Journal of IoT in Social, Mobile, Analytics, and Cloud (ISSN: 2582-1369)
www.irojournals.com/iroismac/

Intra Venous (IV) Fluid Monitoring System with Real-Time Alert

Ravi Sankar S.[1], Yooghasurya V S.[2], Yogeshwaran G R.[3], Prasath M.[4], Prethis Kumar S.[5]

[1]Assistant Professor, [2,3,4,5]UG Student, Department of Electronics and Communication Engineering, K.L.N. College of Engineering, Sivagangai, India.

E-mail: [2]vsyooghasurya18@gmail.com

Abstract

Intravenous (IV) fluid therapy is one of the basic procedures applied for the infusion of fluid, medicine and nutrients to patients. Continuous measurement of IV fluid level is necessary for avoiding risks like dehydration, blood reflux, air embolism and discontinuation of therapy. The current practice for measurement mainly involves manual observation of healthcare staff at regular intervals, which might delay the response in case of emergency due to workload in clinical settings. Hence, in order to resolve this problem, this paper proposes an Internet of Things (IoT) based Intra Venous (IV) Fluid Monitoring System with Real Time Alert and remote supervision of IV fluid therapy. The proposed design involves 5 kg load cell, HX711 amplifier, ESP32 microcontroller, LCD screen, buzzer and Blynk platform to monitor IV bag weight, measure the remaining amount of fluid in the bag and communicate the information wirelessly to the healthcare personnel. Alerts are set based on threshold values and generated both locally and remotely if the level reaches the critical value. The experimental testing proved that the system has an accuracy rate of 98.7%. The system exhibited reliable synchronization in the cloud, quick notifications, and consistent real-time operation, thus proving to be a cost-efficient, scalable, and effective approach towards enhancing patient safety.

Keywords: Internet of Things (IoT), Intravenous Fluid Monitoring, ESP32, Load Cell Sensor, HX711, Blynk Cloud Platform, Real-Time Alert, Healthcare Monitoring.

DOI: https://doi.org/10.36548/jismac.2026.3.004
Extended version of article received from **International Conference on Smart Innovations in Engineering & Technology (ICSIET 2026)**
Received: 27.04.2026, received in revised form: 31.05.2026, accepted: 18.06.2026, published: 29.06.2026

© 2026 Inventive Research Organization. This is an open access article under the Creative Commons Attribution-NonCommercial International (CC BY-NC 4.0) License

1. Introduction

Regular monitoring of IV fluid levels plays an important role for the continuous treatment and safe care of patients. The failure to notice the lack of fluid at the right moment will cause interruptions in fluid flow, blood reflux, air embolism, and delayed medical actions. In many health facilities, IV fluid monitoring continues to be done manually by health care providers. It becomes more difficult in busy health facilities, where there are fewer nurses to monitor the status of multiple patients at once. Recent innovations in the Internet of Things (IoT), embedded systems, wireless technology, and cloud computing have made it possible to design intelligent healthcare monitoring systems.

Many research works have proved the use of IoT-based IV monitoring system capabilities to provide real-time monitoring, remote access, and auto alerts generation. But many of the currently used systems concentrate only on fluid level detection and simple alerting methods while there are many issues like cost-effectiveness, ease of use, accessibility of monitoring, and application in the constrained healthcare environment that still persist. In order to overcome these problems, the proposed system uses load cell sensor, HX711 amplification module, ESP32 microcontroller, LCD display, buzzer, and Blynk cloud server to create a continuous IV fluid monitoring system. Use of both local and cloud-based visualization provides healthcare staffs with real-time monitoring of fluid status and generating alerts in case of any critical situation.

The proposed methodology involves a weight sensing-based mechanism where the fluid level within the IV bag is estimated based on its weight. The load cell constantly measures the weight data that is then amplified and converted into digital form via HX711 module and further analyzed via the ESP32 microcontroller. The results are presented locally and also communicated wirelessly to the Blynk cloud platform. The process is completed with a threshold-based alerting mechanism to detect warnings and critical fluid levels and to provide corresponding notifications. The main aim of the research is the creation of an efficient, affordable and user-friendly IoT-based IV fluid monitoring system.

2. Literature Survey

In healthcare settings, there is a need for constant monitoring of IV fluid delivery to avoid risks due to fluid depletion, reverse flow of blood, and interruption of the therapy process.

However, conventional techniques of IV fluid monitoring require manual interventions by healthcare professionals, which may not be easy in hospitals that have a very low nurse to patient ratio. Therefore, there have been numerous studies conducted to examine the implementation of Internet of Things (IoT) technologies in automated IV fluid monitoring and alerting.

In recent developments in IoT based healthcare systems, it is possible to develop smart IV fluid monitoring systems that allow collecting real-time data and sending alerts remotely. In this regard, an ESP32 based monitoring and control system was designed for the continuous tracking of IV fluid level and to send an alert whenever the set threshold was reached. Through the use of IoT communication technologies, remote monitoring and decreased manual intervention became possible [1]. Moreover, an IoT based framework for the monitoring of intravenous fluids through wireless communication and SMS alerts proved the efficiency of remote alert sending [2].

Many researchers have considered automated monitoring systems by employing sensors to monitor fluid level and identify depletion conditions. An automated monitoring system has been created by using sensor-based measurement technique to monitor the IV drip continuously and enhance the safety of patients through automated alert generation [3]. Internet-of-things-based architectures have been designed for tertiary healthcare facilities that include ESP32 microcontrollers, cloud communication, and remote alerting services in order to increase the efficiency of monitoring process and decrease the chances of late response to an empty IV bag [4].

The recent researches have not only concentrated on monitoring and alerting features, but also considered the use of predictive and intelligent monitoring approach. An Internet-of-things-based real-time monitoring and automatic shutoff system used predictive flow rate analysis in order to predict the fluid depletion and take immediate actions [5]. In this regard, many predictive infusion surveillance frameworks have been analyzed that have the ability to analyze the infusion trends and generate alerts based on fluid consumption patterns [9].

The adoption of cloud platforms and remote health care services has also provided additional options for the operation of IV monitoring systems. The real-time monitoring systems linked with IoT cloud-based systems have allowed health care providers to be able to monitor the infusion data remotely and be notified instantly through mobile apps and webbased interfaces [6], [8]. Infusion monitoring systems integrated with remote patient monitoring functions have proved that there is potential for centralizing the monitoring of more than one patient [10]. Other studies have looked into possible ways of implementing an IV bag monitoring system with embedded devices, sensors, and wireless communication devices in order to enhance monitoring precision and reliability [7].

Despite numerous advancements in the development of IoT-enabled IV fluids monitoring devices, there still exist several issues. For example, most of the available devices have an emphasis on detecting and alerting when the fluid level reaches a certain threshold, but very little has been done regarding integrating multi-channel notifications, synchronization between local and remote monitoring, and cost-effective setup to be used in general hospital wards. Additionally, some of the predictive monitoring platforms may not be scalable and may be complex to implement due to limitations in the available resources. There is a need for a cost-effective and efficient system that can detect fluid levels in real time, establish cloud connection, provide local status notifications, and generate instant alerts.

3. Proposed Methodology

The proposed Internet of Things (IoT) based Intravenous (IV) Fluid Monitoring System is aimed at offering continuous monitoring of IV fluid levels and timely generation of alerts for critical conditions of fluid depletion. This system adopts the method of weight-based sensing, whereby the quantity of the remaining fluids is computed using the weight of the IV fluid. The process involves system architecture design, integration of hardware and software, sensor calibration, data acquisition, cloud communication, and alert management. This way, the system allows for real-time monitoring of IV fluids with minimal reliance on human observation.

3.1 System Architecture

The architectural structure of the developed monitoring system is presented in Figure 1. It includes the load cell sensor, HX711 amplification module, ESP32 microcontroller, LCD screen, buzzer, and Blynk cloud platform. The load cell sensor constantly monitors the weight of the IV fluid bag, and the produced signal is subsequently amplified and digitized by the HX711 module and sent further to the ESP32 microcontroller for processing.

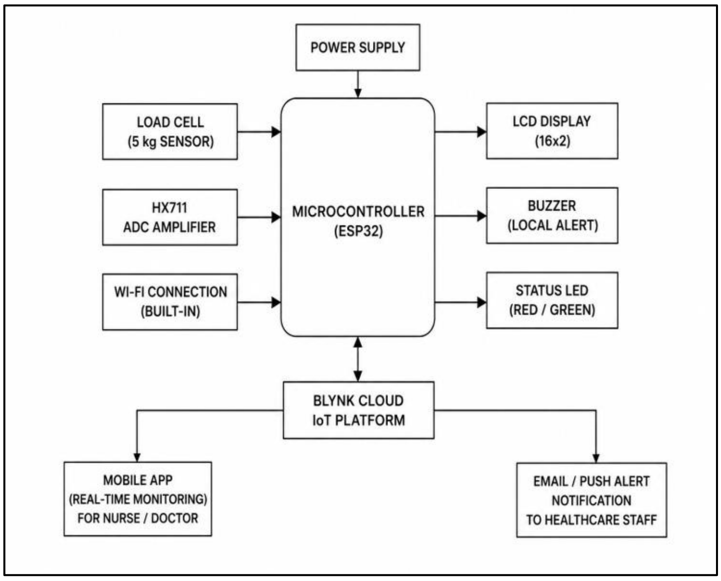

Figure 1. Block Diagram of the Proposed IV Fluid Monitoring System

The ESP32 serves as the control unit of the proposed monitoring system. It processes the collected sensor data, calculates the fluid level, updates the LCD screen and sends the collected data to the cloud platform using the Wi-Fi technology. The combination of local and cloud-based monitoring provides healthcare workers with the possibility of monitoring the state of the IV fluid remotely from mobile devices. Once the fluid level reaches certain predefined levels, the system triggers local and cloud-based alerts.

3.2 Hardware and Software Components

The proposed system combines all of the above subsystems in order to have reliable IV fluids monitoring. Hardware and software modules used are listed below in Table 1.

Table 1. Components of the Proposed IV Fluid Monitoring System

Component	Purpose in the Proposed System	Contribution to System Performance
Load Cell (5 kg)	Measures the weight of the IV fluid bag continuously during the infusion process.	Enables non-invasive estimation of the remaining fluid level by detecting weight variations as the fluid is consumed.
HX711 Amplifier Module	Amplifies and converts the low-level analog signal generated by the load cell into digital data.	Improves measurement accuracy and stability, allowing reliable fluid-level monitoring and processing by the microcontroller.

ESP32 Microcontroller	Acts as the central processing and control unit of the system.	Acquires sensor data, performs fluid-level calculations, controls alert mechanisms, updates display, and manages wireless communication.
16×2 LCD Display	Displays the current fluid level and system status locally.	Provides instant visual feedback to healthcare personnel without requiring access to a mobile application or cloud platform.
Buzzer	Generates audible alerts when the fluid level reaches warning or critical thresholds.	Ensures immediate local notification and reduces the possibility of unnoticed fluid depletion.
Power Supply (5 V DC)	Provides regulated power to all electronic modules within the system.	Ensures stable and uninterrupted operation of sensing, processing, display, and communication components.
Arduino IDE	Used for firmware development and programming of the ESP32 microcontroller.	Supports implementation of sensor acquisition, data processing, threshold evaluation, and communication algorithms.

A 5 kg load cell is used as the primary sensor for weighing an IV bag. Due to the direct influence of the fluid volume on the weight of the bag, it becomes possible to estimate the level of fluid in the bag non-invasively. The HX711 module amplifies and digitizes the low-voltage signal generated by the sensor. ESP32 microcontroller is responsible for data acquisition, fluid level estimation, threshold calculation, and communication with other devices. It uses built-in Wi-Fi connection for communication with the Blynk cloud server and does not require any additional communication modules. 16×2 LCD screen is used for local visualization of fluid level status, and a buzzer is used for generating alerts. Device programming and firmware development were done with the help of Arduino IDE.

3.3 Functional Operation

Figure 2 demonstrates the operational workflow of the proposed system. The working process starts with the initialization of the ESP32 controller, the HX711 module, LCD display, buzzer, and Wi-Fi interface. The ESP32 then establishes a connection with the Blynk cloud platform. After that, the controller acquires weights of objects detected by the load cell using the HX711 amplifier module.

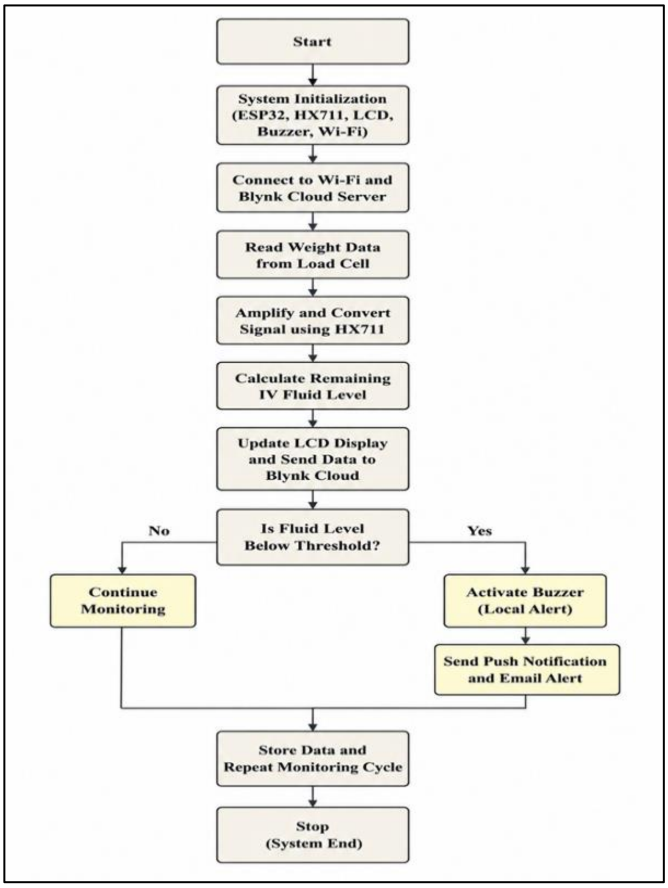

Figure 2. Operational Workflow of the Proposed IV Fluid Monitoring System

The acquired data is then translated into fluid level data by the controller by applying the calibration data present in the controller memory. The calculated fluid level is displayed on the LCD display screen while at the same time being transferred to the cloud-based server to monitor the condition remotely. Such a system makes sure that the data concerning patients' status is available all the time for the healthcare providers. For pro-active monitoring, ESP32 is constantly comparing the acquired fluid level data with the set threshold values. In case the level is in the danger zone, the early alarm is triggered. In case the fluid level is critical, the buzzer will be turned on and notifications will be sent via Blynk application. In such a way, one can prevent the complications associated with empty IV bags, such as lack of fluid administration, retrograde flow of blood and presence of air in the infusion line. The monitoring routine is conducted repeatedly during the infusion period.

3.4 Sensor Calibration and Experimental Evaluation

The correct calibration of the sensing subsystem is critical to accurately estimate the amount of fluid in the IV drip. Calibration of the sensors was done using weights starting from

100 grams to 500 grams. The digital output from the load cell and the HX711 module was recorded and used to plot the linear function for relating the sensor output to the actual weight value. The calibration constant was then programmed into the ESP32 code.

The load cell output was calibrated using a linear conversion model expressed as

$$W = (R - R_0) \times C \tag{1}$$

Where,

- W : is the measured weight (g),
- R : is the raw HX711 sensor reading,
- R_0 : is the offset value obtained during calibration,
- C : is the calibration coefficient.

Since the density of IV fluid is approximately equivalent to that of water, the measured weight values were directly correlated with the remaining fluid volume. The percentage of remaining fluid was estimated using

$$\text{Fluid Level (\%)} = \left(\frac{W_{\text{current}}}{W_{\text{full}}}\right) \times 100 \tag{2}$$

Where,

- W_{current} : represents the current measured weight,
- W_{full} : denotes the weight of the fully loaded IV fluid bag.

To evaluate measurement performance, the Mean Absolute Error (MAE) was calculated as

$$\text{MAE} = \frac{1}{N}\sum_{i=1}^{N} \left|W_i - \hat{W}_i\right| \tag{3}$$

Where,

- N : is the total number of observations,
- W_i : is the actual weight value,

- $\hat{W}_i$: is the corresponding measured weight value.

The measurement accuracy was further determined using

$$\text{Accuracy}(\%) = \left(1 - \frac{|W_i - \hat{W}_i|}{W_i}\right) \times 100 \tag{4}$$

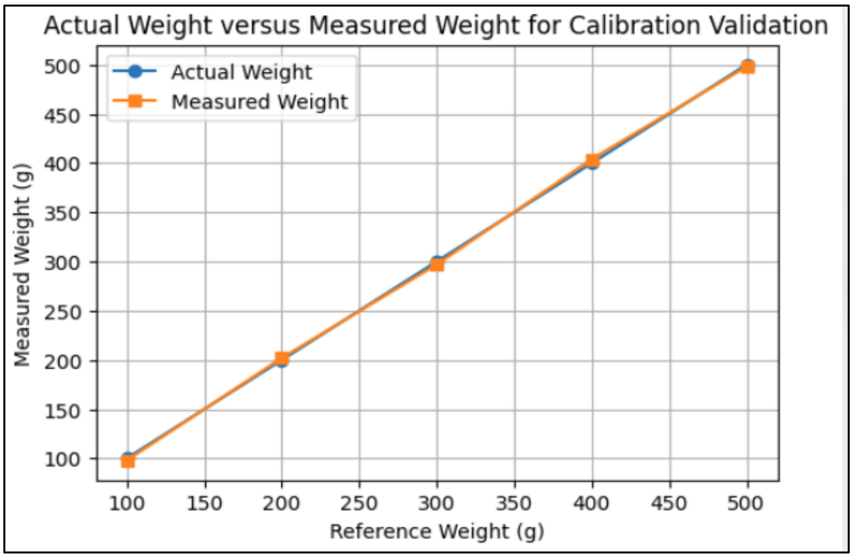

Figure 3. Calibration Validation of the Load Cell Sensor Using Reference Weights

Figure 3 provides the results of the calibration process in terms of the comparison between the actual reference weights and the measurements provided by the load-cell sensing subsystem. Similarity of these two values shows that the calibration procedure is successful and also confirms the ability of the sensor to provide valid weight measurements for the IV fluid level estimation. Linear dependence of these two parameters confirms the appropriateness of the proposed sensing method.

Experimental validation was performed on the laboratory prototype under different IV fluid-levels. Testing concentrated on such aspects as measurement precision, communication delay, packet loss, performance of the cloud synchronization process and notification responsiveness. All these processes were monitored during the whole period of the tests. Also, calibration measurements from reference weights were collected and used to construct performance graphs showing the relation between the actual and measured weights.

4. Results and Discussion

4.1 Prototype Development and System Integration

The laboratory-scale prototype of the proposed IV Fluid Monitoring System has been developed and evaluated. The hardware architecture included the load cell, HX711 amplifier circuit, ESP32 microcontroller, LCD, buzzer, and the Blynk cloud platform embedded in one monitoring device. The first version of the system was assembled and validated on the breadboard and then placed in the housing to increase stability and usability.

Figure 4 demonstrates the development process of the proposed system. The first prototype was used to validate the functions of sensors, data acquisition, the display, wireless communications, and alerts generation. The second version of the prototype demonstrated stable operation and proper interaction between hardware and software modules.

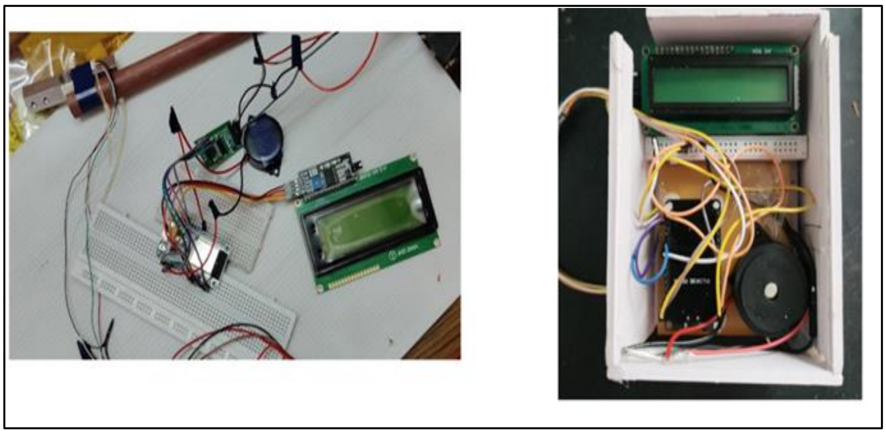

Figure 4. Prototype Development of the Proposed IV Fluid Monitoring System

4.2 Real-Time Monitoring and Alert Validation

The system was tested based on the different simulated levels of IV fluid levels. In the test process, the load cell detected changes in the weight of the IV bag, and the measurements were analyzed to determine the fluid level left. The data collected was displayed locally via the LCD display and was continuously updated during the whole testing process.

Figure 5 shows the working performance of the system. The fluid level was locally shown in real-time on the LCD display, while at the same time, the data was sent to the cloud for remote access. Local alerts and remote notifications were achieved when the fluid level reached some preset thresholds. This demonstrates the ability of the system to provide real-time monitoring and timely alerts about the fluid level depletion.

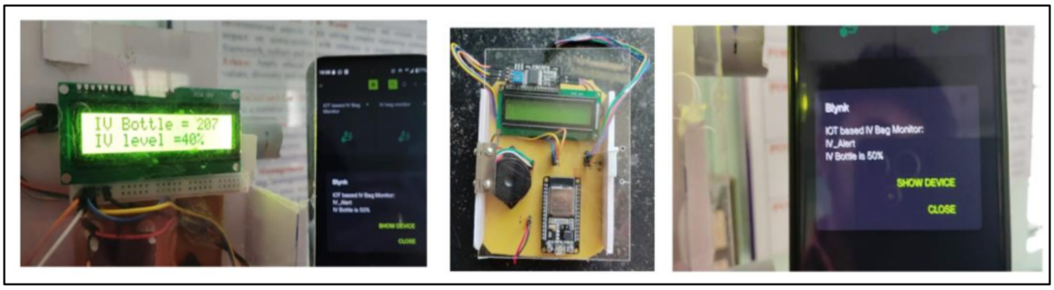

Figure 5. Real-Time Monitoring and Alert Validation of the Proposed IV Fluid Monitoring System

4.3 Performance Evaluation

The performance of the IV Fluid Monitoring System was evaluated based on the measurement accuracy, error analysis, communication latency, and notification responsiveness. For testing purposes, calibrated weights ranging from 100g to 500g were used to simulate different levels of fluids in the IV. Load cell subsystem gave consistent results and helped in accurately estimating fluid level. Comparison between the sensor readings and the reference values indicated high accuracy and agreement. As shown in Table 2, the measurement accuracy of the system reached 98.7%. The low error values can be evidenced by MAE value of 2.8 g and RMSE value of 3.4 g. Moreover, the linear relationship between the measured values and the reference values is proven by the coefficient of determination (R^2) of 0.992. As for communication performance, the ESP32 showed stable connection to the Blynk cloud server that allowed for timely transmission of data. The average delay of cloud synchronization is 1.9 seconds, and alert notifications are activated instantly, the average response time being 1.4 s. It is worth noting that all the alerts were delivered successfully, which means that the notification delivery success rate was 100%.

Table 2. Performance Evaluation of the Proposed IV Fluid Monitoring System

Performance Parameter	Measured Value	Description
Weight Measurement Accuracy	98.7%	Accuracy of load-cell-based fluid level estimation compared with reference weights
Mean Absolute Error	2.8 g	Average absolute difference between

(MAE)		measured and actual weight
Root Mean Square Error (RMSE)	3.4 g	Standard deviation of measurement errors
Coefficient of Determination (R^2)	0.992	Correlation between actual and measured weight values
Average Cloud Synchronization Delay	1.9 s	Time required to update monitoring data on the Blynk dashboard
Average Alert Response Time	1.4 s	Time between threshold detection and alert generation
Wi-Fi Communication Reliability	99.1%	Successful data transmission rate during testing
Notification Delivery Success Rate	100%	Percentage of notifications successfully received
LCD Update Response Time	0.5 s	Average time required to refresh local display information
Continuous Monitoring Stability	98.9%	Stable operation during extended monitoring sessions
Packet Loss Rate (%)	0.9%	Percentage of data packets lost during wireless communication.
Network Latency (ms)	1900	Average communication delay between the monitoring device and cloud platform.

4.4 Cloud Connectivity and Functional Validation

The cloud connectivity of the proposed IV Fluid Monitoring System was verified via constant communications between the ESP32 microcontroller and the Blynk IoT Platform. Through the experiment, the monitoring data collected through the load-cell sensing system could be sent to the cloud dashboard for the purpose of remote observation of the IV fluid state using mobile gadgets. The remote access to the monitoring information was ensured by the cloud interface where healthcare professionals could monitor the fluids remotely without being physically nearby the patient. The integration of wireless communication and cloud services indicates the possibility of using the proposed system for remote healthcare monitoring applications. The effect of Wi-Fi communication failure was also tested during the experiment. As soon as the network connection was lost, the ESP32 device continued working with the sensor data acquisition and processing procedure locally. The LCD and buzzer were fully functioning and therefore local monitoring and notifications were carried out without any interruptions. Nevertheless, due to the lack of network connection, the cloud synchronization was impossible and notifications via the Blynk application did not work until the network connection was reestablished. After reconnection, monitoring data were sent again automatically.

Along with cloud communication, other functions of hardware and software modules were analyzed in order to establish their contribution to the entire monitoring system. The load cell was capable of detecting the changes in the weight of the IV bag, whereas the HX711 amplifier made it possible to convert signals of the sensors into the digital form required for processing. The ESP32 microcontroller proved to be able to control data collection, level estimation, visualization of information, alarm creation, and cloud communication processes. In turn, the LCD screen showed consistent visual representation of the monitoring data, and the buzzer created the alarms in case the fluid status was critical.

5. Conclusion

An IoT-Based IV Fluid Monitoring System is proposed in this paper to automate the process of continual monitoring of IV fluid levels for improved patient safety. The proposed solution incorporates a load cell sensor, HX711 amplifier, ESP32 microcontroller, LCD screen, buzzer, and Blynk cloud platform in order to ensure constant monitoring of intravenous fluid level and generation of both local and remote alerts upon reaching pre-defined thresholds. Experiment results proved successful operation of the system, with measurement accuracy of 98.7%, MAE – 2.8 g, RMSE – 3.4 g, and R^2 – 0.992, thus providing proof of successful fluid-level estimation. The system proved to have stable connectivity to the cloud, with synchronization delay of 1.9 s and alert response time of 1.4 s, which ensured the possibility of timely action by health professionals. Finally, the developed solution can be considered a cheap and scalable solution for automation of IV fluid monitoring.

References

[1] Sandhya, Tuti, Kancharla Niharika, Kompelly Suryaprakash Reddy, Gnanendhra Sreeman, Sama Deepika, Kuraparthi Swaraja, and Rajeev Sobti. "IV Bag Monitoring and Alerting System Using IoT." In AIP Conference Proceedings AIP Publishing LLC 2025, vol. 3157, no. 1: 070015.

[2] Thamboor, Pushpa, Bhupathi Gowthami, Budidha Trisha, and Chinthala Lokesh. "IOT Based Intravenous Fluid Monitoring and SMS Alerting." In 2025 IEEE Silchar Subsection Conference (SILCON) 2025, IEEE, 1-6.

[3] Anand, M., M. Pradeep, S. Manoj, L. Marcel Arockia Raj, and P. Thamaraikani. "Intravenous Drip Monitoring System." Indo-Iranian Journal of Scientific Research (IIJSR) 2018, vol 2: 106-113.

[4] Abiodun, Oladunjoye John, Okwori Anthony Okpe, Adogwu Samuel Junior, and Anthony Obogo Otiko. "Internet of Things Based Intravenous Fluid Level Monitoring and Alert System for Nigeria Tertiary Healthcare Centers Using Esp32 Microcontroller." International Journal of Sensors and Sensor Networks 2025, vol 13, no. 2: 46-55.

[5] Mohandass, Mp, S. Deeja, C. Aswin, and E. Charles. "IoT-Enabled Real-Time Intravenous Drip Monitoring and Automatic Shutoff System with Predictive Flow Rate Analysis." In 2025 Third International Conference on Emerging Applications of Material Science and Technology (ICEAMST) 2025, IEEE, 870-876.

[6] More, Amruta, Prachi Bhagat, Pranali Zagade, Abhijit Wagh, and Suhani Kad. "IoT-Based Intravenous Fluid Monitoring and Alerting System for Automated Healthcare Management." In 2025 2nd International Conference on Integration of Computational Intelligent System (ICICIS)2025, IEEE, 1-4.

[7] Sheikh, Awesh, Akshta Nashine, Sahil Maddalwar, and Raju Pawar. "Intravenous (IV) Bag Monitoring System." International Journal of Scientific Research in Engineering and Management (IJSREM) 2025, vol 9, no. 11: 1-5.

[8] Pabitha, P., and J. Selvakumar. "IoT-Enabled Real Time Intravenous Monitoring and Alert System for Healthcare Management." In 2025 International Conference on Advanced Computing Technologies (ICoACT) 2025, IEEE, 1-8.

[9] Kabilan, S., M. Malathi, J. Amrutha, E. Charumathi, and K. Priya Dharshini. "Smart IOT Framework for Predictive Infusion Surveillance." In 2025 International Conference on Computational Robotics, Testing and Engineering Evaluation (ICCRTEE), IEEE, 2025: 1-6.

[10] Gupta, Pulkit, Aditi Rao, Priya Chimurkar, and Prashant Kasambe. "An Automated IoT-Enabled Real-Time Intravenous Infusion cum Remote Patient Monitoring System." International Conference on Emerging Smart Computing and Informatics (ESCI) 2025, IEEE, 1-6.