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Smart IV Bag System for Effective Monitoring of Patients

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Abstract. The Smart IV bag monitoring system is designed to address the need for effective monitoring of patients undergoing intravenous (IV) treatment. During the course of medical care, patients often receive vital fluids, medications, and nutrients through IV drips. However, the conventional manual monitoring of IV bags is prone to errors and inefficiencies, particularly in busy healthcare environments. To overcome these challenges, the proposed Smart IV bag monitoring system employs sensor technology and interfacing units to provide real-time monitoring and management of IV treatments. The system consists of smart sensors attached to IV bags, a centralized monitoring unit, and a user interface for healthcare professionals. The smart sensors continuously track parameters such as fluid level, flow rate, and temperature within the IV bag. The data collected by the sensors is transmitted wirelessly to the centralized monitoring unit using GSM module. The Smart IV Bag Monitoring System incorporates an automated mechanism to ensure timely replacement of empty IV bags and continuous patient care. When the system detects that the IV bag is empty, it initiates a notification process by sending a text message alarm to the patient. The purpose of this alarm is to prompt the patient to acknowledge the empty IV bag and take necessary action.

Keywords: Arduino · Covid-19 · Glucose reservoir · Internet of things · Smart IV bag

1 Introduction

A smart IV bag monitoring system is a technology that allows healthcare providers to track and monitor IV (intravenous) fluid bags and their contents in real-time. It aims to enhance patient safety, improve efficiency, and reduce errors in the administration of intravenous fluids. In healthcare settings, the proper administration of intravenous (IV) fluids is critical for patient care. However, manual monitoring and potential human errors can pose risks to patient safety. To address these challenges, a smart IV bag monitoring system has emerged as a technological solution. This system incorporates advanced technologies such as barcode or RFID scanning, real-time monitoring, and data integration to revolutionize the way IV fluids are tracked and administered. By ensuring

P. Pareek et al. (Eds.): IC4S 2023, LNICST 537, pp. 308–316, 2024.
https://doi.org/10.1007/978-3-031-48891-7_27

accurate medication delivery, optimizing workflow efficiency, and reducing errors, this innovative system significantly enhances patient safety and improves overall healthcare outcomes [1].

The key features and benefits of a smart IV bag monitoring system includes: fluid identification (uses barcode or RFID technology to accurately identify the contents of each IV bag, including the type of fluid, dosage, and expiration date [2]. This helps prevent medication errors and ensures the right fluid is administered to the patient); drip rate monitoring (measure and monitor the flow rate of the IV fluid, ensuring that the prescribed infusion rate is maintained. If there are any deviations from the set parameters, the system can alert healthcare providers, helping prevent over-infusion or under-infusion); real-time monitoring [3] (provides real-time data on the status of IV bags, allowing healthcare providers to remotely monitor multiple patients simultaneously. This enables better resource allocation and timely intervention if any issues arise); alerts [4] and notifications [5] (can generate alerts and notifications for various events, such as low fluid levels, nearing expiration dates, or potential errors in infusion rates. These alerts help healthcare providers take prompt action and ensure patient safety); data integration [6] and analytics [7] (can integrate with electronic health records (EHR) or hospital information systems, allowing for seamless data exchange and documentation. It also enables data analysis, trend identification, and quality improvement initiatives); inventory management (can track the inventory of IV bags, providing real-time visibility into stock levels, expiration dates, and usage patterns. This helps optimize inventory management, reduce waste, and streamline procurement processes); patient safety and workflow efficiency [8] (helps reduce the potential for human errors, enhances patient safety, and improves workflow efficiency for healthcare providers. It allows nurses and clinicians to focus more on patient care rather than manual monitoring tasks.

The smart IV bag monitoring system represents a significant advancement in healthcare technology, revolutionizing the administration of IV fluids. By leveraging advanced technologies and real-time monitoring, this system enhances patient safety, workflow efficiency, and inventory management. Healthcare providers can rely on accurate medication delivery, reducing the potential for human errors and improving overall healthcare outcomes. As technology continues to evolve, the smart IV bag monitoring system holds great promise in revolutionizing the way intravenous therapy is administered and monitored in healthcare settings.

2 Literature Review

This literature review aims to provide an overview of the existing research and developments in the field of smart IV bag monitoring systems, highlighting their key features, benefits, and impact on healthcare outcomes. Numerous studies have explored the use of barcode and RFID technologies in smart IV bag monitoring systems. The authors in [9] emphasized the benefits of barcode scanning for accurate identification of IV fluids, reducing medication errors, and enhancing patient safety. Similarly, in [10], the authors have highlighted the potential of RFID-based systems in automating IV bag tracking and ensuring efficient inventory management. Real-time monitoring of IV bag contents and drip rates is a crucial feature of smart IV bag monitoring systems. The authors of

[11] has proposed a wireless monitoring system that tracks the fluid levels and flow rates, allowing healthcare providers to intervene promptly in case of deviations. The integration of intelligent algorithms in monitoring systems, as discussed in [12] which enables automated drip rate control and infusion rate adjustments to maintain accurate medication delivery.

The generation of alerts and notifications is a vital component of smart IV bag monitoring systems. The authors of [13] has developed a system that sends alerts for low fluid levels, nearing expiration dates, and potential errors in infusion rates, enabling proactive intervention and reducing adverse events. In [14] emphasized the importance of timely notifications in preventing under-infusion or over-infusion, leading to improved patient safety and reduced medication errors. In [15], the authors have proposed an integrated system that automatically updates EHRs with IV bag information, ensuring accurate documentation and seamless data exchange. Furthermore, the analysis of IV bag usage patterns and infusion data, as demonstrated in [16] which enables quality improvement initiatives and optimization of workflow processes. Several studies have assessed the impact of smart IV bag monitoring systems on patient safety and workflow efficiency. In [17], the authors have reported a significant reduction in medication errors and adverse events with the implementation of a smart monitoring system. In [18] highlighted the improved workflow efficiency and time savings achieved through automation of IV bag monitoring tasks, allowing healthcare providers to focus more on direct patient care.

3 Proposed Model

3.1 Block Diagram

A smart IV bag monitoring system has been proposed (see Fig. 1) based on ATMEGA 328 microcontroller which consist of glucose level sensor, temperature sensor for continuously monitoring patient health condition [19]. The intelligence of every action, as seen in the block diagram, is the microcontroller unit, and the one utilized here is an Atmega328 from the Arduino Platform. The Arduino IDE and an embedded C software has been used to program the Arduino UNO. Thus, the Arduino Microcontroller Unit's general functioning is coded and integrated in the microcontroller unit for its operation. A 16 × 2 LCD display has been utilized to show all project capabilities as well as a step-by-step breakdown of the project's progress. Alphanumeric LCD screens, like the ones used in this instance, can show 32 characters at once. It is known as a 16 × 2 LCD display since it has two rows and each one can display 16 characters. The ultrasonic sensors are employed to measure the glucose levels in the intravenous bags. The ultrasonic sound waves are the basic basis on which the ultrasonic sensors operate [20].

It has a single ultrasonic transmitter and a single ultrasonic receiver; as a result, the ultrasonic transmitter emits ultrasonic waves to the glucose level and the ultrasonic receiver section receives the ultrasonic wave that is reflected from the glucose. One can quickly determine the distance of the glucose from the top of the glucose level by calculating the sending and receiving times of ultrasonic waves [21].

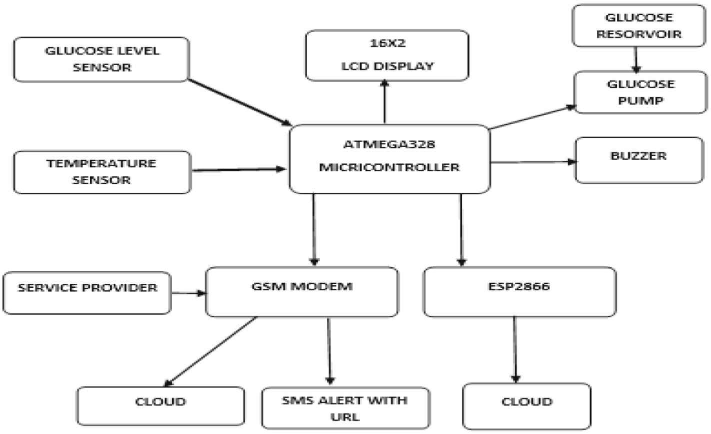

Fig. 1. Proposed block diagram.

3.2 Circuit Implementation

A glucose reservoir and a glucose pump are among the monitoring devices that are included in the prototype model. The circuit connections of the envisioned smart IV bag monitoring system are shown in Fig. 2.

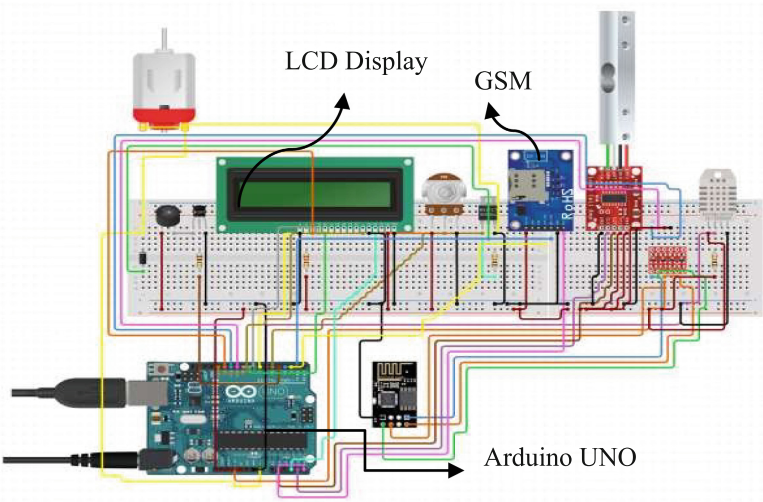

Fig. 2. Smart IV Bag Monitoring System Circuit Diagram [22].

3.3 Projected Hardware Model

Based on the circuit connections, the system (see Fig. 3) for IV infusion flow sensing, signaling, and control was created.

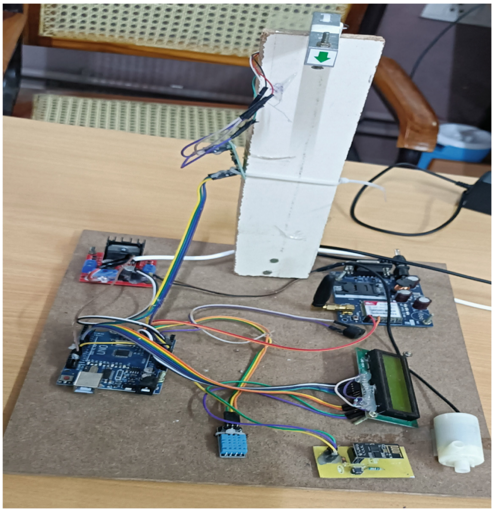

Fig. 3. Proposed hardware model.

Two capacitive sensors are used to detect the maximum and minimum liquid levels in a plastic IV container; however, no information is provided regarding the volume of liquid between these two sensors. Additionally, the flexible capacitive sensor enables liquid detection regardless of the shape and composition of the IV container (glass or plastic). This has a piezo buzzer, an ultrasonic sensor, a step-down transformer, a 16 × 2 LCD display, a glucose pump, and an ATMEGA328 microcontroller.

4 Investigational Outcomes

The Arduino IDE (version R3, 5 W, 7–12 V) was used for programming, and the 16 × 2 LCD display served as the user interface. It can be shown from the experimental findings shown in Fig. 4 that the modem is operational.

Fig. 4. Initial condition of booting modem on LCD display

Fig. 5. LCD display of output demonstrating glucose and temperature levels

The Display shows (see Fig. 5) the room temperature where the patient is being monitored as well as the proportion of glucose being poured into the IV bottle. It continuously monitors the glucose level and displays the results on an LCD. Figure 6 demonstrates the process of informing the nursing station about the glucose level in the IV bottle. The alert will be received by registered mobile number through the server.

Fig. 6. LCD display of output for sending SMS alerts

This graphic (see Fig. 7) demonstrates the DC motor pump beginning when the blood glucose level dropped by less than 25%.

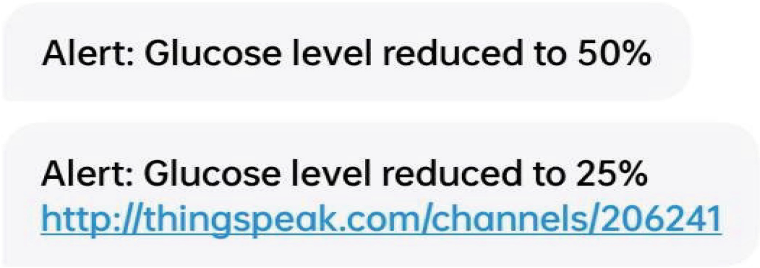

Fig. 7. SMS alerts received on registered mobile number

Figure 8 and Fig. 9 indicates about the Glucose Level and also the Room Temperature that the patient being Monitored on. It indicates the Information that we being send using our server in a Graphical Representation at each instance of time.

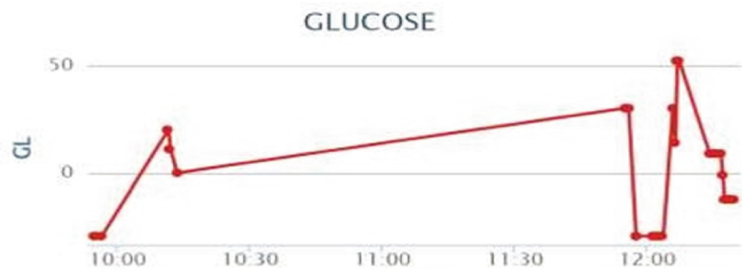

Fig. 8. Glucose level indication on the server

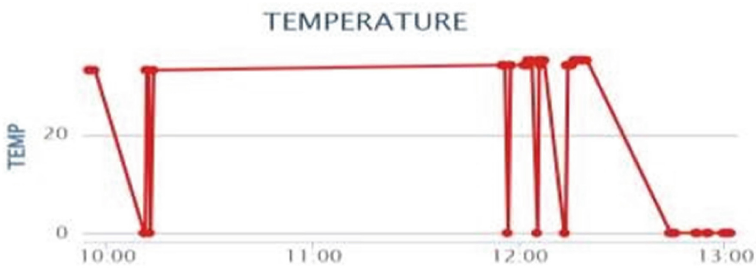

Fig. 9. Temperature level indication on the server

5 Conclusion

This work focused on developing a prototype for easily track the glucose level of the patient and automatically fills the glucose IV bag when it goes critically low and alerts the doctor and nurse station regarding the status of the glucose refilling acknowledgement.

The proposed IV bag monitoring and Auto-refill system uses ATMEGA328 microcontroller. The LCD is used to display the glucose level in the bottle, the room temperature and also indicates the controlling operations ultrasonic sensor is used to monitor the glucose level in the bottle. Temperature Sensor will keep track the room temperature. GSM Modem which works under the protocol of TCP/IP takes the data from ultrasonic sensor. By using that data, if the glucose level in the bottle goes down to 50%. It will send an alert to the nurse who assigned with patient.

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