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IoT based Smart Saline Bottle for Healthcare

Mihir Tilak
Dept. of Biomedical Engineering,
Vidyalankar Institute of Technology,
Mumbai, India

Darshan Bhor
Dept. of Biomedical Engineering,
Vidyalankar Institute of Technology,
Mumbai, India

Amey More
Dept. of Biomedical Engineering,
Vidyalankar Institute of Technology,
Mumbai, India

Dr. Gajanan Nagare
Dept. of Biomedical Engineering,
Vidyalankar Institute of Technology,
Mumbai, India

***Abstract*—The Healthcare sector has progressed by quantum leaps in the past few years. Hence, it is evident that this growth of the industry should be managed properly by all the hospital staff. This causes very little attention to patient monitoring level of the saline bottle and as well as close the saline tube comprising of air bubble to avoid air embolism when the bottle is about to get empty. The Healthcare sector with innovative techniques has brought easiness in day to day life. Automation of the saline system is the need of hospitals. Saline is a basic thing used in every hospital to deliver drugs to the patient to cure them. Whenever saline is fed to the patient there is always a requirement of nurse and caretaker to monitor it. Due to inattentiveness of nurses towards saline or lack of patient to nurse ratio in the hospital causing aeroembolism which may lead to heart attack, stroke or respiratory failure. This paper "LED-Photodiode based system," monitors the saline bottle using Arduino Uno which performs the logical operation and connects the system to blynk or serial monitor terminal application. Blynk is an IoT platform that is with software, and other technologies to connect and exchange data with other devices and systems over the Internet. Whenever the level of the saline reaches the pre-defined critical level, then the nurses, doctors will be alerted through the message and an indicator will glow to alert the nurse station as well as clamps the saline bottle without any further delay. So, that fatal accidents through air embolism and further complication can be prevented.**

Keywords*—Arduino controller, LEDs, Blynk, IoT, Photodiode, Serial monitor terminal.

I. INTRODUCTION

Healthcare industry is becoming expensive day by day, but the number of diseases has also increased. IoT associated gadgets are procuring huge potential nowadays because it is abating the human effort for a certain task which is repetitive. Low-cost IoT products make the system less expensive for patients rather than appointing more staff for tedious work. Healthcare Industry is becoming costlier day by day but the number of patients and diseases is still increasing which causes the overload on the staff as well as abates quality of treatment given nurse station. Blynk mobile application is very user-friendly for hospital staff to monitor many patients simultaneously.

Several works are being done to monitor the saline water level which includes the use of a weight sensor [1] wherein the weight of the saline bottle is being continuously measured but it doesn't include the clamping mechanism, whereas in [2] IR based sensor is used in which output voltage changes when IV is below some threshold; comparator then compares the output with a predefined threshold. In [3], the drip rate is being measured with the use of an optical sensor and a motor, and an actuator to clamp the tube. The firm called shiftlabs has developed a device named 'dripassist infusion rate monitor' wherein it counts drops flowing through the IV tube and is attached to the cannula.

In [4], presented a design study that proposed a system made by electromechanical components. in this design, Spring acts as a weight sensor for monitoring the saline solution. In [5], presented a design study that proposed a system that is built using the Arduino microcontroller. The proposed system comprises an IR sensor that acts as a level detector for monitoring the critical level of the saline in the saline bottle. From, his study the IR sensor-based approach for measuring saline level is understood. In [6], presented a design study that proposed that calibrates the weight of the saline bottle with the volume of saline solution. This saline monitoring system sends an alert to the nurse station when the saline solution weight is below a threshold level as calibrated in the program.

In this work, a new and low-cost approach is used where LEDs and photodiodes are used as sensors and detectors respectively, also clamping mechanism is developed where it will clamp the tube when the saline bottle would be limited.

II. PROPOSED SYSTEM

The proposed system eliminates continuous visual monitoring of the patient by nurses from distinct places. The entire project works on the principle of Beer-lamberts law. In figure 1, the amount of transmitted light from the LED to the photodiode depends upon the electrolyte in the saline bottle. The voltage across the photodiode is monitored every millisecond. Threshold levels of voltage are calibrated on Arduino Uno by programming. Blynk application receives and sends data through mobile. The change in threshold level activates the alarm at the nurse station at the 100 ml mark. However, at the 50 ml mark, a message will be sent to the nurse station as well as a saline tube is clamped through a solenoid plunger to prevent it from air embolism. Table 1 below shows the briefing of the actions taken.

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TABLE I. BRIEFING OF THE ACTIONS TAKEN

Levels	Alerts	Actions
Filled	Green LED glows	No action taken
At 100 ml	Yellow LED glows	Message sent to nurse
At 50 ml	Red LED glows	Message sent to nurse and clamping of tube

A. Block Diagram

Block diagram of the system is shown in figure 1.

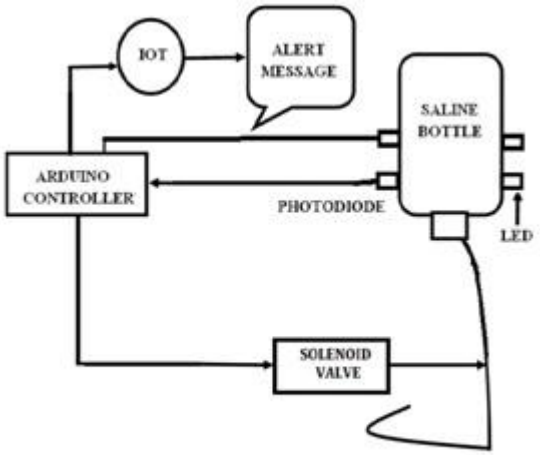

Fig. 1. Example of a figure caption

B. Proposed Architecture

The whole work can be divided into two systems- sensing mechanism and clamping mechanism.

Sensing Mechanism:

Once the system is on, the saline bottle is being checked continuously. When the saline water reaches exactly 20% of the bottle capacity, the alarm is being sent to the nurse station stating that the saline bottle is about to get emptied as shown in figure 2. If the nurse does not arrive until it reaches 10% of the capacity, then the tube would get clamped, and consequently, the message will be sent to the nurse station.

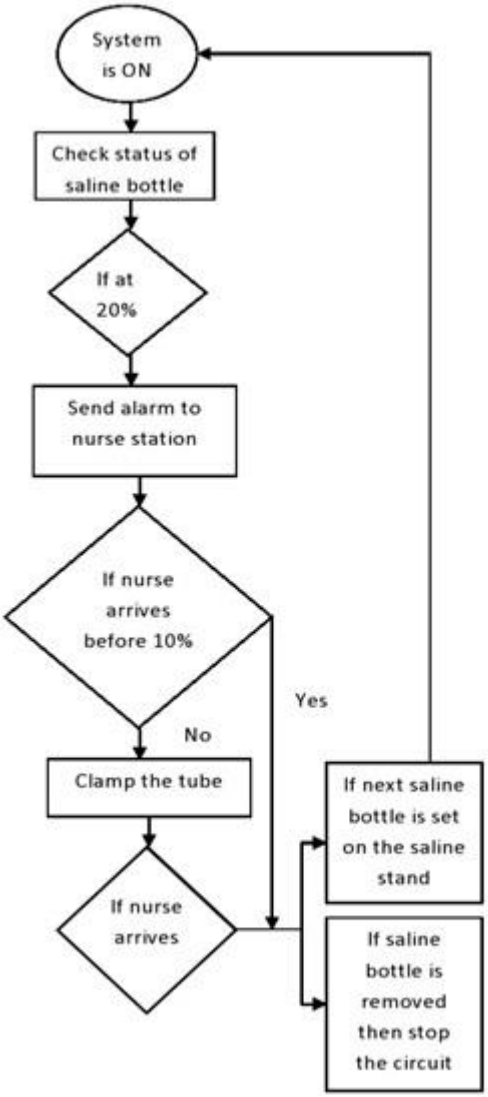

Fig. 2. Process flow of sensing mechanism

Clamping Mechanism:

In figure 3, The power supply is being given to the relay circuit and when the relay circuit would receive the signal from Arduino Uno to clamp the tube, then the transistor will be on (when Arduino logic is 1) and the signal is given to the plunger to clamp the tube.

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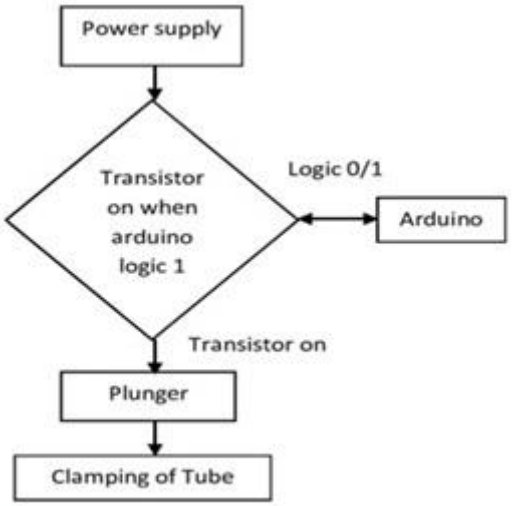

Fig. 3. Process flow of clamping mechanism

III. IMPLEMENTATION

Light Emitting Diode(LED): Light Emitting Diode are used as a light source to pass light between saline bottle, Positioned at the critical level above saline bottle to emit light toward photodiode. In a system, we used blue colour LED of 450 nm, which gave optimum voltage across photodiode.

BPW34: BPW34 is a photodiode made up of p-n junction of semiconductor which works in reverse bias mode (positive voltage supply to cathode & negative voltage supply to anode). Photodiode use to sense light falling on diode and convert light into electrical signals. Photodiodes are placed on a saline bottle opposite the LED.

Arduino Uno: Arduino Uno is an open-source microcontroller board that uses an Atmega328 microprocessor. Arduino Uno used to read sensors electrical signals like photodiode, Wi-Fi module, etc., performs logical operations, And gives a signal as output to connected devices to perform a certain task as the motor rotates with desire speed.

Arduino IDE: Arduino Integrated Development Environment (IDE) is a software platform used to write code for microcontroller boards like Arduino or node MCU which has libraries for particular applications, a serial monitor to show output on a computer screen.

Solenoid Plunger: Solenoid plunger is a mechanical device that uses electric current to provide linear motion of the plunger. When electric current flows from coil magnetic field forms and the back and forth motion of the plunger happens. In the system, the plunger uses to clamp the saline tube of the bottle, when the saline goes below the critical level.

SL100 transistors: SL100 is an NPN transistor used in many electronic devices in the application of switch, amplifying devices. In a system used as a switch application.

Bluetooth module (HC-05): Bluetooth module is used to connect the system wirelessly with two-way (Full duplex)communication in applications like Bluetooth connection between two devices. It uses a 5-volt power supply and communicates with help of serial communication (USART) at 9600 baud.

Blynk: Blynk is an application used for IoT applications, which controls IoT-enabled devices remotely. It collects data from the sensor store it in the blynk cloud & gives access to the user to control the device remotely.

Power supply: power supply unit provides a 12 volt 1 ampere A.C. supply to provide optimum current and voltage to the system.

Wires: Wires are the basic cylindrical structure to use connect devices with an electrical signal.

IV. RESULTS

This project uses the method of optical sensing mechanism, there are different methods of sensing the saline level such as load cell, ultrasound [7], IR and capacitive based sensors. But the advantage of an optical-based system is its cost-effectiveness and very less hardware requirement. In papers [8],[9],[10],[11],[12],[13],[14] and [15] all of these can sense and respond to the low saline level by an alert to the nurse station. In case if the nurse still does not arrive in time, when the saline bottle is about to be empty this project clamps the saline through the solenoid plunger which additional safety backup gives to this system.

The device performance and accuracy were tested for the quantitative determination of saline levels. When light is incident upon photodiode sensor it sends a signal to Arduino and gives the output as values of Red, Blue, or Green colour through LED according to the alert message. The values of output voltages across photodiode against the saline level of the bottle in the sample were used for analysis. Out of these three levels each level has a different analog input voltage across photodiode. Owing to this relationship, a calibration curve was plotted as shown in figure 4 and the microcontroller is programmed accordingly.

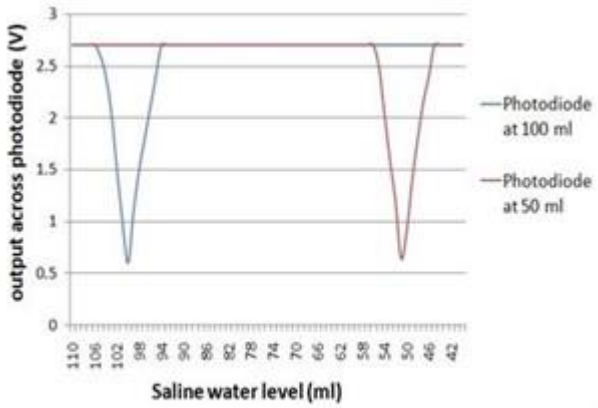

Fig. 4. Output across photodiode

Finally, when the controller receives the output of the LED-photodiode-based sensor, it is put in the program of the microcontroller and the corresponding threshold is checked periodically. Alert message on the mobile and clamping of the saline tube is given as output of the test.

The mobile alert is sent at the nurse station with a message as shown in figure 5:

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Fig. 5. Output of serial bluetooth terminal app

As shown in figure 6, the supply is given to this LED-photodiode pair by Arduino microcontroller. The analog output of the photodiode is sent to the Arduino Uno which is made into a digital output from 0-5volt. 2 to 5 volt signifies saline is above threshold level less than 2-volt output signifies the electrolyte is below a certain level.

Fig. 6. Setup of the system

In figure 7, the microcontroller is programmed in such a way that when electrolyte crosses the first sensor at 100ml it alarms the nurse station through the Blynk mobile app to close the saline.

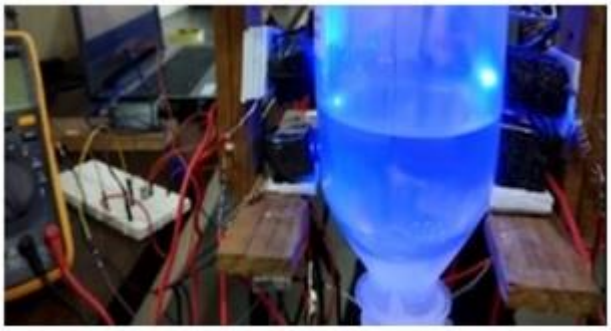

Fig. 7. Detection at 100 ml of saline level

In figure 8, if the nurse does not close the saline bottle at 50ml, the second sensor activates the microcontroller which further triggers a buzzer alarm and clamps the saline tube through the solenoid plunger via the relay circuit without any further delay. To trigger the solenoid plunger it requires a 12 volt 1 ampere supply as well as it has driven through a transistor working as a switch.

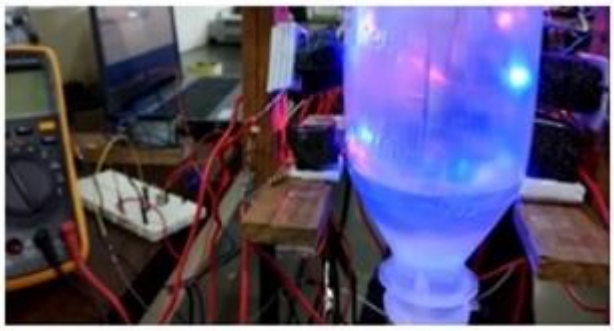

Fig. 8. Detection at 50 ml of saline level

V. CONCLUSION

The utilization of a remote patient monitoring system based on a LED-photodiode-based sensor has enabled patient saline level observation at a minimal cost. This system can be used at night time also when nurses might not be awake. The IoT-based system is cost-effective as well it uses the minimum hardware possible. The major difficulties faced in this project were the clamping circuit mechanism of the saline tube and the testing of different sensors.

On the whole, IoT adds a new dimension in the healthcare industry for patient monitoring. Hence, this system is guaranteed to be sensible and user-friendly to be used in rural hospitals.

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