IoT-Driven Infusion Monitoring & Management System

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Abstract: This research investigates the monitoring and management of an intravenous drip infusion system using the Internet of Things (IoT) and non-contact liquid level sensors, an Arduino circuit board, a GSM interface, and a cloud storage facility. The three sensors in the system are able to detect the presence of fluid without coming into contact with it. They can also send the data they collect to the cloud facility, where it can be used to access drip conditions and monitor fluid levels as well as control infusion flow when needed. This system can be considered an improvement over several systems on the market that are similarly intended to use optical sensors, TDR (Time domain reflectometry), and other types of sensors to monitor the IV drip flow. While it is true that each type of sensor has a combination of benefits and drawbacks, none of the other systems on the market can further regulate the drip flow like this one does. Since the sensors we've employed don't respond to fluids, the patients don't suffer any damage at all.

This is now a crucial necessity in the biomedical industry since human reliance on IV drip infusions has led to a number of incidents, the most serious of which involved the patient suffering severe injuries from back blood flow in the nozzle. This system is made to guarantee that all safety precautions are taken and that the patient and attendant are in the best possible circumstances in order to minimize such incidents, accurately monitor and control fluid flow from drip to patients' veins, and prevent back blood flow.

Keywords: Internet of Things, Intravenous drip infusion, Non-contact Liquid Level Sensor, Thing speak, Esp-32, GSM.

I. INTRODUCTION

The nation's intravenous infusion systems are manually operated devices that do not adhere to patient safety standards, especially in urgent circumstances when the infusion has to be closely watched. The intravenous (IV) infusion procedures need precise and continuous management of the drip rate. Usually, the infusion dripping is visually managed by counting the droplets for 15–30 seconds, and the drip rate is first manually adjusted. A number of factors, including vein dilatation or contraction, a drop in fluid pressure, changes in the patient's body temperature, etc., might affect the set drip rate. Different types of drip rate meters have been developed to lessen the need for medical staff to intervene as often as every 15-20 minutes. Usually, optical sensors are used in these systems' sensing technology to identify the droplets that are dropping into the drip chamber. An further method of monitoring infusion solutions relies on a capacitive system consisting of several non-contacting electrodes around the components of the infusion supply. The complete counting of droplets serves as the foundation for the operation of all of these current systems. The requirement for a precise initial calibration on the drop volume, which is dependent on the geometric dimensions of the particular tubing, is the primary drawback associated with the use of these monitoring methods. Moreover, since the sensing element for optical detection is fixed on the clear drip chamber, an additional crucial concern in this regard is the proper alignment of the optical sensor in order to maximize the sensitivity performance overall.

The limitations outlined in the adoption of these monitoring techniques support the search for

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substitute techniques that use direct liquid volume variation sensing inside the solution container.

It is commonly known that there are several techniques to monitor the liquid levels in IV drips; however, practically all of these methods have drawbacks when it comes to cost or usefulness of the system when applied in Indian hospitals. The most effective technique that might be used in our hospitals is optical liquid sensing, which won't always be exact from drip to drip but will address the issue of nurses frequently having to visit their own wards. Additionally, an internet-based system or application that would enable long-distance monitoring of each IV infusion performed in the hospital would be centrally calibrated with the system. Thus, the suggested approach may be effectively used as a first-rate monitoring instrument for telemedicine initiatives as well as in-hospital patient treatment. As an aside, it's crucial to emphasize that the controlling software can be appropriately set up to sound an alert in the event that the IV drip rate deviates from a certain range or the liquid volume falls below a predetermined threshold.

1.1 Components Used: Creation of Intravenous Drip Infusion Monitoring and Control Systems in Real-Time The following sensors are being used to detect a certain type of object utilizing the Internet of Things concept.

a. **Non-contact Liquid Level Sensor (XKC-Y25-T12V):** In order to perform non-contact liquid level detection, the non-contact liquid level sensor makes use of cutting-edge signal processing technology and a potent chip with a high-speed operating capacity. The module may be used for dangerous applications such detecting strong acids, strong alkalis, and all types of liquid in an airtight container under high pressure since it doesn't come into touch with liquid. The liquid and container don't need to meet any specific standards, and installing and operating the sensor is a simple task.

Figure1. XKC-Y25-T12V sensor

b. **Gsm-Module 800A**: Global system for mobile communication is referred to as GSM. The IEEE 802 Wireless Standard is supported by this gadget. They provide advanced text instructions that allow consumers to communicate with network providers. The RS232 to TTL converter is already included into the computer as part of the connection from the computer to the GSM company.

Figure2.Gsm Module-800a

1.2 **Software Used**

a. **Cloud Partner (ThingSpeak):** Consider Speak is an IoT website operated by a third party. Thing Speak, according to its makers, is an open-source Internet of Things (IoT) application and API for storing and retrieving data from objects via a local area network or the Internet utilizing the HTTP and MQTT protocols. Thing SpeakTM is an IoT analytics platform service that lets us collect, visualize, and analyze real-time data streams in the cloud. It enables users to analyze and display submitted data using Matlab without needing to acquire a Matlab license.ThingSpeak offers real-time visualizations of data uploaded to Thing Speak by your devices. Data uploaded by your devices to Thing Speak is instantly visualized by ThingSpeak.

b. **Arduino IDE-** We use the Arduino IDE to execute all of the aforementioned components. This Arduino IDE is capable of managing pin connections.

c. Eagle is also utilized in PCB and circuit design.

II. LITERATURE REVIEW

Created a technique for monitoring drip infusions remotely in hospitals. A central monitor and many infusion monitoring devices make up the system. The drip infusion rate and an empty infusion solution bag may be detected by the infusion monitoring equipment using a Bluetooth module. These data are then transmitted over Bluetooth to the central monitor situated at the nurses' station. Several infusion monitoring devices send data to the central monitor, which then visually shows it. As a result, the system that was built has the ability to closely monitor the drip infusion status of several patients at the nurses' station. [3].

The technologies of the photoelectric monitor, modulation demodulation, single-chip microcontroller (SCM), wireless communication, etc. are the foundation of a medical infusion monitor and protection system design. By using the infrared photoelectric conversion characteristic, the infusion signal is gathered. In order to create a wireless communication system for data transmission, SCM AT89C51 processes data monitoring, area infusion speed control, and wireless transceiver nRF905 control. Each control node is connected to the main controller via the serial interface MAX487, which allows the higher PC to monitor, control, and renew control schemes for each node in real time. According to experiments, the intelligent infusion system monitor and alarm is successfully completed when the rate of infusion speed monitor error is less than two drops per minute and the stability time is quicker. [7].

A number of advanced approaches have emerged in recent years as a result of technical improvements to ensure that hospital patients recover quickly. The most basic requirement for providing patients with quality care in hospitals is the assessment and treatment of their hydration and electrolyte needs. The majority of hospitals have a nurse or assistant in charge of regularly checking the IV fluid level. Unfortunately, though, because of their hectic schedules, observers frequently fail to replace the saline bottle at the appropriate time. This might cause the patients to have a number of issues, including blood loss and backflow. An inexpensive RF-based automated warning and signaling system that uses an infrared sensor as a level sensor is offered as a solution to this dire circumstance. .. It is predicated on the idea that when intravenous fluid levels fall below a certain threshold, the output voltage level of the IR sensor varies. The IR output is continually compared to a predetermined threshold using a comparator. The Arduino controller detects when the transceiver output is negative, indicating that the fluid level is too low. It notifies the observer by a buzzer, and the LCD in the control room shows the patient's room number for prompt recovery. [10].

An suitable electromagnetic signal, usually a step-like voltage pulse, is used to stimulate the system containing the TDR technique to be monitored. The signal is then transmitted through a probe, and any difference in impedance will result in a partial reflection of the signal as it passes through the probe. The propagating signal will partially reflect with any difference in impedance. The dielectric properties of the material being tested, as well as its quantitative aspects, including the level of liquid materials, may be obtained by analyzing the reflection coefficient in the time domain, or ρ. [15].

III. COMPONENTS USED IN OUR MODEL

Here in our proposed model IoT-Driven Infusion Monitoring & Management System For the following components are used in a required flow. The proposed model required components can be seen in the below table lists.

Table 1: System Specification

Measure	Sensor
Non-contact Liquid Sensor	XKC-Y25-T12V
Management IDE	Arduino ESP 32
Power Supply Details	Regulated (IC7805,) Transformer 12V/1 AMP, Capacitor 1000uf/16V Bridge rectifier
Adapter	adapter 12 V / 1A
Cloud Service	Things Speak
LCD screen	LCD 16x2
GSM System	GSM 800A
Software used	EAGLE(PCB Design) Arduino IDE

We have included ESP 32 in our suggested model. The majority of the pin headers on the ESP32 module are separated out as I/O pins facing each other, which is a nice feature. The ESP32 module is somewhat larger than the ESP8266-01 module and is breadboard friendly. They are overseeing the general,

fixed components of our model. It is possible for this microcontroller to interface with both digital and analog sensors. It has the ability to send and receive internet data as well. Next, we discuss the sensors that we employed in our model: a non-contact liquid level sensor. Each of these sensors is capable of determining an IV drip bottle's level. This sensor notifies the MCU if the IV drip bottle is empty.
Here, physicians and patient family get SMS notifications via the GSM system. Thing Speak is the cloud system utilized in this instance to retrieve sensor data and Internet of Things devices. This location also has an LCD device installed for the display of additional sensor components and liquid level. This LCD measures 16 by 2 (rows * columns). This screen's contrast is preserved by utilizing a 10k ohm potentiometer..

Figure 3. IoT-Driven Infusion Monitoring & Management System

IV. MODEL WORKING

This system operates on a 5 VDC basis. We first extract 230 VAC/5A of voltage from the primary supply source before converting this power from an AC source to DC. Then, since we already know that excessive voltage damages human tissue, we will use a transformer to lower the voltage and current to protect people from injury. The tool that lets you adjust the specified voltage is called a transformer. The transformer's total output voltage and current are determined by the winding choices on this isolated wire winding device, which has two cores: a primary winding and a secondary winding. The output voltage will be chosen based on what the system requires; in our situation, we need 5 Vdc, thus at the very least, we must choose 12 AC. once we had the transformer's 12 VAC. We must convert the 12 vac AC voltage that was obtained from the transformer into DC voltage. We needed a bridge rectifier to convert the ac voltage to dc voltage. As is well known, the component that changes the ac voltage into dc voltage is a bridge rectifier. This component has four diodes that may be used for either forward or reverse biasing. once the voltage was changed to DC. There are additional pulses in the received voltage, or more accurately, the voltage is pulsing DC voltage. We are employing a capacitor to remove the pulsing DC voltage in order to reduce further noise in the circuit. due to the capacitor's ability to either block or pass dc electricity. which we must have. We currently have 12 volts DC, however there is still a problem because we only require 5 VDC.

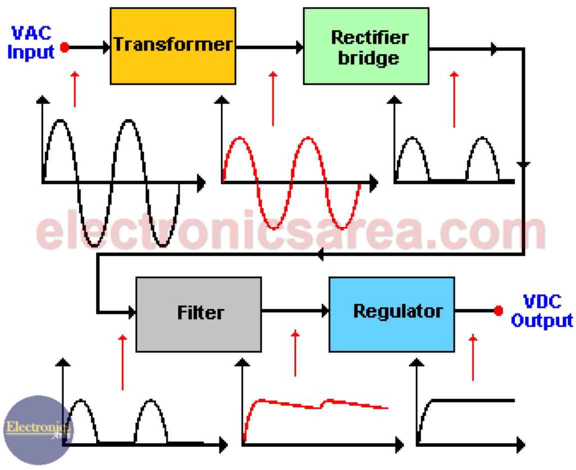

Figure 4.Power supply

The operation of the IoT-Driven Infusion Monitoring & Management System concept that is being presented
It is made up of both hardware and software components. The system is managed and controlled by the Arduino family's ESP-32 microcontroller. This model uses a DC power source. After the power is turned on, a welcome message appears on the LCD. Next, the esp-32 looks for the preprogrammed SSID and password before attempting to connect to the wifi router. Once this is done, the microcontroller begins to use a contactless sensor to measure the IV Infusions' liquid level. and Send it cloud Thingspeak's graph will change based on the condition of the sensors; if a high sensor level is detected, a signal is displayed on the cloud. With the aid of smart wedges, Thingspeak's solenoid valve will automatically adjust based on the condition of the sensors, controlling the flow of liquid. The entire system requires an active wifi connection and power supply to monitor and control this model. If the IV

bottle is empty, the esp-32 sends a signal to the cellular network to send a message alert to the appropriate mobile numbers in accordance with the program. This entire process takes only a few seconds. Every fifteen seconds, the esp-32 sends the overall status to Thingspeak Cloud, where all data uploads automatically in the corresponding graph.

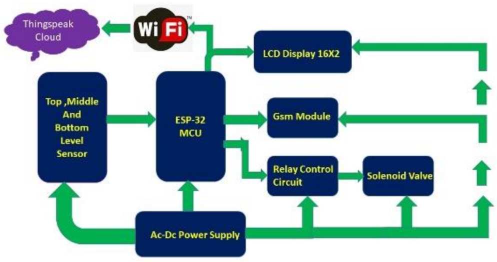

Figure 5. IoT-Driven Infusion Monitoring & Management System Block Diagram & Process

V. RESULTS

The status of intravenous drip infusions was monitored and displayed on a cloud and display screen. Three distinct graphs, representing real-time data representation at the top, middle, and bottom levels, were created, with each level sensor having its own graph and led indication wedges. This outcome might be kept for a very long period in order to comprehend the intravenous drip infusions. given to patients in order to maintain hospital records.

Figure 6. sensor results on an LCD screen

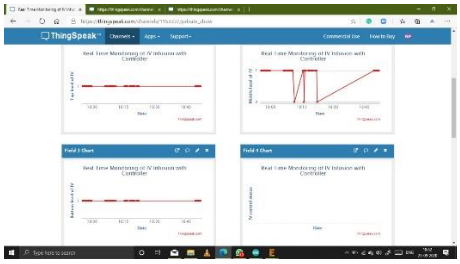

Figure 7. ThingSpeak Real-time data plotting

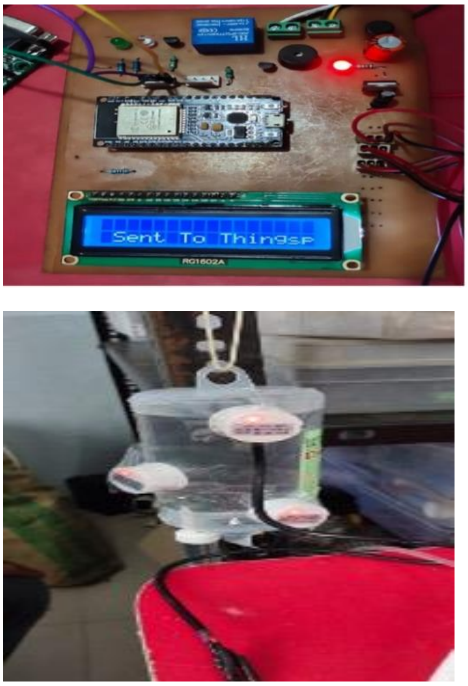

Figure 8. Real-time data Signal Indication

VI. CONCLUSION

An Internet of Things (IoT) model is studied that combines non-contact fluid sensing sensors with other electronic features to monitor and analyze the intravenous drip infusion system's controller in real time. Utilizing a cloud storage platform linked to the GSM service and the sensor element effectively creates a sturdy, affordable, and dependable drip infusion monitoring system under any circumstances. A controller device is integrated into the system to prevent blood from flowing backward into the patient's veins as a result of the suction created in the nozzle that connects the drip system to the patient.

The system's added benefit is that two channels are available for monitoring the data originating from sensing devices. Two options are available for monitoring the drip's top, middle, and bottom levels:

a cloud storage facility and a GSM that allows notifications about the fluid levels in the drip.

With precise sensing components and strong communication amongst the Internet of Things (IoT) components, the system functions well.

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