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IoT Enabled IV Pole with Integrated Patient Healthcare Monitoring System

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Abstract— Intravenous (IV) therapy is a common and effective treatment method in medical settings, crucial for administering medications and fluids directly into a patient's bloodstream. However, traditional monitoring of IV saline bags and patient health is prone to human error, leading to risks such as air embolism or incorrect fluid administration. The project aims to develop a "Smart IV Pole" system using IoT technologies to monitor saline levels during intravenous (IV) therapy. The system integrates an ESP32 microcontroller, load cell, temperature sensor, SPo2 sensor, and LCD display. It automates the monitoring of saline weight and provides a warning when the saline level becomes critically low. An IoT-enabled IV pole with an integrated patient healthcare monitoring system is a smart medical device designed to enhance patient care in hospitals. The IV pole is equipped with sensors and connected to the Internet of Things (IoT) to monitor various patient health parameters, such as heart rate, blood pressure, oxygen levels, and IV fluid levels. This data is transmitted in real-time to healthcare providers, allowing for continuous monitoring and timely interventions.

***Index Terms*— Weight Sensor, Healthcare, IoT, Load cell.**

1. Introduction

For hospitals with thousands of patients being treated it is not possible to assign staff for each patient. So, to reduce these human efforts and to automate this traditional method of manually monitoring the IV Bag, we came up with solution in which using a weight sensor we can constantly measure the weight of the saline bag and match with the weight of empty saline bag with this we can receive an alert on the staff mobile about Status of the saline bag. So that when saline bag is nearly empty the staff can rush towards the patient to change the bag. Also, we have added a feature in this proposed system that with the help of sensors heart rate and SPO2 also can be monitored.

A. Site Visited

We have visited small hospitals in Pune. They Were having a serious problem regarding the continuous monitoring of the infusion bottle. They also have cases where backflow has happened. We have identified this problem as the major issue they were facing. After a healthy discussion with the hospital staff, we came to know what problems they are facing frequently. We found that there are some problems that are needed to be eliminated in order to provide proper patient care in hospitals as patient care is a crucial part of the hospital sector. So, we concentrated more on the problems that affect patient care.

2. Literature Review

There are various automated IV poles are available in the market, as the healthcare sector moving towards the advancement and automation various work in this fields were taken some of this work includes:

Use of image processing to detect the empty bag, so in this system a digital camera is used to take the pictures in specified time this system uses raspberry pi board to process the data and to check the position of surface of liquid using image processing the system will compute the remaining level of liquid so when the liquid goes below critical value or when saline bag is about to run out it will send alert to the staff and also they uses a pinch valve to control the flow of fluid. Also using a web server, the data will be constantly updated to monitor the situation of patient [1].

Another work in this field includes IoT enabled IV monitoring which includes use of IR sensor to detect the empty bottle of saline. In this work authors used ESP32 microcontroller and an actuator to regulate drip rate also they have provided features like accessing the data via HTTP request on webpage [2].

Another work to be said is multi-IV infusion monitoring system. This system uses a voltage divider circuit uses a potentiometer. So basically, when the weight of the saline bottle changes it results in the change of resistance of potentiometer system also uses a photodiode circuit to keep track of saline droplets and servo motor circuit which will adjust the infusion rate of IV bottle [3].

Use of two sensors optical sensor for drop detection and capacitive sensor for level detection approach is used in another system it uses a GSM Module for alert. This system uses a http API as cloud service to store the patient data and also provides features like visualization to easily monitor the data by staff or doctor [4].

A system with consist of solenoid valve, load cell, ESP8266, heartbeat sensor uses same approach for automation of IV pole and uses a Wi-Fi technology for transmission of patient data for monitoring purpose. This approach is used in the proposed

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system [5].

3. Methodology

The proposed system can provide an efficient way for healthcare staff i.e., nurses, doctors, etc. by which they can monitor the health details of the respective patients which includes the heart rate, blood pressure and temperature and will also provide the details about amount of saline liquid present in the saline bottle. When the level of liquid falls below a certain threshold value or level it will notify the staff that particular saline bottle is empty the basic used saline bottle is of 500ml so when the level falls below 40 to 100 ml it can be replaced with another one. A power of 12v is required to electrically power the system. When the saline bottle is hung on the IV pole and connected to load cell/sensor via the screw present on the load cell, the sensor then senses the weight at regular intervals of time.

A. Proposed System

In our proposed model we are concentrating on monitoring the health status of patient with efficient monitoring of saline bottle fluid level. We are aiming to bring the technology closer to hospital and common medical working staff. This system eliminates efforts of monitoring the health status of patient by nursing staff physically.

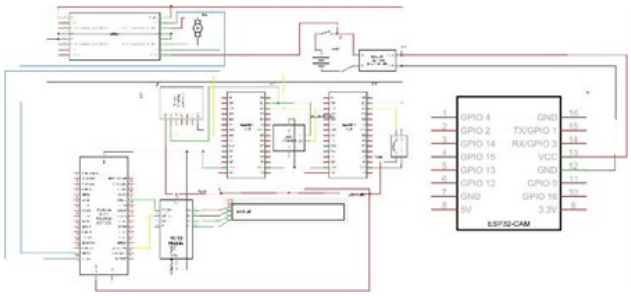

Fig. 1. Circuit diagram of proposed system

1) Working

To achieve primary goal of our proposed system we have divided the system into three different modules. Implemented proposed system will be very useful in scenarios where multiple patients we have to monitor and to reduce the efforts of the hospital staff the proposed automation will be very useful. So, first module consists of load cell. To check whether the saline bottle is empty or filled we have connected a load cell to saline bottle which is capable of converting the applied weight of saline bottle to electrical signal. Basically, it is a force transducer so whenever a force is acting on the transducer it will convert the analog applied force to an intermediate electrical signal. For this we first calculated the weight of filled bottle which we got approximately 500ml (in our scenario we used small bottle of 100ml).

We calculated the raw value of the plastic it was 40gm. So, for the critical value of empty bottle, we had set it as 40ml to 100ml. As we can't let it be completely empty for added precaution. Second module consist of MAX30100 and MLX90614 sensor. MAX30100 is inbuilt pulse oximetry and heart-rate sensor which we used to monitor the heart rate and oxygen level of patient. Also, MLX90614 is ambient temperature sensor which is capable of detect the temperature of patient without being in contact with the patient which will really be helpful. And in third module, Proposed system is completely automated with sensor and also hospital staff can monitor the data on Blynk app. Furthermore, the complete patients' readings can be store on cloud for further processing.

2) Flow Chart

Fig 2. shows the working flow of the proposed model. So, starting with initialization of load cell input connected to ESP32 board based on the load cell input the decision as if weight is below 40ml notification will be sent to medical staff and also alert will be provided using a buzzer. Else the system will be stay silent until the condition is satisfied. Parallelly temperature input from MLX90614 sensor will be visualized on Blynk app. Also, MAX301000 pulse and SPO2 values loaded on Blynk app and parallelly displayed on LCD display.

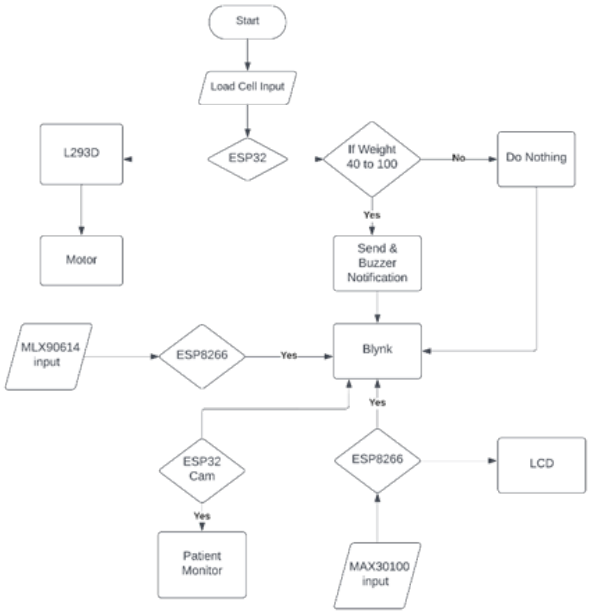

Fig. 2. Flowchart

3) Tools and Technology Used

In this system we have used a load cell which will converts the weight of the saline bottle to electrical signal which can be compared with empty saline bottles wight using a condition in ESP32. If weight is between 40 to 100 ml it will send a notification and activates a buzzer.

Another important component is MAX30100 sensor and MLX90614 sensor. It is an inbuild pulse oximetry and heart-rate monitor sensor and ambient temperature sensor respectively. Which we used to continuously monitor the heart rate, temperature and oxygen level of patient. In this system we have used Hx711 module, I2C protocol.

a) Applications

i. Useful in Healthcare, Ambulances, Hospitals.
ii. Useful in managing large number of patients during times of crisis.

iii. Smart ambulance services.

b) Advantages:

i. Easy to Operate
ii. Low Power Consumption
iii. Automatic Data Logging

4. Results and Analysis

Based on the Load cell transducer for the detection of empty saline bag. From the references existing system uses some similar approaches but our proposed model showcase added features like heartbeat sensing/monitoring, SPO2 sensing and low SPO2 alert, low temperature alert, saline bag empty alert, pole height adjustments, live patient monitoring. After successful testing of the prototype accurate results were noted. Fig. 3, 4, 5 shows heart rate, SPO2, temperature graphs. The system provides a very efficient alert system as shown in fig.6 showing the graph plot of saline bottle level which showing the reducing level of saline bottle as time goes on and fig 7 showing the alert we getting after the saline bottle gets empty also it giving notifications for low temperature and low SPO2.

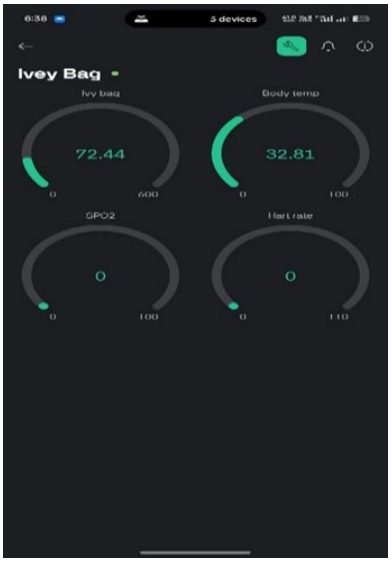

Fig. 3. Blynk dashboard

Fig. 4. Blynk dashboard

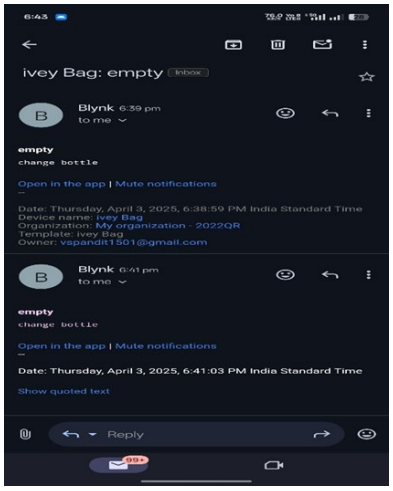

Fig. 5. Notification

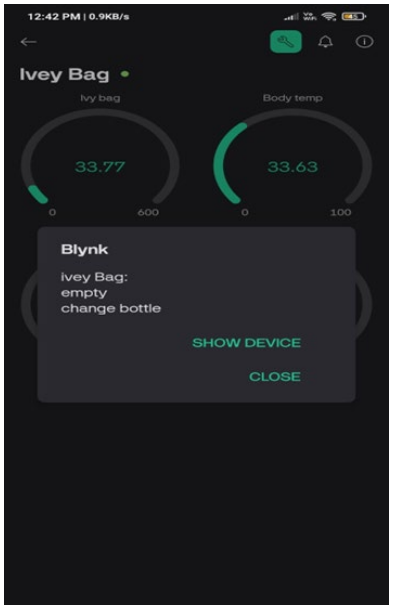

Fig. 6. Alert

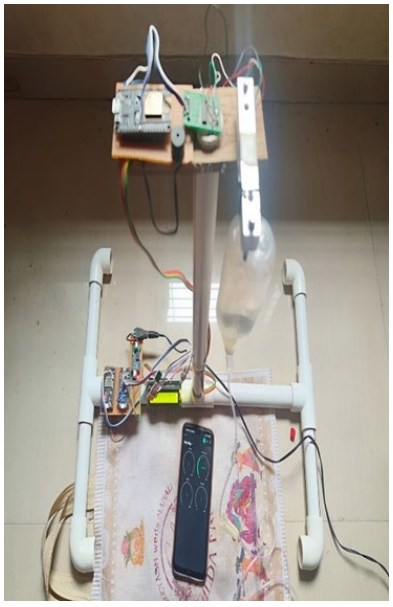

Fig. 7. IV Pole Monitoring prototype

5. Future Scope

This system also has image processing or computer vision as its one of the future scopes on which work can be done to make the system more efficient. We can collect images of patient obtained from ESP32 cam module and from patients' facial expression we can predict the condition or abnormal behavior of patient whether he is feeling well or not.

We can also use two IR Sensor OSRAM(SFH4554). Tx and Rx of those are matched two operate at IR of 850 nanometer wavelength and has illumination diameter of 5 mm which can help to calculate Drops per Minute (DPM) from which the system can actuate drip infusion system or DPM can be controlled using solenoid or stepper motor actuation.

6. Conclusion

This paper has proposed design and implementation of a smart iv pole monitoring system with SPO2, heartrate and temperature detection. It also has the feature of simple android application called "Blynk" IOT application. It can be also used on web console. This system consists of hardware devices and software application. So, this system can efficiently provide an alarm system and which can help very much to the hospital staff in monitoring of the patient.

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