INDIAN INSTITUTE OF INFORMATION TECHNOLOGY ALLAHABAD

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SEMESTER PROJECT REPORT

for

Indian Institute of Information Technology Allahabad
(Information Technonolgy)

by

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IoT based
Intravenous Drip Monitoring System

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CERTIFICATE FROM SUPERVISOR

We hereby declare that the work presented in this end semester project report of B.Tech (Information Technology) 6th Semester entitled “IoT based intravenous drip monitoring system”, submitted by us at Indian Institute of Information Technology, Allahabad, is an authenticated record of our original work carried out from January 2020 to May 2020 under the guidance of Dr. Vijay Kumar Chaurasia.

Due acknowledgements have been made in the text to all other material used. The project was done in full compliance with the requirements and constraints of the prescribed curriculum.

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Abstract

In Medical field, many devices have introduced a drastic change for monitoring the body measures like blood pressure, heart beat rate, diagnosis of heart attack symptoms and much more automatically with interdisciplinary nature. Health care system is becoming more valuable these days. In this we propose an Intravenous fluid monitoring system that automatically sends a notification to the nurse through an Mobile Application and also a Web Interface. The project is aimed to continuously monitor the level of fluid in the IV bag and turn off the flow of the liquid from the IV bag by using a valve when the liquid level goes below a certain level. The valve can also be controlled manually through the app or web interface. This technology reduces the work of the nurse to keep a watch on the IV Fluid system, but more significantly reduces the chance of reverse flow of blood through the intravenous line. One of the greatest advantages of the project is the ease interface with users which functionally can be managed by means of mobile or web applications.

Due to the COVID-19 pandemic, we could not work upon the hardware aspect of the proposed project that involved the designing of the Drip Monitor using sensors and integrating it with Arduino to send the notifications to the user interface, that included the software aspect of the project. As for the hardware implementation, we have included the basic course of working of the modules in our report along with the detailed review of the Mobile Application and the Web Interface.

Content

1 Introduction:

Automation in healthcare is an emerging field unknown to us. In the current era, there is no time for youngsters to concentrate on healthcare as it requires more time and work. In terms of business, it has much profit. By introducing automation, time and stress can be reduced for a Nurse/Monitoring person. As we are moving to a future of healthcare, we have to save a person’s health.

According to a survey by India Brand Equity Foundation**[6]**, India is placed the 154th position in quality of healthcare services among the 195 developing countries in the world. According to the National Health Policy 2017 aimed to raise public healthcare expenditure to 2.5% of GDP from current 1.4% with more than two-thirds of those resources going towards premier healthcare**[7]**. Healthcare is highly central to India’s progress and shares a significant piece of the overall socio-economic development of India. The growth of health facilities has been imbalanced India.

There are many disadvantages in the healthcare system like infection control due to assessments of doctors, heart attack due to clot of Air embolism in backflow of blood in intravenous fluid, medication errors due to surgery and clinic respective. This project helps to rectify those problems and hopes youngsters to concentrate on healthcare as it is an emerging field which is required for the future.

Intravenous therapy is the infusion of fluid substances directly into a vein. Intravenous simply means “within vein”. IV system may be used to correct fluid imbalances, to deliver machines, for blood transfusion or as fluid replacement to correct. This way is the fastest way to deliver medicines or fluids. Therefore, it is necessary to monitor treatment through IV therapy.

Quite a number of automated Intravenous systems have been in use today but most of them are making the use of some form of Level Sensors to determine the level of fluid. The use of Level Sensors comes at the cost that there should be contact between the fluid and the sensors which may not be good for certain scenarios. We hence use IR sensors and Load sensors so that the same work can be done without making any direct contact with the fluid. The introduction of a Mobile Application and a Web based interface further adds mobility to the automation system.

2 Problem Statement:

Intravenous drip is the continuous, slow introduction of a fluid into a vein of the body. An intravenous drip monitoring system is an automated device that measures the level of IV fluid in the dispenser and takes a note of the rate of flow of the fluid. In most of the hospitals the supervision of the IV Fluid level and flow rate is monitored by the assistants and nurses, who are prone to make errors. If the level of the fluid in the IV dispenser drops below a certain level then it may result in reverse flow of blood from the patient’s body, and this has been evident in several fatalities over the medical history.

There have been several prototypes made recently but the majority of them were using Level measuring sensors, because of which the prototypes were not clinically appropriate to be deployed. The following proposal proposes an Automated drip monitoring system with the use of Load sensors and IR sensors, so as to ensure that we do not make any contact with the fluid. We intend to maintain a real-time data of the level and flow rate for each patient and broadcast the data over Mobile Application and Web interface.

The monitoring system will be designed in a manner that when for a patient, the level of fluid drops below a level, it sends an alert through the application or web interface to the concerned people, and also cuts the flow of fluid so that there is no chance of reverse flow of blood. The monitoring system is intended to be a low cost and safe healthcare assistance alternative that would not only increase the safety of patients but also aid in reducing the risks and work-load for the nurses.

3 Literature Review:

With the help of recent papers in the study of intravenous drip monitoring , we realised that the following results have already been worked over and proposed in previous papers.

Study by Mithuna and Kalpana(2015) **[1]** in their paper developed a low cost RF based automatic alerting and indicating device. It works on the principle that IR sensor output voltage level changes when intravenous fluid level is below a certain level. They implemented a comparator to continuously compare the IR output with the predefined threshold. If the output of the receiver becomes negative then the arduino identifies that the fluid level is too low and it alerts the observer by buzzer.

Our project is the extended version of the above proposed project with the additional mechanism of flow control using a hardware valve.

Study by Assogba and et al(2016) **[2]** in their paper proposed a hybrid architecture over a ubiquitous platform for a patient monitoring system for detection of risky situations and alert using collaborative sensor networks with the help of WiMax and RFID technology. This hybrid architecture of wireless technology has the advantage of uniting in a platform for converged data transmission services for the efficient transport of medical data.

Study by Bhavasaar and Praveena (2019) **[4]** in their paper developed a method that lowers the chances of heart attack due to air embolism and reduces difficulties involved in IV therapy using beam load cell and amplifier INA125P supported by arduino as software. They also proposed this tool for automatic heart beat sensoring.

Study by Rao and K. Evangili (2019) **[3]**, in their paper built a wireless sensor network based liquid level and drop count measuring system using ultrasonic sensor HC-SR04, LM35 temperature sensor, and GSM-SIM900A and Texas Instruments CC3200 based on Energia IDE and written in embedded C language.

Study by Zhang and et al(2018) **[5]**, in their paper built an infusion monitoring system that monitors the real-time drop rate and the volume of the remaining amount of drug during the intravenous infusion by proposing an architecture to connect intelligent things using Narrowband IoT (NB-IoT). They also introduced edge computing in the architecture to reduce the latency of applications which were mainly deployed on edge computing and edge storage servers.

Study by V.Ramya and et al**[8]**., proposes an “Embedded patient monitoring system”, in which the system monitors the status of the patient continuously by using an embedded system. Here the PIC microcontroller and sensor sense the temperature and drip status, which is later provided to the PC. If the temperature obtained is greater than the threshold value, then it will send an alert signal to a mobile phone and produce an alarm until the doctor responds to that message.

4 Methodology and Implementation:

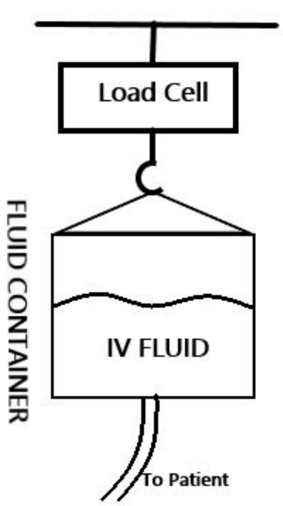
In this project, we propose ways to monitor the fluid levels in the Intravenous system. Intravenous system(IV) is a method of injecting medicinal fluids directly into a vein. It is the fastest way to administer medicines as it delivers it directly into the bloodstream. It is used for various functions such as fluid volume replacement, to correct electrolyte imbalances, to deliver medications, and for blood transfusions. Intravenous infusions are commonly referred to as drips.

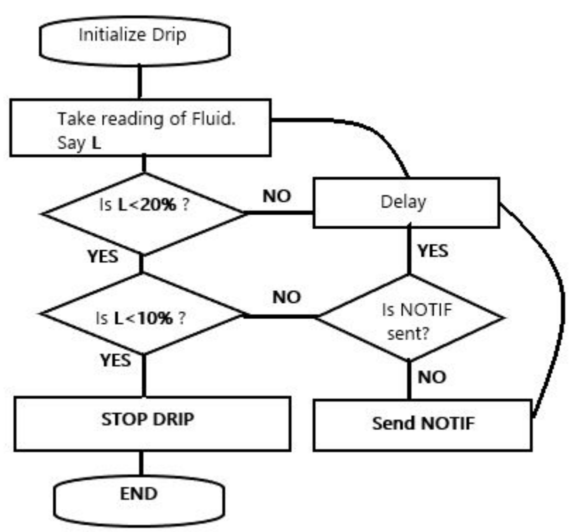
If the fluid level in the Intravenous system falls below a certain level it can induce reverse blood flow in the system from the person's veins to the saline solution bottle. The reverse blood flow happens when the pressure in the bottle is less than the pressure in the veins and this forces the blood from the veins to the bottle.

4.1 Measurement of level of fluid

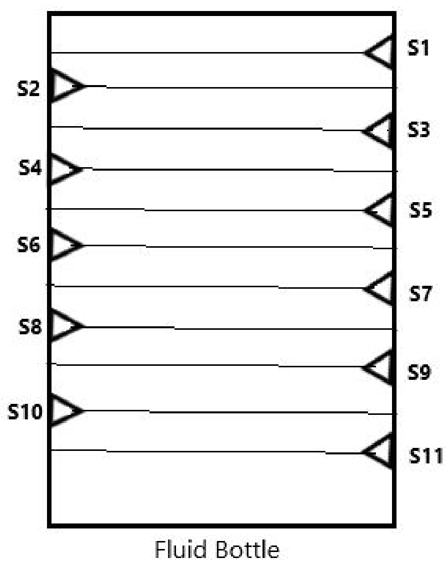
To measure the amount of fluid remaining in the system we propose to use weight sensors such as Load cells which send out proportional electric signals to weight. We also use an IR sensor (Transmitter and Receiver) to measure the amount of fluid present so as to reduce the error margin.

For the use of Load Cell, we propose the use of any miniature Load Cell, but having a dependable response, using which we can hang the Drip Bottle. The Load Cell will continuously measure the weight of the bottle and depending upon the fluid that has been used in the drip, if the weight of the drip bottle comes to a threshold, assumed to be 20% here, it send an alert notification for the concerned person to take care of, and if the the weight goes low to, let's assume 10%, then stops the flow.





Since with the use of Load Cell we could only monitor the change of fluid level using weight, using which we can counter Reverse Flow of blood, but to address the problem of stoppage of flow due to clot, we need the flow also to be monitored. We could have addressed the same using Load Cell only but to increase the reliability and reduce the margin of error, we propose the use of IR sensors, precisely SST Liquid Level sensors to continuously monitor the level of fluid and take a note of the rate of flow of the fluid.
The following is the proposed usage of SST sensors and the flowchart of the working.

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WorkFlow -

Si - ith Sensor
T - Threshold Time for fluid flow
    between consecutive sensors.
Initially -
    S1 = True and all other Si = False

Report Notif () -
    if ( S10 == True AND S11 == False)
        Report Notification
        continue
Stop Flow () -
    if( S11 == True )
        Stop Fluid Flow
        break
Report Clot () -
    say Sj == True AND S(j+1) == False
        if ( Time > T )
            Report Clot
            break
```

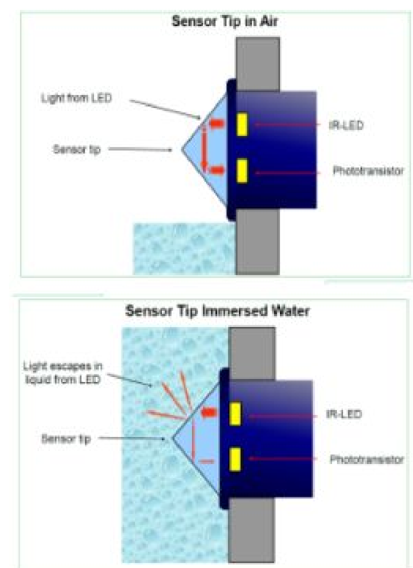


Fig. *- The working of SST IR sensor and design.*

In the above proposed diagram it should be noted that each Si denotes the binary reading of the ith SST sensor. If Si is true then it denotes that level of fluid has crossed the level corresponding to that sensor. S1 hence denotes a full bottle and S11 denotes the level at which we intend to stop the flow of fluid. In the **Report Clot** module, we measure the Time that the fluid has passed below the Sj sensor and has not yet reached the S(j+1) sensor. If this time exceeds the predefined measure then we conclude a blood clot.

4.2 Controlling the rate of flow of fluid

The NodeMCU then checks whether the values are less than the preset value, if it is then NodeMCU sends a signal to Arduino to stop the flow of fluids.To control the flow rate we propose to use a solenoid valve or we may also use the arduino to control two servo motors which then turn the pipe into an U shape and stop the flow of fluid. We use arduino only for the control of the servo motors as NodeMCU may not provide enough power to control the motors.

The flow rate can also be controlled from the mobile application, if a signal is sent from the mobile application then it is stored in the database and it is forwarded to NodeMCU. NodeMCU then again sends the signal to Arduino to control the flow rate.

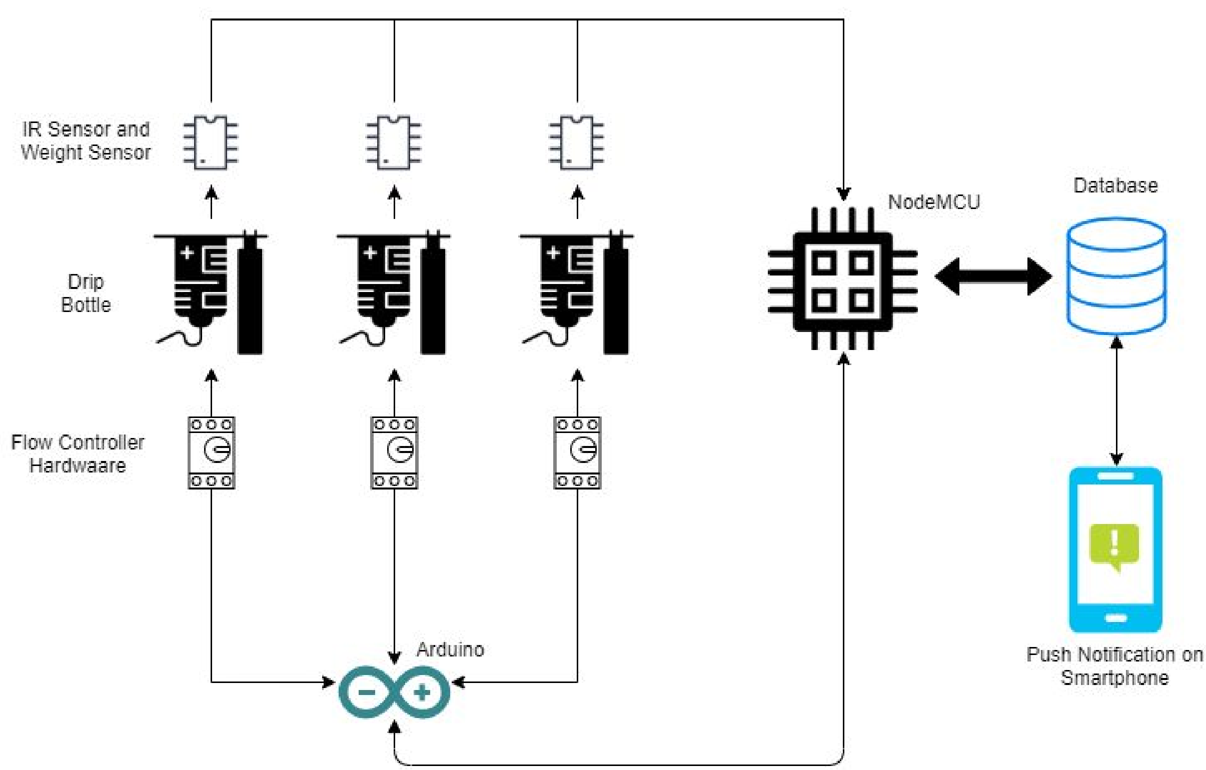
4.3 Storing the values in the database

The values which NodeMCU receives from the sensors are sent to the database where it is stored. If a signal is sent to Arduino to stop the flow, then the Arduino also sends a reply signal to the NodeMCU when the flow is stopped. This piece of information is also sent to the database on whether the flow is stopped or not.

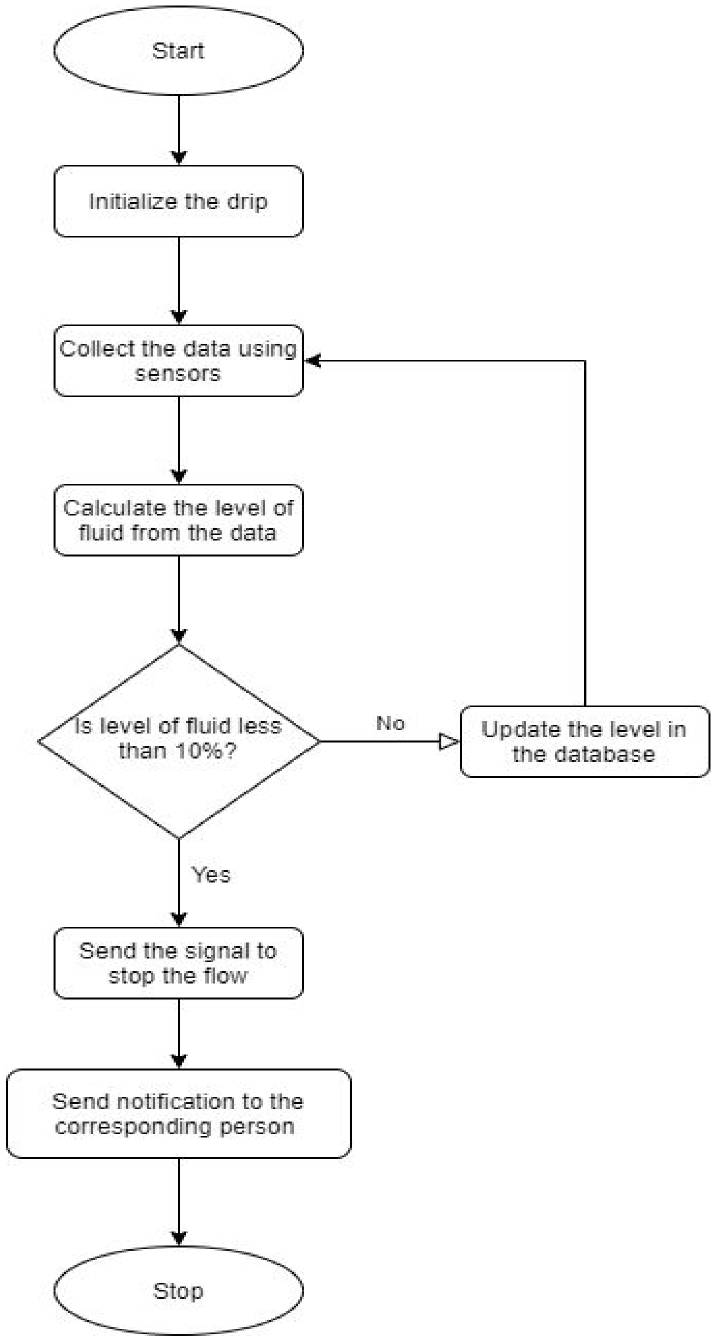
4.4 Control from the app

A mobile application is created which is connected to the database. The mobile application shows the amount of fluid present in the system and the flow rate and the estimated time to replace the fluid bottle. The app fetches real time updates from the database, so whenever there is a change in the values, it gets updated in the app too. If we wish to stop the flow then the stop option can be selected which sends the signal to the database and it propagates on.

4.5 Overview of the Model



4.5 Working Flowchart of the Model



5 Software & Hardware Requirements:

NodeMCU: NodeMCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. It will be needed to take the readings from sensors and will compute the level of the fluid.

Arduino UNO: The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. It will be needed to control the Flow Controller Hardware.

Weight Sensor (Load Cell): A load cell is a type of transducer, specifically a force transducer. It converts a force such as tension, compression, pressure, or torque into an electrical signal that can be measured and standardized. It will be needed to detect the level of the fluid.

IR Sensor: An IR sensor is a device which detects IR radiation falling on it. It will be needed to detect the level of the fluid. Precisely we propose the use of SST Level Sensor owing to its better accuracy.

Servo motor: A servo motor is an electrical device which can push or rotate an object with great precision. It will be needed to control the flow of the fluid.

Firebase Realtime Database: The Firebase Realtime Database is a cloud-hosted database. Data is stored as JSON and synchronized in realtime to every connected client. It will keep the app as well as web updated with the latest data in realtime.

6 Final Deliverables:

- An Android App, which will show the status of each node deployed.
- A web app, which will show the detailed view of each node of the system.
- Working Hardware prototype with a drip bottle.

7 Results:

6.1 “Hospital Drip Management” Desktop website

The below image shows the User Interface of the “Hospital Drip Management” website. It’s a dashboard which displays all the beds available in the particular hospital and their current status (vacant/occupied). If the beds are vacant they are marked “green” in color, else they are marked “grey” in color.

The dashboard for the website has been built in a generic way so that it can be used by the hospitals and medical workforce for multiple purposes and to be scalable in nature.

The details of each bed are shown in detail. The details include Bed-ID, Patient name, Doctor allotted, Rate of Flow of fluid, Time Left for drip bottles to get empty and the medications prescribed for the patient.

Each bed has two more attributes namely “Patient Profile” and “Manage Bed”.

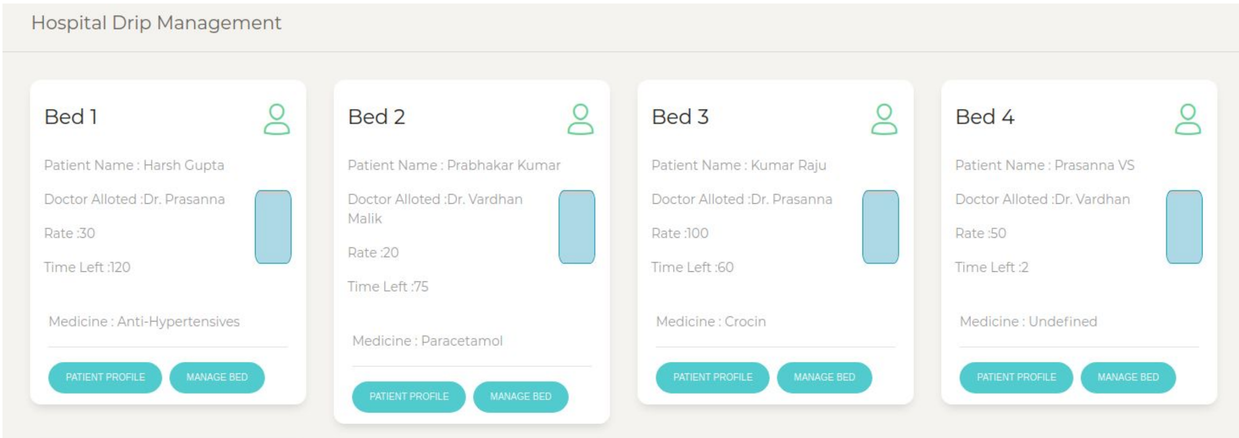
By clicking the “Patient Profile” tab, we can have a look at the detailed report of the patient’s medical profile which includes information like Disease name, past medical history, ongoing treatment, medicine prescribed and nursing incharge.

By clicking the “Manage Bed” tab, we can have a look at the detailed information about the drip bottle amount left, rate of flow, time to empty and a button, clicking of which sends a signal to the database to stop the flow of fluid.

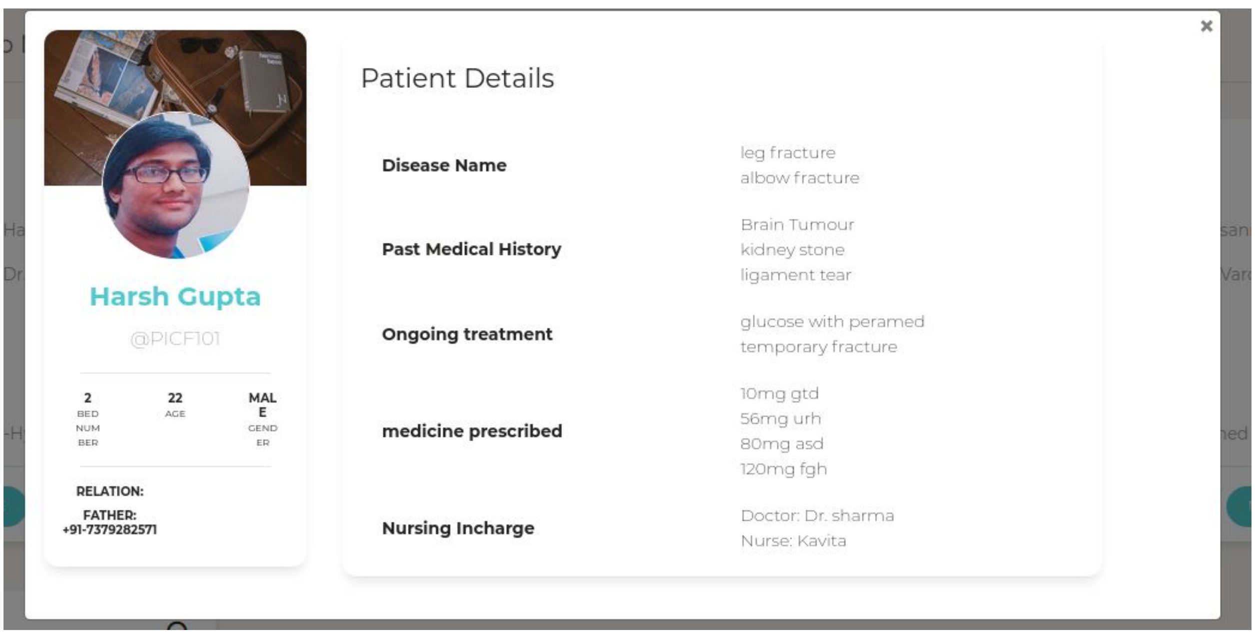
The website has been built using HTML, CSS, Javascript, Bootstrap for the frontend and Firebase for the backend. The patient details, bed details and drip bottle details are stored in Firebase.

Due to Firebase, the updates are done in real-time which is very crucial for healthcare software systems.

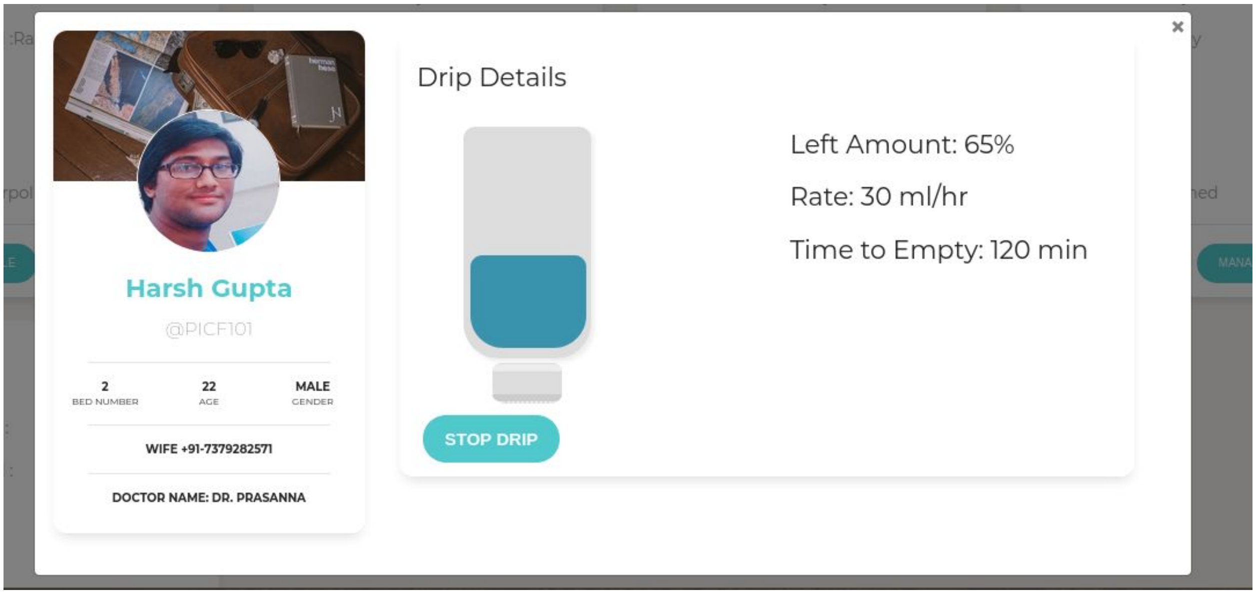
Below is a working screenshot of the Dashboard of “Hospital Drip Management” website.



Below is a screenshot of the “Patient Profile” tab from the website:



Below is a screenshot of the “Manage Bed” tab from the website:



6.2 “Hospital Drip Management” Android App

Here are the screenshots of the Android App:

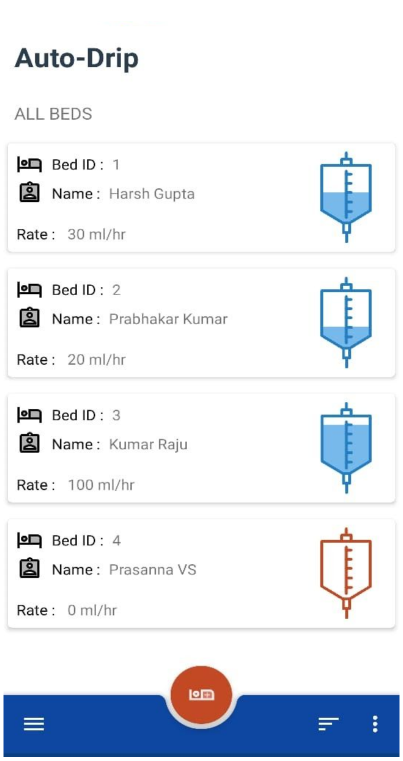


Fig 1

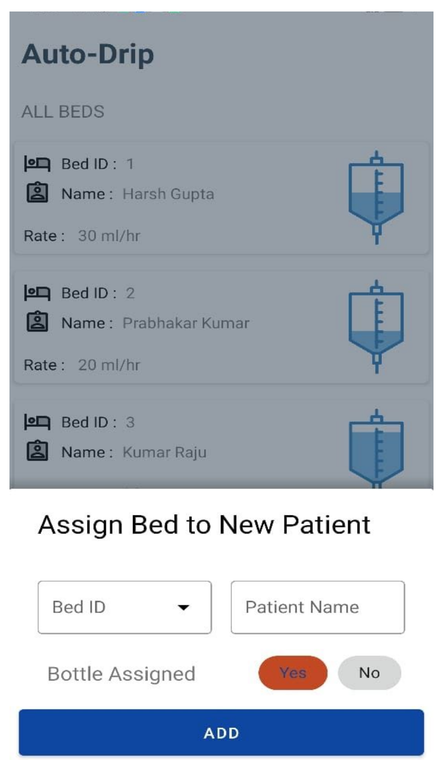


Fig 2

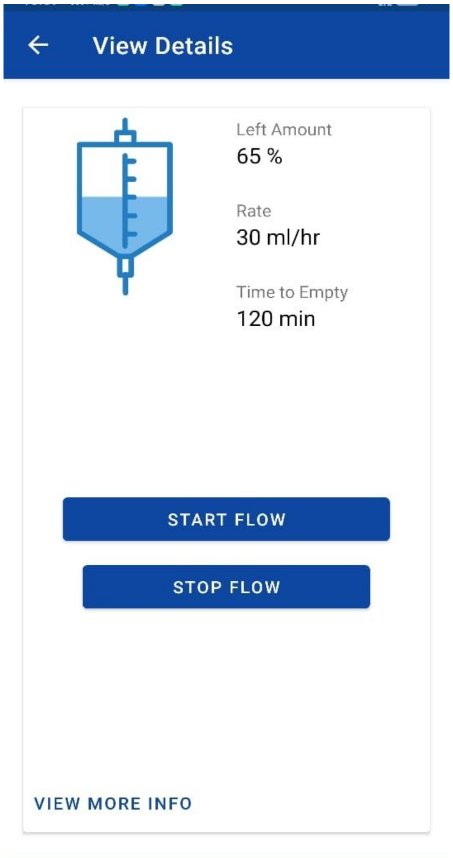


Fig 3

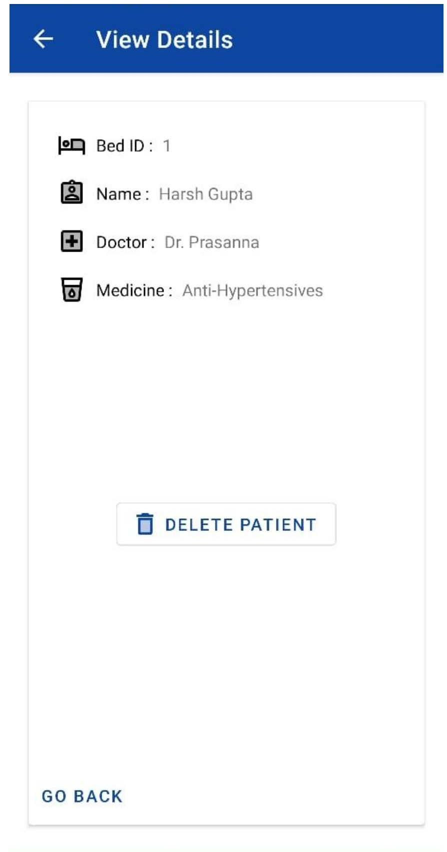


Fig 4

Fig 1 shows the home page of the app which displays the list of all the available beds and also shows the status of the drip.

Fig 2 shows the user interface to assign a bed to a new patient.

Fig 3 shows the detailed view of the status of the drip and also provides an option to start or stop the flow.

Fig 4 shows the detailed view of the patient information and also provides an option to un-assign the patient.

8 References:

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