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IoT Based Smart Electrolytic Bottle Monitoring

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Abstract. In hospitals, Electrolyte is fed to patients in many ways. One of the important functions is in the form of saline to treat dehydration and thus improve the healthiness. In contemporary health care procedures, whenever a saline is nursed to any persevering, the persevering is unceasingly observed by a nurse or any custodian. Monitoring the Saline level in a bottle attached to a patients' body is one of the most important tasks for a Nurse/caretaker. In cases involving ignorance or carelessness, the bottle may get empty and blood can start flowing reverse into the bottle from patients' body. This is a risky situation and needs a better solution. We are developing an IoT based bottle level monitoring system that will detect the saline bottle level at all instances by sending an alert to monitoring room of hospital when the bottle content reaches below threshold level. The proposed system is not electrolyte specific and can monitor any fluid. The system can be incorporated with existing bottle stands so it has an added advantage of flexibility and modularity. The app interface will be easy to operate and understand so that anyone with basic technical knowledge will be able to use it. As of now, it can operate for monitoring purposes and we have added automatic flow stop control to improve it further. In case of power failures, the system will still function as its battery powered but database updates will not be updated, so a physical alert solution like a beeper is also being planned will be incorporated.

1. Introduction

Due to rapid advancements in technology in recent times, humans have become totally dependent on the electronic gadgets for reducing their workload to make their life easier in many ways. India is sited 154 position in healthcare amongst 195 developing countries globally. This is one of the biggest employment source and a largest socio-economic growth on the Nation. After that the improvement of health parameters are imbalanced throughout the country. Hospitals have a simple electrolyte bottes with no indications and will create issues to the patients and flow will start in reverse direction. In this situation the blood from the human body will flow towards the bottle. In hospital all the sec-

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tions such as OPD, CCU, ICU NICU requires similar kind of intelligent automated and displaying unit. Our paper proposes a system to provide an automatic monitoring and flow stopping system to minimize the work load of the care taker and prevent the above difficulties faced. If still not taken care of might even lead to some medical accidents. so constant observation of saline level in the electrolytic bottle is very important. We calculate the initial weight of the bottle connected with our load sensor and save it in the database. The sensor continuously senses the weight until it reaches to 30% of the initial weight. That is where the critical level of the bottle is. We send an alert to the application user at 30% to change the bottle. If no one responds, and the bottle goes even below to 20% we send a control signal to the monitoring person's device. We wait for the monitor to respond, and if no one responds it will stop the flow to save patient's life. This system not only replaces the need of caretaker but also keeps a database of all bottles connected to the bed. we have also taken in consideration, the distinguishing of different beds in hospital with huge number of beds to avoid confusion between systems. we are using NodeMCU 1.0 v3 as the primary microcontroller and for wireless communication and load sensor for sensing the weight and database is designed using firebase.

2. Related Works

This section describes the work and findings made so far related to monitoring systems for saline/electrolytic solutions used for infusion and healthcare in general. An Internet of Things based saline level intensive care and spontaneous alert device [1] proposed a system for monitoring and halting the flow of IV solution based on Arduino. Also, their system is not designed to be modular and needs the entire set to function. IoT based drips monitoring at hospitals [2, 3] only performed monitoring drips but instead of Bluetooth, they are using gsm module for connectivity with which they can send SMS alerts to the person monitoring. A complete pervasive healthcare explanation on an Android mobile based system [4], that brings in the concept of Wireless sensor networks to health care. Patient monitoring is done using sensor nodes with ZigBee based connections. These connect to Android based devices through which the patients are monitored. The required data is deposited and loaded on an online database for access from any device. This system solves the shortcomings of using GSM and Bluetooth based wireless connections and moreover enables devices to access the data from any Android device [5]. The disadvantage here is that the system being exclusive to Android devices. The causes are of Asthma are prejudiced by genetic and environmental factors, in which environmental factors have a great impact [6]. This paper provided a portable device integrated with an android app that monitors the environmental factors faced by asthma patients as well as their health parameters and transmits this data to the cloud. In the care taker organizations, the care taker is responsible for the monitoring of electrolyte bottle level of the patient [7, 8]. Many times the care taker will forget to remember the timing of the bottle scheduled to the patient. Thus the places such as CCU, OT and ICU needs an intelligent monitoring and alert indication system. Care taker organizations are emerging day by day and a solution for better medical guidelines and representations are made for the current life style of the people [9, 10]. In the busy world for the health care organizations a remote drip infusion monitoring and control system is proposed [11] with infusion monitoring device using IR and a central monitoring system which displays the

necessary information in the workstation. The existing system used for health care are getting up due to population and the manual time requirement is time-consuming [12] and the intervention requirement with low cost in urban and rural areas. The system eliminates the continuous monitoring of physical staffs and are automated using sensors and a wireless module CC2500. A device to monitor the crucial level of saline bottle level is designed and developed [13] which automatically stop the flow of liquid when the liquid in the bottle is going to become empty. A device to monitor the patients care organization to power OFF the unused commercial devices using a combination of sensor and IoT technology is developed [14, 15]. In order to convey the patient's physiobiological information to remote controlling station optimized routing protocols are used in [16, 17]. A device to monitor heartbeat and temperature using ZigBee technology for the Indian patients mainly affected by heart attack and they lose their life because of the timely help is mentioned in [18, 19]. An automated device using sensors are developed to feed the saline to the patients and to indicate the emergency situation and if there is a change in drop rate, the system can be used in both hospitals and homes [20, 21]. A device in rural public hospital beds to correctly monitor the saline droplet statuses delivered to the patients with a warning system with different colour lights are developed as a low cost comfortable system for the care taker [22]. By the evolution of sophisticated advancements in technology in the field of medical electronics smart drip monitoring system is developed for critical patients using Arduino controller and an ultrasonic sensor. The sensor is used to monitor the level of the fluid and to reduce the workload of the care taker in the hospital [23].

3. Proposed System

Our Fluid Level monitoring system is an loT based project that replaces the need of a Nurse/caretaker to constantly keep an eye on the electrolyte bottle used. It uses ESP8266 12E NodeMCU 1.0 v3 as the microcontroller and utilizes the inbuilt WiFi module for connection to the internet, through which the device sends data to the online database. The load cell with HX711 amplifier is used to detect the weight of the bottle. Power is

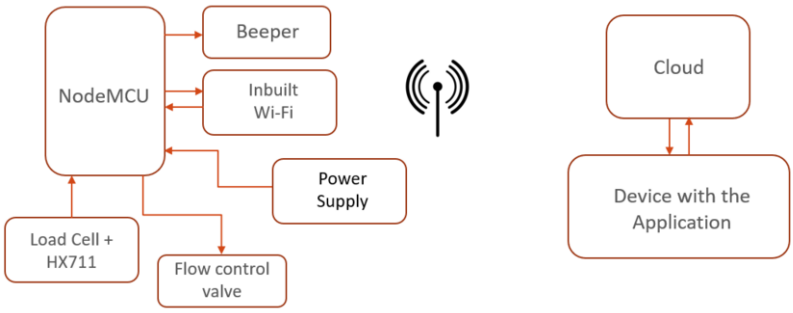

Figure 1. System Diagram

supplied to the system by a 9V battery. An 8mm electric flow control solenoid valve is used for stopping the fluid flow. From the database, the web app interface retrieves data

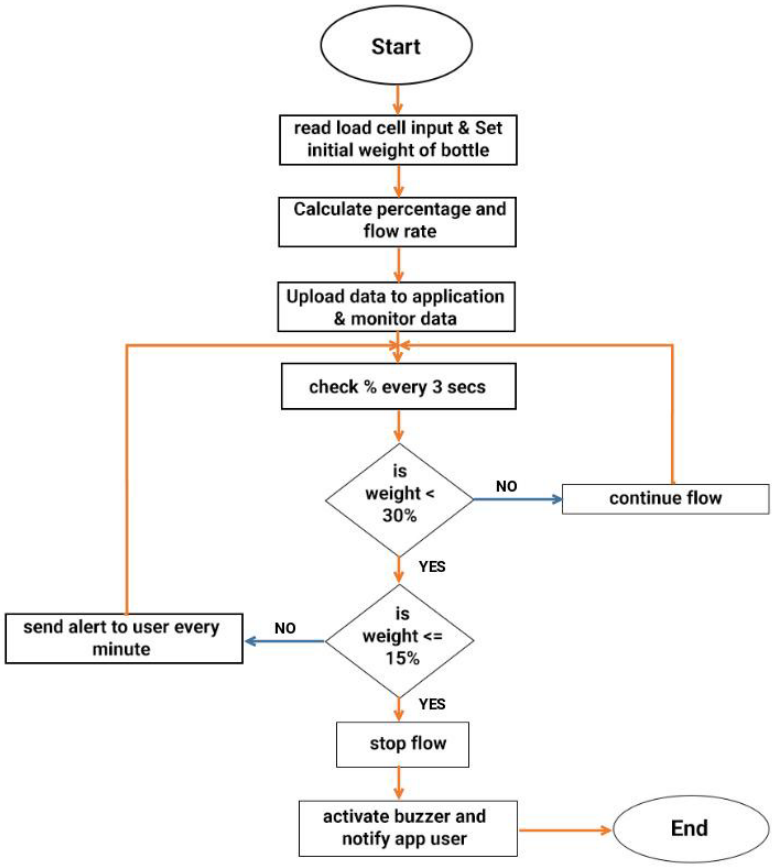

Figure 2. Process Flow Diagram

through which the monitoring is done. The system calculates the initial weight of the bottle connected with our load sensor and saves it in the database. The sensor continuously senses the weight sends data to the microcontroller which detects if has reached a threshold level. That is where the critical level of the bottle begins. Figure 1 shows the block diagram of the proposed system and the processed diagram is illustrated in Figure 2.

System sends an alert to the care takers at threshold, for example 30%, to change the bottle. If no one responds, and the bottle goes even below to 20% we send an alert again to the app user. We wait for the nurse or caretaker to respond, if there is no response it will automatically stop the flow with help of a flow valve.

- The default and minimum threshold value will be 25%. Higher value can be set by user if required.
- If there are any abnormalities in the flow due to any leakages an emergency alert will be sent to the user.

- To save battery values in the database will be updated every 3 or 5 minutes depending on the flow rate.
- There will also be a buzzer present in the system to provide sound alert in case of network failure.
- After the threshold level, continuous alerts and beeps will be given to prevent complications as soon as possible. If the flow is still not stopped the flow control valve will automatically halt the flow of the fluid.

This entire system can be used with already existing IV bottle stands and does not require any exclusive setup. The outcome of the project is given below.

- In this model, the patient was given some analyses by doctor in some portion of the hospital
- This will transfer the required information from the sender and receiver wirelessly with the use of transceiver.
- The complete health monitoring unit, that was proposed is combined into a minor compact unit as slight as a cell phone.

Initially the initial weight has to be calculated using load cell and hx711, the weight has been stored in the application for calibration also fix the critical level and threshold level weight of the bottle is noted and the reading is recorded continuously at all instances of time and if the bottle weight reaches the fixed critical level the alert message is sent to the doctor or caretaker also if no one responses and the weight is reaches below my critical level it will stop the flow of saline solution. Load cell is a transducer which converts

Figure 3. Load Cell

physical force, pressure or compression into electrical signals. The electrical signal from the load cell is directly proportional to the pressure applied to the load cell. When the weight or the Strain increases accordingly the electric signal also increases. The output from the load cell is measured using four coloured wires namely black, white, red and green. Red wire represents excitation + or Vcc, Black wire represents excitation – or GND, White wire Represents output + or Signal +, Green wire represents output – or signal - . 3kg load cell is used in our project and since the output voltage from the load

cell is low hx711 (load cell amp) is used to amplify the signal before feeding the data to the microcontroller. Figure 3 shows the load cell used in this system. HX711 is a

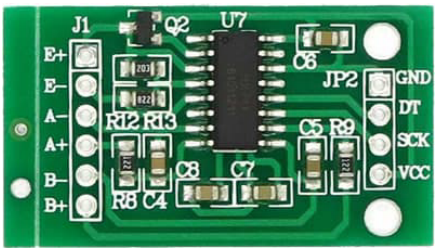

Figure 4. HX711 Component Side

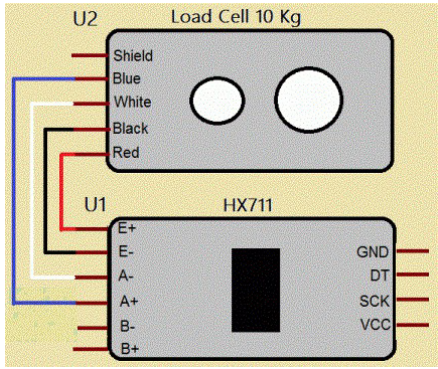

Figure 5. HX711 Layout

Dual-Channel 24-bit A/D weight pressure sensor load cell amplifier and ADC module. HX711 is a weighing sensor that uses a two-wire interface; one for clock and one for data communication. For controller the GPIO pins are used for read the data from HX711. The output from the load cell is fed to the hx711. It has combination of 8 pins and act as a interface between the load cell sensor and the microcontroller. The four pins is used to get the input from the load cell sensor and it can able to amplify the voltage to the certain extend and feed as a input to the microcontroller which can able to sense the voltage from the sensor, so it act as backbone of data processing section and sensing the weight of the bottle accordingly. Figure 4 and 5 shows the HX711 board.

The main code of the system is dumped into the NodeMCU which is the primary microcontroller. It is programmed to obtain the data from the components used and process them. Using the data obtained from the load cell, it calculates the flow rate and remaining time through which it finds the threshold level at which the flow of the solution should be halted. These data are also uploaded to the online database, based on Firebase's Realtime Database service. The weight of the bottle is updated locally and online constantly, whereas the flow rate is calculated every minute. Utilizing the data uploaded to the database, the web application displays the current level, remaining time left for emptying of the bottle. It also starts sending notifications to the app user as soon as the threshold level is reached, until the flow is stopped. Figure 6 shows the screen shot of the database and Figure 7 shows the screenshot of app prototype.

The stand is an essential part of our project, all the components of our project are being fixed on it. Load cell is being fixed with the stand to remove and replace the saline bottle on it whenever required and also for accurate readings. Our stand is designed in a way such that it can be fitted to any of the existing drip stands in the hospitals. Portability and modularity are given the first preference. Initially the prototype was made of wood. Currently we are testing it in PVC and metal pipes, according to the further process and considering various factors like durability, rigidity and strength, the material going to be used will be finalized. Figure 7 shows the model stand designed and developed. The same will be developed using stainless steel material with a height of seven feet and proper holding mechanisms for the saline bottle to be hold on the stand and all the electronic

components will be packed within a small box and is fixed on the stand itself. The power requirement and the wiring for the device will be kept inside the pipe, so that it will not create any disturbance to the patient.

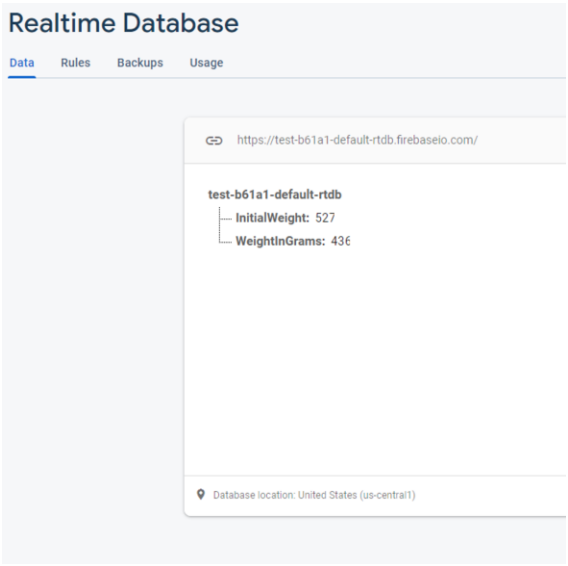

Figure 6. Realtime Database Screen Shot

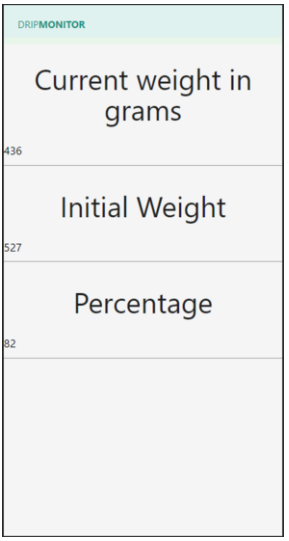

Figure 7. App prototype

NodeMCU, ESP12E is a low cost open source IoT platform. The microcontroller is considered as the heart of the IoT based projects. In this project we use ESP12E microcontroller which can act as an interface between the sensors and cloud. It has an inbuilt Wi-fi module which can send and receive data wirelessly. It is a micro controller with an availability for Wi-Fi module for the proposed system. Apart from the other microcontrollers, it has maximum code efficiency which can achieve the desired output with minimum number of code lines. It supports a wide range of libraries for numerous components so the effective way of getting a chance for desired output is maximized. Figure 8 shows this module.

A solenoid valve is an electrically managed valve. The valve is used to forestall the float of liquid thru the valve. The valve has a solenoid, that's an electric powered coil with a movable ferromagnetic core(plunger) in its center. In the relaxation position, the plunger closes off a small orifice. Electric contemporary thru the coil creates a magnetic subject. The magnetic subject exerts an upwards pressure at the plunger starting the orifice. This is the simple precept this is used to open and near solenoid valves. Figure 9 indicates the solenoid valve. The final structure will be displayed in stainless steel material. In our project the working of micro- controllers has multiple functions involved. It is able to get the input from the load cell connected with the load cell amplifier (HX711), and upload into the hospital's database which can be viewed later, this microcontroller will perform two fundamental operations 1. Get the input from the load cell at all instances of time 2. The input from the load cell is being uploaded into the cloud database which was designed using Firebase. This micro-controller is not purely dependent on the internet, it can function effectively without any internet facility (especially in rural village hospi-

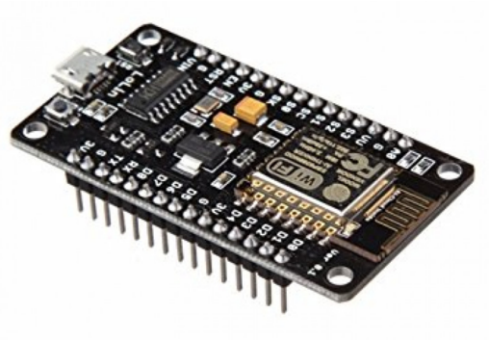

Figure 8. ESP12E

Figure 9. Solenoid Valve

tals), but since in our project we are developing a system that can function universally (in any hospital), working with the internet facility is required for uploading data in the database. The NodeMCU and the rest of the setup will be powered by a 9V replaceable battery, with the help of a driver shield.

4. Conclusion

Thus, our solution provides a modular system that can be used with existing IV bottles to monitor IV fluids being injected to patients. Since it is a web app-based monitoring system it can be accessed on any device with an internet connection. Complications due to lack of attention and reverse blood flow can be prevented or minimized at least with the functioning of this system in a flexible and cost-effective way.

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