Design and Fabrication of Flow Meter for Intravenous Infusion Tube

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Abstract: In hospital setup intravenous flow rate is monitored manually. In order to avoid human error, automatic intravenous fluid flow meter can be used to regulate flow rate. The aim is to develop an automatic flow meter for intravenous tube and fluid level detector for saline bag**. T**his project uses Arduino Uno R3 which is a micro-controller board with input voltage of 7-12V and an operating voltage of 5V to control the system. The other components used in the study are Stepper motor to control the flow, DC supply, IR sensor to measure level of saline in bottle, LCD screen to display the flow rate and a buzzer in order to signal the flow level of saline bag. The system helped the healthcare worker to regulate the flow rate effectively and minimize the human errors. It also helped to know and display the flow rate of intravenous fluid. The buzzer worked efficiently to indicate the saline level. The automatic intravenous fluid system is advanced way of monitoring the intravenous fluid flow rate. It is helpful in minimizing the human errors as the adjustment of the flow rate can be done by the use of automatic flow system and a buzzer to signal the saline level.

Index Terms **– Automatic IV fluid regulator, IR sensor, LCD screen.**

I. Introduction

In this modern era as the technology evolves the concern on human safety also comes into consideration. In the field of medicine, technology is also improving which lead to development of new ideas and ensures patients safety. In the previous time the health care professionals used to face difficulty in providing patient care. But as technology improves the ease of working also improves. In the past few years there was great difficulty in administering intravenous fluids. It showed errors in administration and also it was time consuming. But the new advancement in intravenous fluid infusion such as use of flow meters has really helped the health care personnel to work efficiently. The Automatic fluid feed system is a system that allows controlled flow of the intravenous fluid which is simple and inexpensive and easy to handle. Intravenous Drip/Blood Meter is extensively used in clinical and home care settings to treat conditions such as severe fluid loss, pneumonia, dehydration, electrolyte imbalance, anaemia, high fever, etc. Numerous complications like Biochemical disturbance, Hemodilution, Renal impairment, Hypersensitivity, etc. can occur as a result of fluid therapy. Hence monitoring and controlling the drip rate of intravenous fluid becomes very crucial because any slightest change in the drip rate of intravenous fluid might cause severe side effects. Munem Farhan, et.al.[1] proposed design and fabrication of automatic i-v fluid feed system. The system consists of a saline bag with a water flow valve attached with the Arduino connected to dc power supply along with Servo motors to push the injection syringe. A real-time clock was used with a Solenoid valve which opens in pre-set time and allows IV fluid flow thereby controlling the rate of flow through that IV tubing to the patient by using a water flow valve. Tawade, et.al.[2] conducted a study on design and development of saline flow rate monitoring system using Flow Sensor, Microcontroller and RF ZigBee Module. The study uses A Hall Effect based flow sensor was attached at the neck of the saline bottle. The droplets pass through the sensor which is sensed by the pinwheel and the magnet inside the sensor. Omamageswari M, et.al.[3] proposed Patient IV and oxygen control system using IoT. This design employs a liquid flow sensor, pressure sensor, and pulse detector sensor the micro-controller (Node MCU) to assist the health care provider to control the saline circulation rate and oxygen level through a wristwatch using IoT (wi-fi module). Dinesh Kumar J.R, et.al.[4]Worked on "design on intravenous Infusion System monitoring for the betterment of health Monitoring System using ML-AI. Geun Joo Choi,et.al.[5] studied the Accuracy of Automatic Infusion Controller for Intravenous fluid administration". They used four devices to test the accuracy of flow rate. Terufusion TE-112, volumed VP7000, Auto Clamp & Infusion were the four devices used for testing. Gavimath, et.al.[6] Worked on "design and development of saline flow rate measuring system and GSM based remote monitoring". This paper describes the development of an automatic saline monitoring system using a low cost indigenously developed sensor and GSM modem. They have used 8051 microcontrollers for providing coordination action, IR sensor is used at the neck of the saline bottle to know the flow rate of the liquid. Pranshul Sardana, et.al.[7] worked on design, fabrication, and testing of an internet connected intravenous drip monitoring device. It describes a monitoring system retro-fittable for the existing intravenous infusion setup and describes an internet-connected monitoring platform for Intravenous drip chambers. Elizabeth, et.al.[8] worked on the novel intravenous fluid level indicator for smart iv systems. The main aim of that project was to relieve human effort by automatically controlling the dripping system of the patient in a hospital.

II. METHODOLOGY

This system consists of Arduino Uno R3 which is a micro-controller board with Input Voltage of 7-12V and an operating voltage of 5v to control the system, Stepper motor to control the flow, DC supply, IR sensor to measure level of saline in bottle, Led screen to display the flow rate and a buzzer in order to signal of flow level in saline bag. To regulate the intravenous fluid Arduino gives the input signal to the stepper motor which rotates the spindle. Due to this rotation, the flow of fluid is controlled. The drip chamber is attached to IR sensor which sense the flow rate and transmit signal to Arduino, DC Power supply is used in the system. To detect the level of fluid in saline bag IR sensor is fixed to bottom of saline bag so that it detect minimum level of fluid and transmits signal to Arduino as described in figure 1 and 2. When fluid reaches minimum level Arduino receive signal from IR sensor and therefore buzzer gets activated. This buzzer alarms the nurses to change the saline bottle.

2.1 Block Diagram

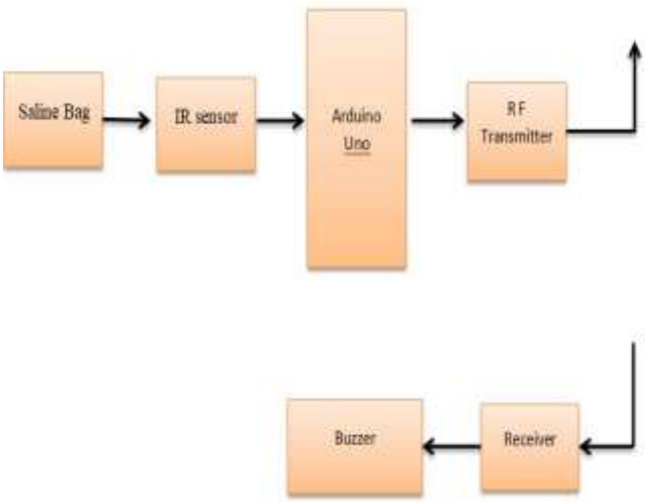

Fig. 1: Block Diagram for Level Indicator

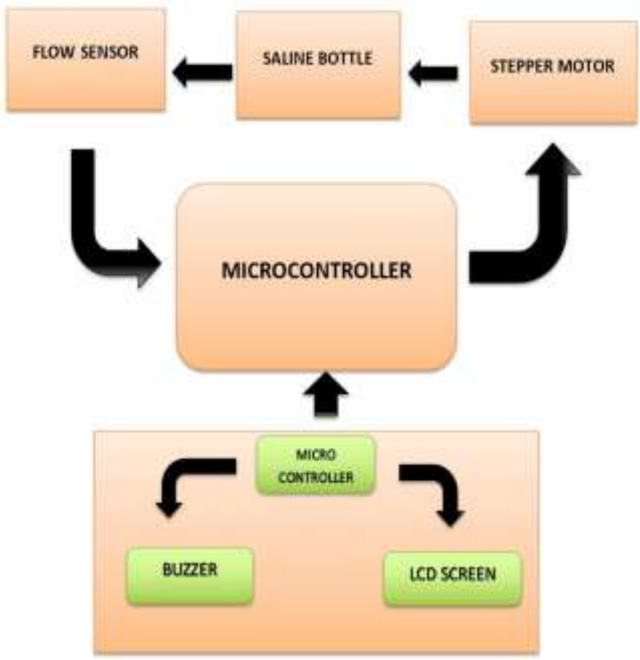

Fig. 2: Diagram for Flow Regulator

2.2 Hardware Descriptions

The current work uses the components such as Arduino, Saline Bag, Flow Regulator, IR Sensor, and Stepper Motor.

2.2.1 Arduino

Arduino is an electronic component that provides an open source platform to use hardware and software easily as shown in figure 3. It depends on Microchip ATmega328P microcontroller. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) by means of a sort USB link. Essentially associate it to a PC with a USB link or power it with an AC-to-DC connector or battery. The input source for the Arduino is light on a sensor, a finger on a button, twitter message etc. It converts into output-activating the motor, turning on an LED. Table 1 describes the specifications of Arduino.

Table: 1 Specifications of Arduino

Micro controller:	Atmega328
Operating Voltage	5V
Input Voltage	7-12 V
DC Current	40mA
DC current for 3.3 V pin	50mA
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
Flash Memory	32 KB (ATmega328) of which 0.5 KB
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz
PCB size	18 x 45 mm
Weight	27.95g

Fig 3: Arduino

2.2.2. Saline Bag

A saline bag is a bag that consists of solution (such as sodium chloride, ringer lactate etc) which is administered to patient's during intravenous infusion as shown in figure 4.

Fig. 4: Saline Bag

2.2.3 Flow Regulator

Flow regulator is a device which controls flow of fluid inside the intravenous tube. It consist of blade which has a roller connected to it. With the help of stepper motor the roller rotates and controls the flow of the fluid with different velocity.

Fig. 5: Flow Regulator

This system provides flexible values of flow. As stepper motor rotates the blade with rollers create pressure on the pipe. Due to pressure on pipe creates obstacle for intravenous fluid flow in pipe. At different angle the pressure on the pipe varies which results in the change in the flow rate of the fluid and the proper flow of fluid in is controlled. Finally can set flow rate for various values. The flow regulator was printed by 3-D printing technique as shown in figure 5. Table 2 describes the specifications of IR sensor.

Table: 2 Specifications of flow regulator

Length	8.5cm
Breadth	5cm
Thickness	2cm
Material used	Acrylonitrile Butadiene Styrene

2.2.4. IR Sensor

An IR sensor can quantify the warmth of an item just as recognizes the motion. These kinds of sensors estimates just infrared radiation, as opposed to transmitting it that is called as a detached IR sensor as shown in figure 5.

Fig. 5: IR sensor

Generally in the infrared range, every one of the items emanate some type of warm radiations. These sorts of radiations are imperceptible to our eyes that can be recognized by an infrared sensor. The producer is basically an IR LED and the identifier is just an IR photodiode which is touchy to IR light of a similar wavelength as that discharged by the IR LED as shown in figure 5. At the point when IR light falls on the photodiode, the protections and these yield voltages, change with respect to the size of the IR light. Table 3 describes the specifications of IR sensor.

Table: 3 Specifications of IR sensor

Operating Voltage	5VDC
I/O pins	5V and 3.3V compliant.
Range	Up to 20cm.
Sensing Range	Adjustable
Built-in	Ambient Light Sensor.
Supply Current	20mA
Size	50 x 20 x 10 mm

2.2.5. Stepper Motor

A stepper motor, also known as step motor or stepping motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. This helps to control the angular or linear position, velocity and acceleration. Stepper motor receives the signal from arduino which in turn helps the spindle to rotate. Due to the spindle rotation the fluid flows into the fluid line as shown in figure 6. Table 4 describes the specifications of IR sensor.

Fig. 6: Stepper motor

Table: 4 Specifications of Stepper Motor

Size	42.3 mm square × 48 mm
Weight	350 g (13 oz)
Shaft diameter	5 mm
Steps per revolution	200
Current rating	1.2 A per coil
Voltage rating	4 V
Holding torque	3.2 kg-cm (44 oz-in)
Inductance	2.8 mH per coil
Lead length	30 cm (12″)

2.2.6. LCD Screen

Liquid crystal display is a display that provides information on the flow rate of Intravenous fluid per unit time. It is connected to Aurdino as shown in figure 7.

Fig. 7: LCD screen

2.2.7. Buzzer

The buzzer is used to indicate a sound when the level of the Intravenous fluid in the bottle goes down. This alerts nurse about the change or the removal of the intravenous drips bottle that is to being administered to the patient. With the help of this, it prevents backflow and other side effects to the patient

III. RESULTS AND DISCUSSION

This model was designed as described in this paper and it may use in hospital. Macro-drip tubing was used for administration of 500ml of normal saline for 180 minutes. The flow rate was adjusted for 56 gtts/min and was observed for complete fluid administration. As soon as saline bottle got emptied the IR sensor transmitted signal to buzzer and buzzer got activated. Total time taken was 175 minutes which was almost near to prescribed time. The same was repeated for drop factor 15 and result obtained as 42 gtts/ min. The system regulated the flow rate conveniently and displayed the value of flow rate. The automatic intravenous fluid system worked efficiently as designed. The system helped the healthcare worker to regulate the flow rate effectively and minimize the human errors. IR sensor effectively sensed the minimum level of fluid in saline bag and transmitted this signal to Arduino. The nurse was alarmed by the buzzer when saline bottle was empty. Therefore, the automatic intravenous fluid regulator and saline bag level indicator worked as designed.

IV. CONCLUSIONS

The intravenous fluid administration in hospital is either done by manual method or an existing system where intravenous fluid was regulated using preset values. These preset values of existing system cannot be altered at desired values where as our model was flexible and can be used by nurse conveniently. It helps to regulate the flow rate and also detect the saline level. The nurse have to constantly look whether saline bottle is empty or not. To overcome situation the saline level indicator and buzzer helps the nurse work efficiently and effectively. Therefore, the developed model is helpful in minimizing the human errors as the adjustment of the flow rate can be done by the use of automatic flow system. This advancement can be used in further studies.

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