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Advancements in Healthcare through Design and Development of an Intelligent Intravenous Bag Monitoring and Alert System

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ABSTRACT: The Intelligent Intravenous Bag Monitoring and Alert System is a device designed for nighttime patient monitoring, allowing nurses to focus on other duties and prevent air bubbles from entering the patient's bloodstream. The device uses an S-type load cell to measure IV bag contents, and the Blynk app to display readings on a smartphone. The device's CPU, a NodeMCU, operates on a voltage range of 5V to 12V. The device's goal is to monitor the current IV content level, which can be checked using a smartphone and the LCD display. This innovative solution is particularly useful for intravenous (IV) treatment, which allows patients to receive fluids, medications, and nutrients directly into their veins. The device's effectiveness is further enhanced by the Blynk app.

KEYWORDS: LCD Display, Blynk, Smartphone, Nurse, NodeMCU, Intravenous

1.0 INTRODUCTION

It is widely accepted that one of humanity's greatest medical potentials is the use of technology. One of the most recent innovations made by humans is intravenous therapy, which can be managed online. Intravenous (IV) treatment is the process of absorbing a liquid into a vein (Dougherty, L., & Lamb, J. (2008)). Blood, nutritional formula, and drug treatment solutions are a few examples of these liquid materials (Dougherty, L., & Lamb, J. (2008) and Plumer, A. L. (2006b)). As of right now, there are two ways to regulate the amount and rate of fluids given during intravenous therapy: manually and with a pump (May C., L. 2019). Particularly for patients who are extremely sick, intravenous infusion (IV) needs to be given continuously with precise flow rate control.

A growing number of patients are being seen lately due to various illnesses that are having an impact on their well-being. Furthermore, the longer COVID-19 is around, the more people who will require hospitalization for observation or who are seriously ill. Due to the increase in patients, the hospital staff will surely be under a lot of strain. One problem is the short amount of time allotted to verify the current condition of the IV bag contents. Inadequate IV bag content level monitoring for the patient could also result from a staffing shortage. To address this issue, a novel instrument was developed. This revolutionary gadget is called the Intelligent Intravenous Bag Monitoring and Alert System.

The project aims to facilitate the monitoring of medication levels in IV bags by hospital staff. It will also develop a system that tracks the contents of IV bags and displays results on an LCD screen and a smartphone. Lastly, the system will notify or warn the nurse when the IV bag's contents drop below a predetermined level and need to be replaced.

2.0 METHODOLOGY

The overall methodology for this project is depicted in the block diagram and flow chart that are part of it. This section also addresses software and hardware development in addition to that. Before the system can be developed, it must first be designed. The system is designed after the proper component has been selected. When every component has been listed, the next step is to assemble them all. This section will focus mostly on using IDE software. The software will be finished and complete once the system is configured.

2.1 IoT IV Bag Monitoring and Alert System Overview

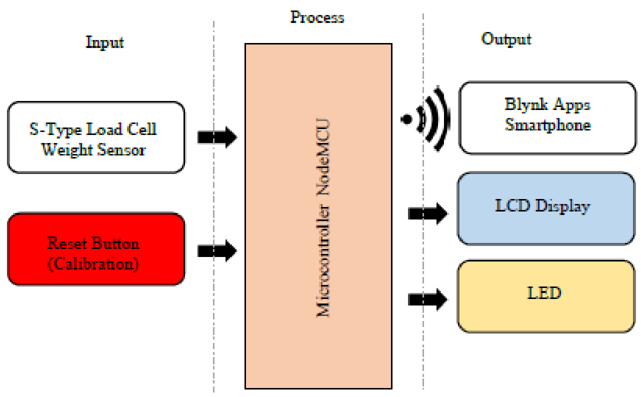

Figure 1: Block Diagram for the Intelligent Intravenous Bag Monitoring and Alert System.

Figure 1 shows the entire block diagram for this innovation project. Based on the block diagram, the project's input, processing, and output components can be divided. The input section consists of a calibration reset button and an S-Type load cell weight sensor. An LCD display, an LED notification, and Blynk smartphone apps make up the output component, while the NodeMCU microcontroller which was created using ESP8266 WiFi is used in the process section. The IV bag cannot be hung up until the Blynk App on the smartphone is activated. Make sure the 0.00kg range is displayed on the LCD display. If the measurement is not 0.00kg, press the reset button to correct it.

When the IV bag is suspended from the S-Type load cell weight sensor hanger, the current IV bag reading will be displayed on the LCD display and on the Blynk app on the smartphone. If the contents of the IV bag are less than the minimum level, which is less than 0.10 kg, the LED will light up and the LCD display will show the minimum level. This is when a notification will arrive on the smartphone.

2.2 Software Development

This software is an open-source Arduino application. The code will be written using this program and uploaded to an Arduino board. The Arduino board, which is always changing to meet changing needs and problems, is available in a variety of forms, from simple 8-bit boards to devices for IoT applications, wearable technology, 3D printing, and embedded environments (Patil, K., Mhatre, M., Govilkar, R., Rokade, S., & Gawas, Prof. G. (2016). Rasberry Pi, Arduino, and other devices can be controlled over the Internet with the Blynk platform (Krishnamurth, K., Thapa, S., Kothari, L., & Prakash, A. 2015).

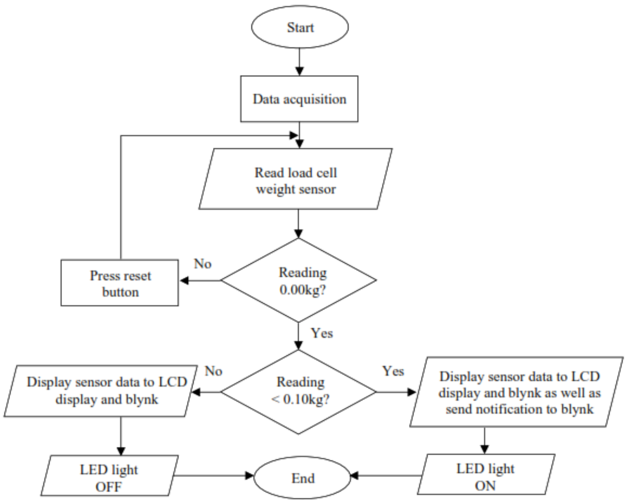

Figure 2: Process of IoT IV Bag Monitoring System

2.3 Hardware Development

The NodeMCU microcontroller, shown in figure 3, is the most crucial component of the hardware. As an open-source platform, NodeMCU's hardware design is editable, modifiable, and buildable. The ESP8266 wifi-enabled chip is the core of the NodeMCU development kit/board. Espressif Systems created the low-cost Wi-Fi chip ESP8266, which uses the TCP/IP protocol. The NodeMCU is based on the Espressif NON-OS SDK and is implemented in C. Originally created as an add-on to the well-liked ESP8266-based NodeMCU development modules, the firmware is now compatible with any ESP module and is supported by the community.

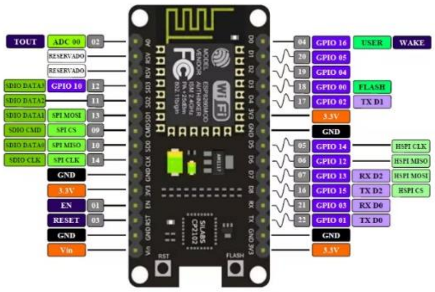

Figure 3: NodeMCU Microcontroller

The Arduino I2C LCD display is seen in Figure 4. Liquid crystals are the main component used in LCD (Liquid Crystal Display) flat panel displays. Owing to their extensive integration into devices such as computers, televisions, cellphones, and instrument panels, LEDs have a plethora of uses for businesses and consumers alike.

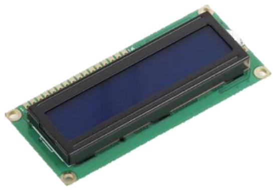

Figure 4: I2C LCD Display

A weight sensor for an S-type load cell is depicted in Figure 5. The force this sensor is measuring is directly proportional to the electrical signal produced by a transducer, or load cell. The indirect voltage to load conversion involves two steps. Strain gauges are commonly used as the sensing element in modern designs. Because foil gauges are available in such a large range, they are frequently used in load cell designs. A strain gauge distorts when a force is applied due to a mechanical setup. The strain gauge converts electrical impulses resulting from deformation (strain) into voltage. An instrument commonly used in the weighing industry is a load cell. An S-type load cell is among the most widely used varieties (Prof. Kamlesh H. Thakkar, Prof. Vipul M. Prajapati, & Prof. Bipin D. Patel (2013)). The size, shape, and electrical components and connections of the load cell structure, as well as other factors, affect the load cell's results (Chung Ket, T. (2013)).

Figure 5: S-Type Load Cell Weight Sensor

A push-button switch controls the operation of a machine or other process. They are also referred to as push buttons or push switches and are commonplace components found in homes and workplaces. The push buttons are typically made of plastic or metal and can be flat or shaped to meet ergonomic requirements. There is a vast array of button switch variations that can act in a latching or momentary manner. When the pushbutton is open, which is the same as being depressed, the pin is connected to ground (through the pull-down resistor), so we read LOW in this scenario. When the button is closed, or pressed, the pin is connected to 5 volts, which results in a HIGH reading.

Figure 6: Push Button

A Light Emitting Diode (LED) that was utilized as an indicator in this project is shown in Figure 7. When current passes through a light-emitting diode (LED), a semiconductor device, light is released. Electrons and electron holes recombine inside the semiconductor, releasing energy in the form of photons. The energy needed for electrons to cross the band gap of the semiconductor determines the color of the light, which is related to the photons' energy. A layer of light-emitting phosphor or multiple semiconductors can be used to produce white light on a semiconductor device.

Figure 7: Light Emitting Diode (LED)

3.0 DISCUSSION AND VALIDATION OF RESULTS

This section provides a brief description of the circuit's results. All hardware equipment is being deployed, and some type of data from related projects is being reviewed to ensure that the system is operating consistently and in the necessary state. The analytical part keeps track of the project outcomes. Using this tool, users can assess how well the system performs and functions considering the findings and system data analysis. Table 2 displays the observation results.

Table 1: Findings from the Intelligent Intravenous Bag Monitoring and Alert System Analysis

Load Cell Reading	Blynk App	LCD Display	LED
> 0.10kg	Display actual reading	Display actual content	Light OFF
0.00kg – 0.10kg	Display actual reading and receive notification	Display actual content and display notification	Light ON

According to this discovery, no notification will be sent out if the reading condition shown on the LCD display and the Blynk application is greater than 0.10 kg. Figure 8 illustrates that the LED is likewise off. But a notification will be sent to blynk if the reading in the blynk application and on the LCD display is less than 0.10kg. The "Minimum Level" notification and the current IV bag reading will be displayed simultaneously on the LCD display. The LED will also turn on simultaneously, as seen in figure 9. Figure 10 displays the blynk app on a smartphone.

Figure 8: When Reading Exceed 0.10kg

Figure 9: When Reading Less Than 0.10kg

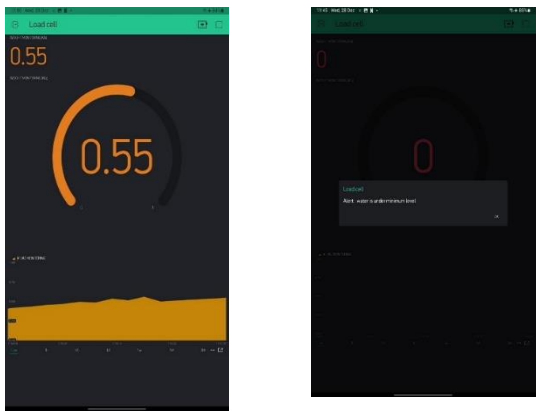

Figure 10: Displaying on the Smartphone

4.0 CONCLUSION

This invention project, named "Intelligent Intravenous Bag Monitoring and Alert System" was created to support medical professionals, including nurses. The project's original objective—to make it easier for hospital staff to monitor the medication in patients' IV bags—was achieved. The second objective, which has also been achieved, was to create a system that could continuously check the contents of the patient's IV bag and display the results on an LCD screen and a smartphone. Providing the nurse with a warning or notification system if the IV bag's contents fell below a predetermined level and required replacement was the third objective. This objective was also fulfilled.

The project's investigation's conclusions led to the conclusion that its users—nurses who work in hospitals with a high patient volume, in particular—will benefit immensely from it. Thanks to this clever technology, nurses will have more time to complete other tasks in addition to checking the patient's IV bag on a regular basis. Another benefit of this discovery is its suitability for nighttime patient monitoring. This novel instrument is also considered to have considerable potential because of its low development cost and high commercialization potential.

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