to the Blynk platform enables remote monitoring and alerts to healthcare personnel. The system can reduce the need for continuous manual observation, support timely identification of abnormal IV conditions and improve the efficiency of IV fluid monitoring. The work demonstrates the potential of IoT and sensor-based technology in healthcare monitoring, while further clinical validation and safety testing are required before practical deployment.

Future scope

The system can be enhanced by adding automatic flow control, air-bubble detection and patient monitoring sensors such as heart rate, SpO₂, temperature and blood pressure. A dedicated mobile or web application can give remote access to the IV level, flow rate, alerts and historical data, and a centralised dashboard can support multiple-patient monitoring at the nurse station. Cloud storage and AI/machine-learning techniques can be used to store the infusion history and to identify abnormal infusion patterns. A rechargeable battery backup, improved wireless connectivity, automatic sensor calibration and emergency SMS or mobile alerts can further increase reliability. Laboratory testing, safety validation and clinical evaluation are required before practical healthcare deployment.

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