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IoT-Based IV Infusion Control System

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Abstract*: In current medical care system, monitoring patients in a hospital throughout the day is tiresome. Doctors and Nurses are loaded in monitoring multiple patients. This causes many problems. The health-related work should be properly done and that too in an accurate manner. An example of such type of work in the hospital is injecting saline or Intravenous (IV) fluids into the vein of the patient. If the drip system is not monitored on time, it will cause problems like backflow of fluid, blood loss, etc. In order to reduce the workload and overcome such a critical situation in the area of an intravenous drip monitoring system, we proposed a system called IoT Based IV Infusion System. This Project emphasizes monitoring Intravenous fluid (IV) using a load cell and solenoid valves. Intravenous therapy is a typical method of treatment that may be used for better modification of electrolyte imbalances in the body, to deliver medications, for transfusion of blood, or for fluid injection. The proposed method reduces the difficulties involved in IV therapy and monitoring patient parameters remotely on a webpage.*

Keywords: Intravenous, flow control, IV drip monitoring, IV fluid, IoT, IV Therapy

I. INTRODUCTION

In the current world, population density is increasing. Because of that, in the medical care system, monitoring each patient throughout the day is not possible for doctors and nurses. In such situations, automation comes handy.

This system focuses on the flow control of IV fluid. It is necessary to monitor the flow and level of IV bag fluid regularly, otherwise, it causes problems like reverse blood flow and blood loss. Also, if there is a fluctuation in the body temperature or heart rate of the patient, the flow of IV fluid must be slowed down, so it shows the temperature and heart rate of the patient on the system's screen. As regular monitoring of patients is not possible, this system automated the IV infusion control.

IoT-Based IV Infusion control system continuously monitors the level of fluid. It not only monitors the level but also keeps track of the flow of fluid and controls its flow whenever necessary. Also, this system provides a user interface to show a patient's body temperature and heart rate.

II. LITERATURE SURVEY

In [1] we implemented the idea of Technologies like Wireless Sensor Networks (WSN) are used to monitor the vital signs of patients reported to doctors in hospitals. The system is built around the LM35 temperature sensor, IV fluid level sensor (moisture sensor), Arduino Uno, and Hc05 Bluetooth module. This system collects vital patient data and notifies the respective medial authority via mobile application installed in a cell phone , but the IV bag flow has to be controlled manually by some medical personal. Basically, this system does not automatically control the flow of the IV bag which is an important drawback of this system, and on the other hand, this system is beneficial as it optimizes power and energy consumption. As of now any system with a centralized data representation ability is not developed, which inspired us to develop a system with a centralized monitor to show various health-related parameters of the patients to notify doctors and respected medical practitioners. Web Technologies and the Internet of Things (IoT) are used to establish a modification in this current system along with some added hardware component to regulate or terminate the flow of the liquid.

The system proposed in [2] have a similar workflow of an infusion control mechanism as ours. This system is implemented using Raspberry Pi, Arduino Uno, servomotor, and optical sensors. It focuses on the development of a database and program for the microcomputer; the establishment of a wireless connection between the server and the microcomputer, the statistical evaluation of the performance of the prototype versus the conventional method. The

Raspberry Pi can establish a wireless connection with the server and securelyaccess the database through a Secure Shell (SSH) connection. It carries out the essential calculations required to determine the drop rate for a particular prescription. Additionally, the minicomputer supervises the microcontroller, which decides whether the servomotor should adjust to tighten or loosen the IV tube. This decision is based on the data obtained from the opticalsensors. The system monitors the interval time between a drop andthe next drop. This would determine if the drop rate is going fast or slow then computes the remaining fluid volume and send it back to the processor. However, it is observed that a need of precise fluid control mechanism and a simplified control unit is required, in order to deal with this issue, some modifications are made such as using a solenoid valve to control the flow of the fluid and a node MCU module in order to receive and send data through local area network (LAN). Also, a history of the patient's health is also maintained in a database for subsequent evaluation by medical authorities.

This reference paper [3] has a similar objective of having to monitor the quantity of the fluid byobserving the level of the fluid in an IV bag and checking if the level drops beyond the particular level and sensing air bubbles orembolisms appearing in the tube before it enters into the vein of the patient. Also, to alert the nurse station with the help of an alarm system so that suitable action can be taken and ensure that the patient under treatment is not subject to unwanted difficultieslike swelling, etc. Finally, to extend IV fluid monitoring systemsto entire wards for better monitoring so that it benefits more patients. This system comprises the load cell, heartbeat sensor, Arduino Uno, and Zigbee module. Such a system is beneficial to patients undergoing an operation, Patients under dehydrated, Patients undergoing blood transfusions, Pregnant Women, and Cancer patients (Chemotherapy). However, an important modification in this can be made to have a precise method to control the liquid flow. In order to implement these features, a micro solenoid valve, heartbeat sensor, temperature sensor, and load cell are included in the system to have more reliable and user-friendly support.

III. PROPOSED SYSTEM

Most of the incidents involving intravenous infusion are subjected to the complexity of the administration process and insufficient medical service provider-to-patient ratio. The growing number of incidents like these calls for the development of an automated intravenous administration process. If the drip system is not monitored regularly, it will cause problems like backflow of fluid, blood loss, etc. In order to reduce the workload and overcome such a critical situation in the area of an intravenous drip monitoring system, we proposed a system called IoT Based IV Infusion System.

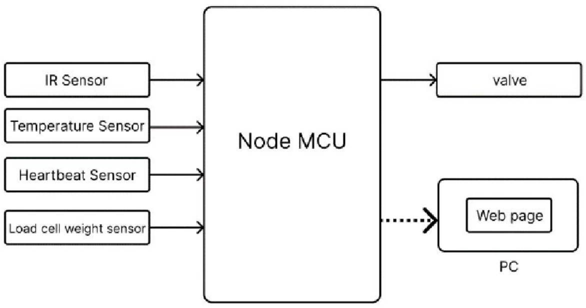

Fig. 1. Proposed System

The diagram shows how all the sensors are going to work together to control the IV Infusion. It shows how the flow of data should be throughout the process. Basically, all the sensors on the right-hand side are taking data from the external environment and giving that data to node MCU. Then node MCU processes this data and passes it to the solenoid valve for proper control of the fluid. Also, all the data like IV bag fluid level, weight, patient's temperature, and pulse rate are being read by the sensors and are shown on the web page by fetching it from the IP address given by node MCU. Whenever the fluid level goes beyond a certain limit the nurse then gets a push-up notification for concern. Here the load sensor comes into action it senses that the fluid is beyond the specified amount and the IR sensor detects its level of it. Our system also monitors the heartbeats of patients to control the flow of the fluid to be passed by the solenoid valves.

Different sensors are used to monitor the flow of the IV bag and monitor patients' conditions. The following are the sensors are used to measure different parameters:

3.1 Temperature Sensor

DS18B20 is a One-Wire digital temperature sensor from Maxim IC. Reports degrees in Celsius with 9 to 12-bit precision, from -55 to 125 (+/-0.5). These temperature sensors are devices that can measure temperature with less amount of hardware and wiring.

Fig. 2. Temperature Sensor

These sensors use a digital protocol to send precise temperature readings directly to your development board. It does not require an analog-to-digital converter or other extra hardware. The conversion is done internally by sensor itself.

3.2 Heartbeat Sensor

The heartbeat sensor{sen-11574) is based on the principle of photoplethysmography. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ

Figure. 3. Heartbeat Sensor

When the heartbeat detector starts working, the light emitting detector (LED) blinks simultaneously for every beat. The output of this LED flash is in digital form, which can be processed to measure the beats per minute (BPM) rate

3.3 IR Sensor

An infrared sensor (IR sensor) is an optoelectronic radiation-sensitive component with spectral sensitivity in the infrared wavelength range of 780 nm-50 µm. It's model no is LM393

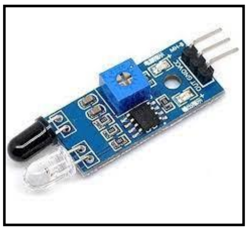

Figure. 4. IR Sensor

This sensor is used for detection between 100cm-500cm (1-5 meters / 3-15 feet). The long-range makes them a good replacement for sonar sensors. It is used to detect the critical level in this system.

3.4 Load cell Weight Sensor

Load cells(sen0160) create a special section of our weighing sensor portfolio. They are used in weighing systems, like scales or other devices for weighing goods.

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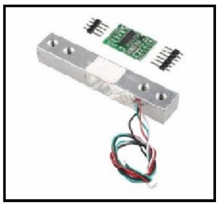

Figure. 5. Load cell Weight Sensor

The measurements of this sensor is given in grams, kilograms, or tons. Typical load cells depend on bending or shear beams. It is used to detect whether critical weight is reach or not it the system.

All the data coming from the sensors is fetched and processed using Arduino IDE. Depending upon the conditions like whether the critical level of the IV bag is reached? Whether the heart rate or temperature of the patient is in the normal range or not? signals are sent to the valve to stop the flow or not. Also, the data like body temperature, heart rate, and flow rate are shown on the central system, which is a simple web page developed using HTML, CSS, and JavaScript. Doctors and nurses can also get information about the conditions of patients. It reduces their workload and provide single point access to monitor multiple patients.

Table.1. Pin Connections

Component	Pin Configuration	Pin of Node MCU
Heartbeat Sensor	VCC	3V3
	GND	GND
	OUT	A0
IR Sensor	VCC	3V3
	GND	GND
	OUT	D2
Temperature Sensor	VCC	3V3
	GND	GND
	DQ	D4
Load Cell	VCC	3V3
	DOUT	D6
	PD_SCK	D5
	GND	GND
Relay	VCC	3V3
	GND	GND
	INPUT	D1

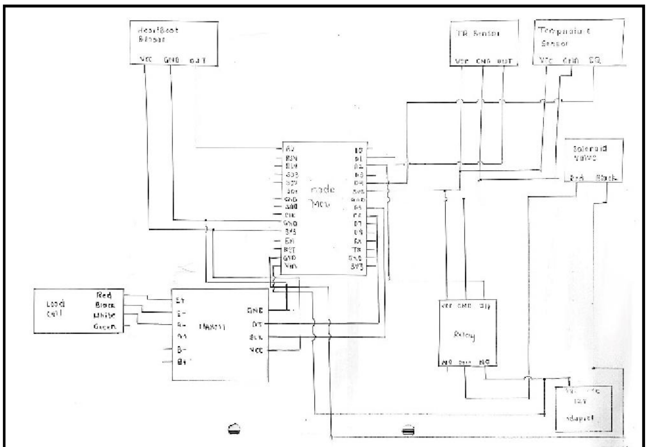

Figure. 6. Interfacing Diagram

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IV. RESULTS AND DISCUSSIONS

Real-time results refer to data or information generated and made available immediately or without significant delay. In the context of the system mentioned, real-time results would refer to the immediate data and information gathered and displayed by the system during its operation. These real-time results could include various parameters such as fluid level, heart rate, and body temperature, which can be monitored and analyzed in real-time using the web application. By presenting these real-time results, users of the system can make informed decisions and take appropriate actions to ensure the safe and effective administration of medication to patients.

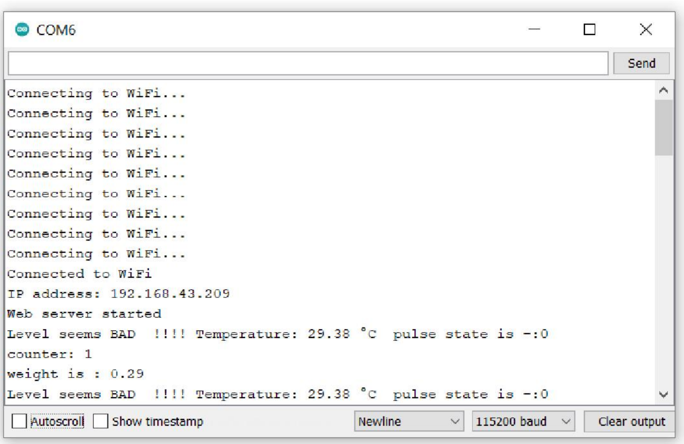

Figure. 7. Nodemcu connecting with Wi-Fi

First NodeMCU connects with the Wi-Fi and provides us with its IP address which is assigned to the NodeMCU. This IP address is used to communicate with the NodeMCU from other devices on the same network. As shown in fig.7, the IP address given by NodeMCU is visible. When we server starts it starts taking data from sensors and shows this data to the serial monitor and also on a web page as shown below.

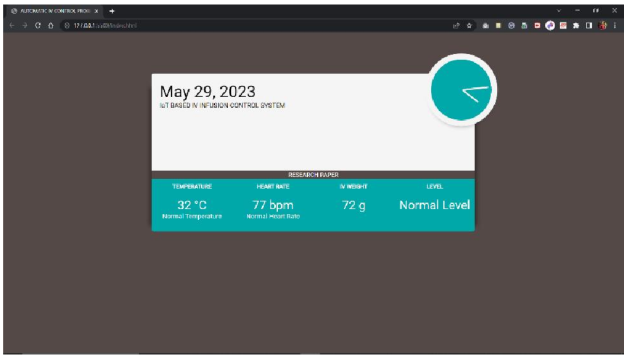

Figure. 8. Dashboard when patient's conditions are normal

This result presents several parameters, including a temperature of 33°C, a heart rate of 80 bpm, an IV bag weight of 650g, and a normal fluid level. The fact that all parameters are within normal ranges indicates that the system is functioning correctly and that the patient is stable. By monitoring these parameters in real-time, healthcare professionals can ensure that patients receive the appropriate care and that any deviations from normal values are promptly detected and addressed. Overall, this result demonstrates the system's ability to monitor and analyze patient data in real time, providing valuable insights into the patient's condition and enabling effective medical decision-making.

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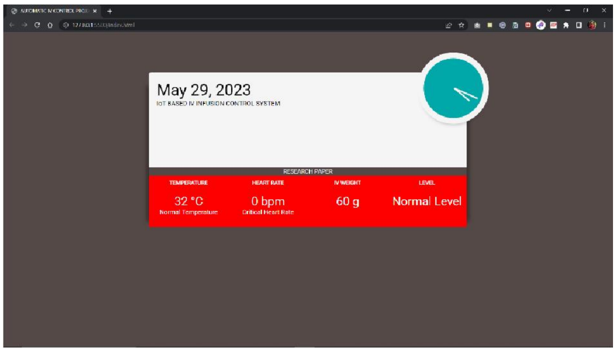

Figure. 9. Output when heart rate is not detected

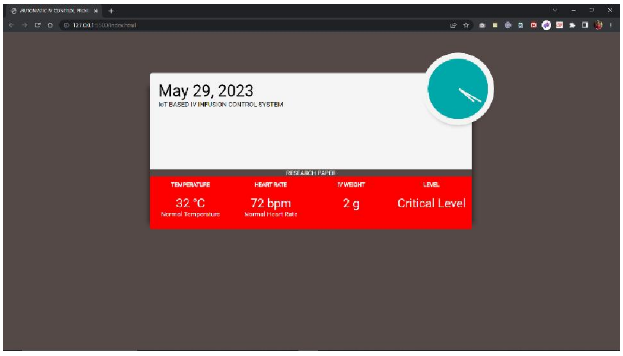

Figure. 10. Output IV level is crossed the critical level

The preceding results demonstrate the system's response to abnormal conditions, such as a zero heartbeat and a critical fluid level. When the fluid level exceeds the critical threshold, the system automatically stops the flow of the IV bag. These scenarios highlight the system's ability to detect and respond to critical situations in real-time, thereby ensuring the safe and effective administration of medication to patients.

The real circuitry of a system refers to the physical components and wiring that make up the system. In the context of the system mentioned, the real circuitry would refer to the actual hardware components and wiring used to create the IoT device and its associated sensors, microcontrollers, servomotors, and other components.

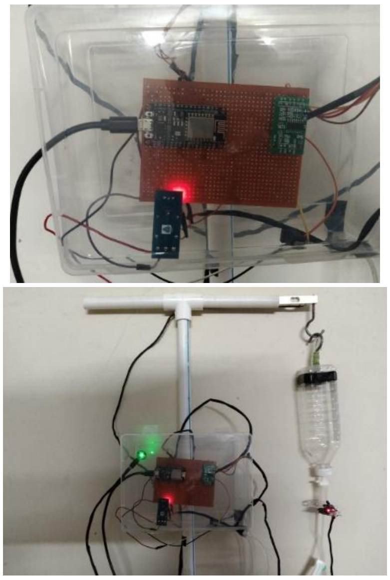

Figure. 11. Circuitry on PCB

This overall circuitry illustrates the actual physical layout and wiring of the system's components, including the IoT device, node MCU, and solenoid valve. They would provide a detailed visual representation of how the components are connected and how they function together to perform the system's intended task.

Figure. 12. Overall Circuitry

The application of this system is Real-time healthcare monitoring and Reverse blood flow avoidance system.

V. CONCLUSION

The IoT-based IV infusion control system is low-cost, safe, and automated. It is capable of avoiding reverse blood flow and blood loss. This system regularly monitors the patient and provides information about the patient's health condition and IV bag level using a centralized display system integrated with the respective medical infrastructure to ease medical authorities' work. A wi-fi-enabled system will be obtained to carry out healthcare measures.

The future scopes for the IoT-based IV infusion control system project include integrating with other healthcare technologies, developing a mobile application, implementing a wider range of healthcare settings, incorporating machine learning algorithms, and enhancing security measures. These potential areas of development could improve patient care and reduce healthcare professional workload while also enhancing the system's capabilities and impact on healthcare.

APPENDIX

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We are feeling very humble in expressing our gratitude. It will be unfair to bind the precious help and support which we got from many people in a few words. But words are the only media for expressing one's feelings and my feeling of gratitude is absolutely beyond these words. It would be our pride to take this opportunity to say thanks.

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