Review on IoT-Driven Infusion Monitoring & Management System

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Abstract:
Effective intravenous (IV) infusion management and monitoring are essential in today's healthcare environment to guarantee patient safety and improve the standard of care. In order to overcome the drawbacks of conventional IV drip monitoring techniques, this study describes the creation of a contactless, Internet of Things-driven infusion monitoring and management system. With the use of cutting-edge sensor technology and Internet of Things connection, the suggested system combines real-time IV drip liquid level monitoring and control, delivering precise and ongoing updates. Healthcare practitioners may now monitor and analyse patient data remotely thanks to the gathered data's constant updating and transmission to the Think Speak cloud platform. With its combination of real-time data collecting, cloud-based analytics, and emergency alert features, the proposed contactless IoT-driven infusion monitoring and management system represents a substantial improvement in healthcare technology. Using the power of IoT and cloud computing, this invention seeks to enhance overall patient outcomes, optimize IV treatment administration, and decrease human monitoring efforts. To increase patient safety, the system has an emergency alarm mechanism based on GSM modules. This feature ensures that caregivers are notified promptly of any irregularities or critical IV drip levels, allowing for prompt treatment. By providing real-time signals, the device lessens the risks related to delayed reactions to IV fluid failure or depletion. Formulating a real-time model for IV drip liquid level monitoring is the main goal of the system. By employing non-invasive sensors to identify and record the drip rate and fluid levels, this gadget assures precise tracking without having physical contact with the IV apparatus.

Keywords: **Internet of Things, ESP32 microcontroller, Biomedical, GSM, Relay, LCD Display.**

1. Introduction

A vital component of contemporary medical care is intravenous (IV) therapy, which is widely utilized to provide patients fluids, drugs, and nutrients straight into their circulation. Traditional IV drip monitoring devices, while crucial, are frequently labor-intensive and manual, which increases the risk of human error, postpones treatments, and compromises patient safety. To improve IV therapy's effectiveness and dependability in the face of these obstacles, a novel, contactless IoT-driven infusion monitoring and management system is required. The aim of this study is to develop and deploy an all-encompassing system that utilizes the Internet of Things (IoT) to offer real-time IV drip liquid level monitoring and control. By utilizing cutting-edge sensor technology and Internet of Things connection, this system seeks to overcome the drawbacks of traditional techniques and provide accurate, ongoing, and contactless monitoring. Through the development of a real-time IV drip liquid level monitoring and regulating model, the system automatically updates the status on the Think Speak cloud platform, enabling healthcare personnel to supervise patients remotely. The suggested system's capacity to deliver emergency notifications via a GSM module upon detection of critical IV drip levels is a key component. This feature makes sure that caregivers get alerts in a timely manner, so they can react quickly to any problems like low fluid levels or irregular flow rates. In addition to improving patient safety, the integration of IoT with cloud computing and GSM technologies maximizes workflow efficiency in healthcare settings. The suggested contactless Internet of Things-driven infusion monitoring and management solution fills a major void in the way medicine is currently practiced. To offer a strong IV treatment management solution, it integrates cloud-based analytics, emergency alarm systems, and real-time data collection. This system intends to enhance patient outcomes, lessen the workload for healthcare professionals, and establish a new benchmark for IV drip monitoring in clinical settings by eliminating manual intervention and utilizing the power of the Internet of Things. This paper outlines the design and implementation of the system, detailing the technological components, data flow architecture, and emergency response protocols. The introduction of this advanced monitoring solution has the potential to revolutionize IV therapy management, ensuring higher standards of care and safety for patients worldwide.

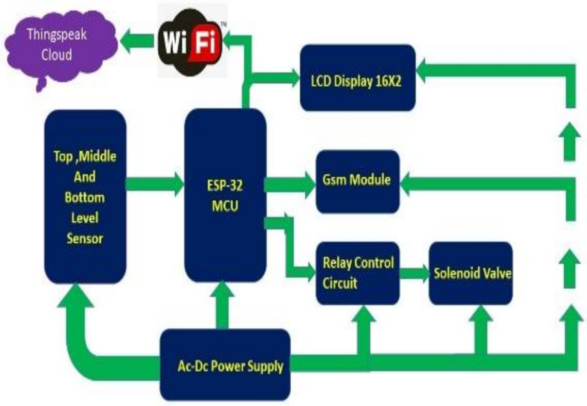

Fig.1: IoT-Driven Infusion Monitoring & Management System

2. Objectives of project

In this paper, we introduced the following three objective ideas related to IoT-Driven Infusion Monitoring System.

A. Design and Implement a Non-contact IoT-Powered Intravenous Supervision and Management System Create a system that uses non-invasive sensors to track the amounts of IV drip fluids, guaranteeing precise and ongoing data collecting without requiring physical contact. Incorporate IoT technology to facilitate connection and data transfer with ease.

B. Make an IV drip liquid level monitoring and controlling real-time model. To precisely measure IV drip rates and liquid levels, use real-time monitoring algorithms. Create control systems that use real-time data to automatically modify IV drip rates. Update and view the monitoring data continuously on the Think Speak cloud platform, enabling healthcare professionals to access and analyze it remotely.

C. Provide IV Drip Level Warning Alerts Using a GSM Module: Include a GSM module to enable alerts for emergencies in real time. Make sure the system can identify abnormalities or critical IV drip levels and notify caregivers in a timely manner so that they may take appropriate action.

3. Related Work

Amano et al. [1] 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.

Xining Wen [5] designed a medical infusion monitor and protection system 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].

Priyadarshini [8] developed a technique for good patient care in hospitals, assessment, and management of patient's fluid and electrolyte. 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].

Cataldo, G. Cannazza, and N. Giaquinto [13] developed a remote system for real-time control of intravenous drip infusions. 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]

Wei, Lee, J.H. Seung, and K.W. Kim [16] designed a wireless flexible capacitive sensor detection system to detect liquid levels in plastic bag intravenous drip sets. Here they used flexible capacitive sensors, which was over the bottle setup which is a low cost and simple structure & compact, but it provided binary value for the liquid level use of consumable, i.e., glue spray.

[1]. In hospitals, caretakers and nurses continuously monitor intravenous drips. Our system is designed to keep track of the IV fluid levels within the bag and generate an alert for medical staff. The fluid levels are displayed on a graphical chart that can be accessed by nurses at the nurse station via a webpage. Furthermore, utilizing the Thing Speak cloud, physicians have the option to transmit a patient's prescription to the nurse station via the webpage. To determine the initial capacity of the fluid in the IV drip, the system employs a Load Cell for measurement. The fluid level is then displayed on the nurse station's graphical chart. Once the fluid starts flowing, a Load Cell connected to an HX711 measures the data, which is then sent to the microcontroller. The HX711 converts the analog data to digital, which is displayed on an LCD. The level is continuously monitored on the web interface through ESP8266. If the value reaches 25%, the buzzer generates a sound until the nurse changes the fluid. The relay module will assist in stopping the fluid flow through the use of a solenoid valve. To achieve E-prescription functionality, we use the Thing Speak cloud. After creating a Thing Speak channel, the data can be written, analyzed, and visualized in the channel. Then the data can be accessed through the webpage.[1]

4. Major challenges of Internet of Things

There are three major challenges to designing an IoT ecosystem that's capable of supporting these services:

- High reliability
- High scalability
- Desirable trade-off between accuracy and real-time processing

Once the IoT service is up and running, it needs to run continuously – unexpected crashes or downtime may have critical consequences.

5. Problem Statement

The Development of IoT-Driven Infusion Monitoring & Management System Using the Internet of Things (IoT) System is based on internet connectivity better internet connectivity providing fast data sharing over the cloud. The problem statement is without any internet connectivity this system cannot able to share the live status of Intravenous Drip Infusions .other hand we are using the GSM modem for massage alert which is based on network communication and in Embedded system most GSM modem works on 2G Network [6-10]. The network status of 2G in India works fine but in the embedded application prototype we have to use a readymade design modem. This project having two different software stages first one programming and the second one is hardware design software.

6. Proposed Approach

Our proposed approach is to design IoT-Driven Infusion Monitoring & Management System Using IoT with the help of Eagle Software, Software IDE. The proposed model connected and test with the different communication technology think speak or Wi-Fi Technology [10-13], Embedded System, Embedded Communication, Cloud and Wireless Communication.

7. Used components

The hardware components used in the " IoT-Driven Infusion Monitoring & Management System " project are listed below [19-21]:

A. **ESP Module 32 now wireless communication module:** The ESP32 is a powerful microcontroller module that includes built-in WiFi and Bluetooth capabilities. It serves as the central processing unit and communication interface for the electric vehicle system.
B. **LCD 16×2:** The 16x2 LCD display is used to provide visual feedback and display relevant information to the user, such as vehicle status, sensor readings, and system messages.
C. **Relay 12V DC:** The 12V DC relay is an electromagnetic switch used to control high-power electrical devices or circuits. It enables the ESP32 to control various vehicle components such as lights, motors, or actuators.
D. **BC-547 NPN Transistor:** The BC-547 is a general-purpose NPN bipolar transistor used as a switching and amplifying device in electronic circuits.
E. **Power Supply (AC-DC & DC-AC):** The power supply converts the available electrical power into the required voltage and current levels for different components in the electric vehicle system.
F. **Capacitor 1000µF-25V:** The capacitor is used to store electrical energy and stabilize the voltage supply in the circuit, reducing voltage fluctuations and noise.
G. **IC-7805:** The IC-7805 is a voltage regulator that ensures a stable 5V supply to power low-power components in the system.
H. **LEDs (5mm, Red, Green, Blue):** LEDs are used as indicators to show the status of various functions, such as power on, system status, and sensor readings.
I. **Resistors (1K, 2.2K & 10K):** Resistors are used to limit current flow, set voltage levels, and provide necessary resistance in different parts of the circuit.
J. **Buzzer:** The buzzer is an audio output device used to generate audible alerts or warnings for the driver or users.
K. **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.
L. **Lights**: The lights in the electric vehicle system may include headlights, taillights, indicators, and interior lights.

a. **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.

M. Switches: Switches are used to control various functions of the electric vehicle, such as turning on or off specific systems or components.

The combination of these components forms an IoT-Driven Infusion Monitoring & Management System that utilizes the Internet of Things (IoT) concept to monitoring, enhance control and communication capabilities, and improve the overall efficiency and performance of the medical field.

8. Software/Tool Explanation

A. Arduino for coding: Arduino is an open-source software and hardware platform widely used for programming and prototyping electronic projects as shown in figure 6. It provides a simple and user-friendly Integrated Development Environment (IDE) that allows developers to write, compile, and upload code to Arduino microcontrollers. The Arduino IDE uses a C/C++ based language to create sketches (programs) that control various electronic components and sensors connected to the Arduino board.

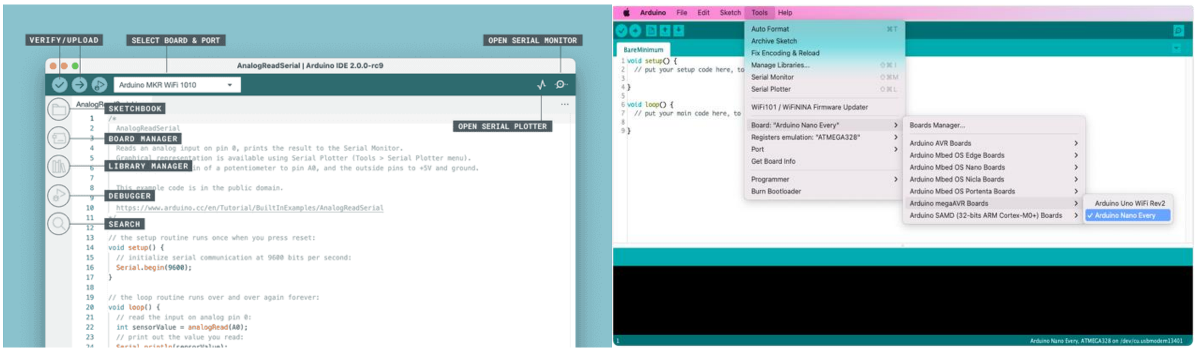

Fig.2: Arduino IDE

B. Eagle-Circuit design: Eagle (short for EAGLE - Easily Applicable Graphical Layout Editor) is popular Electronic Design Automation (EDA) software developed by Autodesk. It is used for designing electronic circuits, printed circuit boards (PCBs), and schematics. With Eagle, users can create and layout complex circuit schematics, design custom PCBs, and generate manufacturing files for PCB fabrication.

C. Tinkercad- Simulation: Tinkercad is a web-based 3D design and simulation tool developed by Autodesk. While it is primarily known for 3D modeling, it also offers basic circuit simulation capabilities. Users can create virtual electronic circuits by connecting components and simulate their behaviours. Tinker cad's intuitive interface makes it suitable for beginners to learn and experiment with electronic circuits without needing physical components.

D. Thing Speak: Data streams in the cloud: ThingSpeak is an Internet of Things (IoT) platform developed by MathWorks as shown in figure 7. It provides cloud-based storage and analysis of sensor data from IoT devices. With ThingSpeak, users can create channels to store and visualize data sent from various IoT sensors. It offers APIs and integration options to connect IoT devices and applications to the cloud for data monitoring and analysis.

Fig. 3: Thing Speak Website view For IoT Platform

Each of these software/tools plays a crucial role in different stages of the electronic project development process:

- Arduino is used for coding and programming the microcontroller, allowing the project to control and interact with various electronic components.
- Eagle is employed for designing the circuit schematic and PCB layout, enabling the physical realization of the project as shown in figure 8.
- Tinker cad offers a platform for virtual circuit simulation, allowing developers to test and validate the electronic circuit before physical implementation.
- Thing Speak provides a cloud-based solution for storing and analysing sensor data, enabling the project to interact with the cloud and implement IoT functionalities.

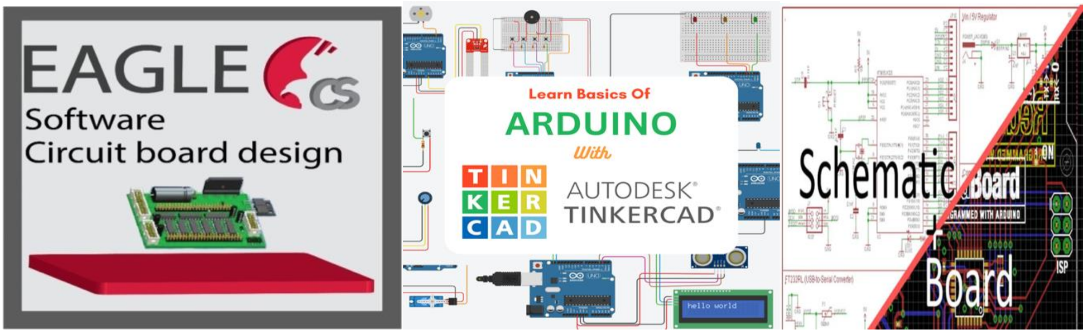

Fig. 4: Eagle Software for PCB Design

9. Proposed study on PCB layouts

The printed circuit board is the main process for electronic hardware implementation the consists of designing and developing both methods first we need to design the circuit diagram with help of software.

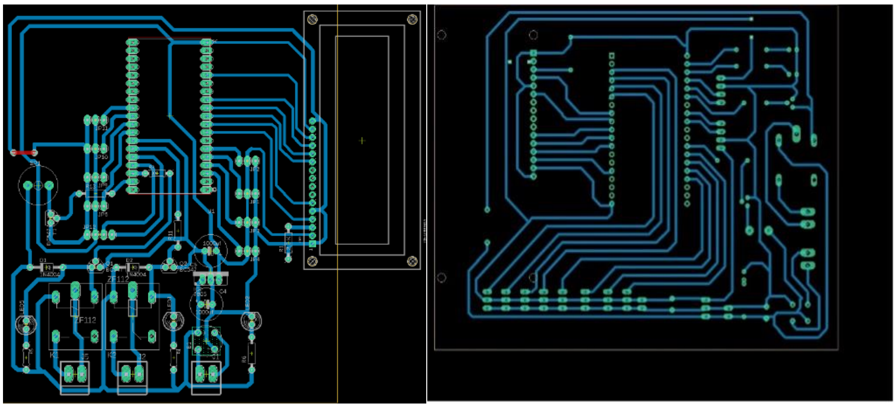

Fig. 5: Board layout of Proposed Model

For designing of the circuit, there are lots of software are available we use anyone. To developing of this system we have used eagle software. We have proposed Vehicle zone Board layout as shown in figure 2.

10. Conclusion

Investigated is an Internet of Things (IoT) model that combines non-contact fluid sensing sensors with other electronic features to track and analysed the intravenous drip infusion system's real-time monitoring in conjunction with its controller. A strong, affordable, and dependable system for monitoring drip infusions under all circumstances is established by the utilization of a cloud storage facility linked to the GSM service and the sensing element. In order to prevent blood from flowing backward into the patient's veins as a result of the vacuum created in the nozzle connecting the drip system and the patient, the system is equipped with a controlling device.

One additional benefit of the system is that two channels are available for monitoring the data obtained from the 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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