# Development of Real-Time Monitoring & Controlling of Intravenous Drip Infusions Using the Internet of Things (IoT)

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**Abstract:** This paper explores the use of non-contact liquid level sensors, Arduino circuit board, GSM portal, and a cloud storage facility to monitor and control the Intravenous drip infusion system using the Internet of Things (IoT). It has become a common problem across the hospitals that every drip infusion system requires a human attendant which exhausts a lot of human resources, which could be utilized for other useful purposes. This project is based on the motivation to eliminate this problem by providing an automated outlook to the infusion system. The system uses non-contact type liquid level sensors to detect the presence of fluid in the drip and uses that data to monitor the system remotely. At the same time, the system also has the control unit for the infusion to stop whenever required. This project explores several experiments to establish an Internet of Things (IoT) between the IV system and the electronic equipment to register the desired output. The sensors used here are non-reactive to the fluid in any form which makes it a reliable system to monitor the IV infusion. The electronic devices used here are also safe concerning patients' health. Graphs for the actual condition of the IV are also plotted at the 'ThingSpeak' cloud storage facility which could be accessed from any part of the world in real-time. A solenoid valve is used to control the flow of liquid when the drip is emptied.

This has become a major requirement in the Bio-medical field where the human dependency on IV drip infusions has caused several accidents which include mainly the back blood flow in the nozzle resulting in some severe damages to the patient. To reduce such happenings and to precisely monitor and control fluid flow from drip to patients' vein and to avoid the back blood flow, this system is designed in such a way as to ensure all the precautionary measures and to deliver best conditions for the patient and the attendant.

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

## I. INTRODUCTION

The Intravenous infusion system used across the country are manually controlled units that do not comply with the patient's safety in particular when it comes to critical situations when the infusion must be monitored thoroughly. The intravenous (IV) infusion processes require constant and accurate control of the flow rate and the correct dripping. Typically, the drip rate is initially regulated manually, and the infusion dripping is controlled visually by counting the drops for 15-30 seconds. The fixed drip rate may vary due to different causes such as dilation or contraction of the vein, decrease of the fluid pressure, variation of the patient's body temperature, etc. To reduce the frequent intervention of medical personnel, which typically would occur every 15-20 minutes, different kinds of drip rate meters have been developed. The sensing technology of such systems, typically, relies on optical sensors, which detect the drops falling in the drip chamber. Another infusion solution monitoring system is based on a capacitive system formed by some non-contacting multiple electrodes wrapped around the infusion supply components. For all these existing systems, the basic working principle is based on the total counting of drops. A first limitation arising from the adoption of these monitoring solutions concerns the need of performing an accurate preliminary calibration on the volume of the drops, which depends on the geometric dimensions of the specific tubing. Furthermore, when dealing with optical detection, since the sensing element is mounted on the transparent drip chamber, another critical issue relates to the correct alignment of the optical sensor to optimize the overall sensitivity performance.

The described limitations arising from the adoption of these monitoring methods, justify the investigation on alternative methods, involving the direct sensing of the liquid volume variations inside the solution container.

It is well known that monitoring of liquid levels in IV drips can be performed through various ways but almost every method has a limitation of either cost or ease of usability when it comes to applying the system in Indian hospitals. The best method which could be applied in our hospitals is the optical sensing of liquid which would not necessarily be drip-to-drip accurate but will provide a solution to the frequent intervention of nurses to their respective wards.

The system would also be centrally calibrated with an internet system or application that would provide long-distance monitoring of every IV infusion taking place in the hospital. As a consequence, the proposed method can be successfully adopted as an excellent monitoring tool both for in-hospital patient management and for telemedicine programs. On a side note, it is important to underline that the controlling program can be suitably designed to give an alarm if the IV drip rate gets out of a fixed range, or when the liquid volume decreases below a certain value.

**1.1 Components Used:** Development of Real-Time Monitoring & Controlling of Intravenous Drip Infusions Using the Internet of Things model we are using the following sensors for the detection of a particular kind of thing.

a. Non-contact Liquid Level Sensor (XKC-Y25-T12V): The non-contact liquid level sensor utilizes advanced signal processing technology by using a powerful chip with high-speed operation capacity to achieve non-contact liquid level detection. No contact with liquid makes the module suitable for hazardous applications such as detecting toxic substances, strong acid, strong alkali, and all kinds of liquid in an airtight container under high pressure. There are no special requirements for the liquid or container and the sensor is easy to use and easy to install.

Figure1. XKC-Y25-T12V sensor

b. Gsm-Module 800A: GSM stands for global system for mobile communication. This device works on IEEE 802 Wireless Standard. They support advance text commands for communication between users to network providers. The communication from the computer to Gsm Company has already provided onboard the RS232 to TTL converter in it.

Figure2.Gsm Module-800a

1.2 **Software Used**

a. Cloud Partner (ThingSpeak): Think Speak is a third party website for IoT. According to its developers, Thing Speak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network. Thing Speak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license, Thing Speak™ is an IoT analytics platform service that allows us to aggregate, visualize and analyze live data streams in the cloud.ThingSpeak provides instant visualizations of data posted by your devices to Thing Speak.

b. Arduino IDE- For the execution of all these above components we are using the Arduino IDE. The connection of every pin can be handled by this Arduino IDE.

c. Eagle is also used for the design of the circuit and PCB.

## II. LITERATURE REVIEW

Developed a remote drip infusion monitoring system for use in hospitals. The system consists of several infusion monitoring devices and a central monitor. The infusion monitoring device employing a Bluetooth module can detect the drip infusion rate and an empty infusion solution bag, and then these data are sent to the central monitor placed at the nurses' station via Bluetooth. The central monitor receives the data from several infusion monitoring devices and then displays graphically them. Therefore, the developed system can monitor intensively the drip infusion situation of several patients at the nurses' station. [1].

A medical infusion monitor and protection system is designed based on technologies of the photoelectric monitor, modulation demodulation, single-chip microprocessor (SCM), and wireless communication, etc. The infusion signal is collected by infrared photoelectric conversion characteristic. SCM AT89C51 processes to monitor data and control area infusion speed and controls wireless transceiver nRF905 to constitute a wireless communication system to transmit data. Through the serial interface MAX487 connected the main controller with each control node, upper PC can monitor and control each node in real-time and renew control-schemes. Experiments showed that the rate of infusion speed monitor error is less than 2 drops every minute, and stability time is faster, which effectively completes the intelligent infusion system monitor and alarm. [5].

During recent years due to technological advancements, many sophisticated techniques have been evolved for assuring fast recovery of the patients in hospitals. For good patient care in hospitals, assessment, and management of patient's fluid and electrolyte need is the most fundamental thing required. Most in all hospitals and assist/nurse is responsible for monitoring the IV fluid level continuously. But unfortunately, most of the time, the observer may forget to change the saline bottle at the correct time due to their busy schedule. This may lead to several problems for the patients such as backflow of blood, blood loss, etc. To overcome this critical situation, a low-cost RF-based automatic alerting and indicating the device is proposed where an IR sensor is used as a level sensor. It is based on the principle that the IR sensor output voltage level changes when the intravenous fluid level is below a certain limit. A comparator is used to continuously compare the IR output with a predefined threshold. When the transceiver output is negative then the Arduino controller identifies the fluid level is too low and it alerts the observer by buzzer and LCD at the control room indicates the room number of the patient for quick recovery [8].

Here the system contains the TDR method to be monitored and is stimulated through an appropriate electromagnetic signal, typically a step-like voltage pulse, which is propagated through a probe, any impedance variation will cause the partial reflection of the propagating signal through a probe. Any impedance variation will cause a partial reflection of the propagating signal. The analysis of the reflection coefficient in the time domain, ρ, allows the retrieval of the dielectric characteristics of the material under test, as well as of its quantitative parameters, such as in the case of the level of liquid materials [13].

## III. COMPONENTS USED IN OUR MODEL

Here in our proposed model DEVELOPMENT OF REAL-TIME MONITORING & CONTROLLING OF INTRAVENOUS DRIP INFUSIONS USING INTERNET OF THINGS (IoT)

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 |

In our proposed model we have used ESP 32 the ESP32 module is slightly bigger than the ESP8266-01 module and is breadboard friendly since most of the pin headers are broken out as I/O pins facing each other which is a great thing. They are managing overall components that are fixed in our model. This microcontroller is able enough to handle digital and analog sensors. It can also able to sending and receiving internet data. Then we come up with the sensors used in our model that is a Non-contact Liquid Level Sensor. All these sensors work for detecting the level of an IV Drip bottle. If the IV Drip bottle empty then this sensor sends a signal to MCU.

The Gsm system is used here for sending message alerts to patient relatives and doctors. The cloud system here used is the Thing Speak for the access of the Sensor data and the IoT devices. An LCD unit is also fixed here for the display of liquid level and other sensing elements. The LCD used here is having 16x2 (columns * rows). The contrast of this screen is maintained by using the potentiometer of 10k ohm.


Figure 3. Real-time monitoring & controlling of intravenous drip infusions using the internet of things

## IV. MODEL WORKING

This presented model 'DEVELOPMENT OF REAL-TIME MONITORING & CONTROLLING OF INTRAVENOUS DRIP INFUSIONS USING INTERNET OF THINGS (IoT)' consists of both software and hardware peripheries as per requirement.

- The microcontroller of the Arduino family ESP-32 has been used to control and manage the system, the power supply of the whole model is DC.
- Once the power is 'ON', a welcome message is displayed on LCD, then the Arduino Board ESP-32 searches for the programmed SSID.
- After that, it connects with the Wi-Fi module embedded in the board with asking for password and trying to connect with Wi-Fi router.
- Once Wi-Fi is successfully connected, microcontroller starts capturing the liquid level of IV INFUSIONS with the help of contactless sensors at three levels (Top, Middle, Bottom) of the IV drip and send it to cloud data collector 'Thing Speak'.
- According to the conditions read by the sensors' condition, 'Thing Speak' graph will vary with changing conditions of the liquid level in the drip.
- When the drip is full, all the three sensors detect liquid in the drip and thus sends signal to the 'Things Speak' which enables the user to track the condition through well described graphs.
- When the liquid level drops at the middle, one of the three sensors changes its polarity which gets presented on 'Things Speak' via 'ON/OFF Button' module and also the graphs now plotted changes their course.
- When the liquid level totally drops in the drip, all the three sensors shows 'Low' signal and the same information is being presented at the 'Things Speak' through graphs and buttons. Also, a text message is sent to the registered user that the 'IV is Empty' which makes the person approach the IV and change the syringe.

- While the bottom sensor also shows a negative value on presence of liquid in the drip, a solenoid valve will automatically close the loop of the flow thereby triggering the process of vacuum creation which could initiate back blood flow conditions in the patient and the syringe attached to the subject.
- This complete process is done in few seconds; every 15 seconds ESP-32 continues to send the overall status to 'Thing Speak' cloud where all data gets uploaded automatically in the respective graph.
- This entire system conversely need an active Wi-Fi connection and power supply to monitor and control the model.

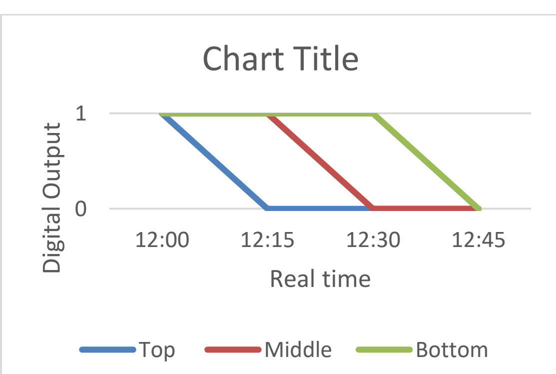

Figure 4. . Real-time monitoring & controlling of intravenous drip infusions using the internet of things Block Diagram & Process

## V. RESULTS AND DISCUSSION

The results were generated taking all the necessary conditions intact and they were as follows:

### 5.1 When IV is full

When the drip is full, all the sensors showed the presence of fluid in the drip, and thus the LCD screen in the Arduino board printed "IV is Full", and the 'ThingSpeak' platform drew the graphs showing fluid at all levels of the IV as shown in fig 5.2. An integrated graph showing how the sensors change their signal is shown in fig 5.1.




Graph 1 Integrated positions of fluid.


Graph 3 Sensor plot of full IV.

### 5.2 When IV level drops

When the fluid in the drip starts to fall and when it nearly reaches the middle level, one of the three sensors shows the absence of fluid in the drip, and the other two sensors planted at the middle and bottom level showed the presence of fluid and thus 'ThingSpeak' platform draws graphs showing IV filled to the middle as shown in fig 5.3.


Graph 2 ThingSpeak plot of middle-level IV.

### 5.3 When IV is emptied

- When the fluid level drops to the end, the LCD screen shows the message, "IV is Empty", "Please change IV". Also, the 'ThingSpeak' draws graphs that show no presence of fluid in the drip as shown in fig 5.4.


Graph 4 Real-time data Signal Indication of empty IV.

- At this time, when the IV is empty, the solenoid valve gets active and it stops the flow through the syringe thus avoiding a vacuum to be created in the syringe.
- When the IV has dropped to its minimum value and the data is sent over various platforms, the solenoid valve as shown in fig 5.5, which is attached in between the syringe is activated it stops the flow and avoid vacuum to be created.

Fig 5 LCD screen indication III.

- Any fluctuations in the signals which are being received from the drip are automatically uploaded on the 'ThingSpeak' cloud platform as shown in fig 5.7.

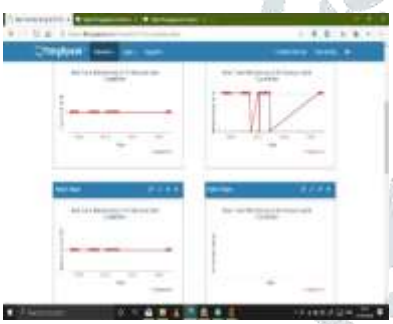


Fig 6 ThingSpeak Real-time data plotting.

### 5.4 Discussion

The results I have generated in the experimental analysis of the system satisfactorily attain the objectives of this project which were:

1. Monitoring of the IV infusion.
2. Signal processing and data retrieval of the monitored system and
3. Controlling of the fluid flow when the IV gets emptied.

Thus, the proposed prototype could be used for real-time monitoring of IV infusions with a precise approach.

## VI. CONCLUSION

An Internet of things (IoT) model including non-contact type fluid sensing sensors with other electronic functions to monitor and examine the real-time monitoring of the Intravenous drip infusion system with its controller is investigated. The use of a cloud storage facility connected with the GSM service and the sensing element powerfully establishes a robust, low cost and reliable system to monitor drip infusions in any conditions. The system is embedded with a controller device to object the backflow of blood in the patient's veins due to the building of the vacuum in the nozzle connected with the drip system and the patient.

The extra advantage of the system is that there have been provided two channels to monitor the data coming from sensing elements. One is the cloud storage facility where the top middle and bottom level of drip could be monitored and another is the GSM which would help to get notifications regarding the fluid levels in the drip.

The system works efficiently with accurate sensing elements and good connectivity between the Internet Of Things (IoT) used in the system.

the model can be implemented in the future.

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