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Development of Intelligent and Smart Saline Bottle

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Abstract: Health threat is not an age-dependent issue due to our hectic schedule and irregular lifestyle in the modern era. Internet of Things offer a relatively easier solution for patients' real-time health monitoring from a remote place like from the hospital as well as home or from any other places. One of the very important aspects is surveillance of saline level in hospitals. Often due to negligence and casualty of hospital staff the saline bottle is not changed and as such it proves fatal for the patients. This paper focuses on developing a saline level monitoring system using IR sensors and load sensor along with a machine learning based approach which predicts the time when the saline bottle needs to be changed ahead of time so that there is absolutely no faulty situations coming up. The proposed system helps in increasing the overall patient care.

Keywords: Internet of Things, Machine Learning, Node MCU, IR sensor, Load Sensor

I. INTRODUCTION

Internet of Things commonly referred to as IoT is the "next big thing" in the world right now with an estimated presence of around 30 billion devices by the end of this decade. It is a system of connecting devices together over the internet thus making them smart. The devices range from vehicles, lights, tools and many more having sensors fitted on them which enables exchanging data amongst themselves. This technology along with artificial intelligence has become the locomotive of innovation and economic growth. Machine learning is another such advancement which has come up in order to help us with future trends and predictions of various activities. IoT and machine learning together thus enables us here to design a complete and secure system through future prediction and the system of networks. The IR sensor which is an RF based device is used as a level sensor here which returns the drop rate and the load sensor returns the weight of the bottle in terms of voltage which is sent to the ThingSpeak for constant monitoring and further sending the SMS notification alongside displaying the data in a dedicated application. The data of the load sensor is saved in an excel sheet for applying the machine learning algorithm (linear regression) on it. When a hospital staff forgets to change the saline bottle blood flows from body towards the bottle thereby creating a fatal problem. This system gets rid of this disadvantage through the integration of sensors and artificial intelligence. The existing systems refer to saline level monitoring by using microcontrollers and sensors, some incorporates IoT and others setup a control system. They focus on real time data of fluid levels. Yu proposed a system for smart hospitals in which diagnosis treatment are automated which would have a profound effect on the mass [1][2]. Ghosh built a system using ESP-32 system on chip and a load cell which employs IoT to publish messages in desired devices [3]. An intravenous fluid level indicator is proposed which alerts the concerned whenever the fluid level falls below a threshold using a buzzer and LCD display using IR sensors connected to a microcontroller. [4]. Using a GSM module based alerting system whenever there is shortage in glucose level by using level sensor is suggested by RamKumar[5]. .Kalaivani made a system which detected ECG levels and saline level using IR sensors and a microcontroller [6]. An automatic saline level monitoring system was designed using Bluetooth module and CC2500 trans receiver module [7]. Tawade incorporates flow rate sensor to determine saline flow and uses RF zigbee module for transmitting and receiving signals [8]. Janani has used a pic microcontroller and an IR sensor at the neck of the bottle to measure the drip rate. This wireless sensor alarms whenever the drip rate is low[9]. Development of a control system is done using these few designs but they cannot be monitored remotely. Baviskar[11] and Dharmale[12] made a IoT based system using IR level sensor which sends responses to the staff whenever an emergency rises. These systems are more efficient than the controller based systems. Our system incorporates an IoT based system using IR sensor and load sensor to measure the drip rate and weight alongside using machine learning algorithms to predict the next occurrence of bottle change. These features make our design more advantageous than the other IoT based system. A dedicated application also ensures better monitoring and

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higher level of patient safety. This system also avoids the fatal risk of air bubbles entering the patient's blood stream which is a serious threat as air bubbles in blood can cause immediate death.

II. SYSTEM METHODOLOGY

A. Working Process

The working process of the proposed design is very simple. Node MCU, the microcontroller reads the data from the load cell and the infrared sensor. This data is displayed on the Arduino IDE and is further sent to the ThingSpeak server using the WiFi module present in it. The IR sensor measures the drop rate or the drip rate and sends it in the form of voltage data. Similarly the load cell module measures the weight of the bottle and sends it in the form of voltages. Depending on the corresponding weights and drop rate three LEDs of different colors are connected to the Node MCU which returns the condition of the fluid level in the bottle. The red LED glows when the level of fluid in the bottle has reached below the threshold limit that has been set. Yellow is for the medium fluid level as per the threshold set and finally the green LED signifies optimum level of fluid present in the bottle. Adding on to this a buzzer also beeps on the reaching below the threshold level. Adding on to this the Node MCU sends the data of the IR sensor and the load sensor to the ThingSpeak channel using a network connection through the WiFi chip present on it. This data is used to send notifications to the concerned persons in case of an anomaly via IFTTT and ThingHTTP protocol. Using this data obtained an app is made which displays the data remotely anywhere. It is made by MIT App inventor. The machine learning algorithm is applied on the data obtained from the sensors after transferring it to an Excel sheet. This data is then imported into Anaconda IDE for applying the linear regression algorithm. The algorithm is used here in order to predict the future moment when the saline bottle needs to be changed by the medical staff. There is one dependent variable and one independent variable hence linear regression satisfies our requirement. The independent variable is the level of fluid and the dependent is the moment of changing the saline bottle. The level of fluid is calculated by using the data returned by the load sensor and the drop rate given by the IR sensor. Ultimately the entire system becomes full proof since the error of mistake or failure to change the saline bottle reduces. The patient's safety is ensured in all aspects. The block diagram for the above process is shown in the Fig.1.

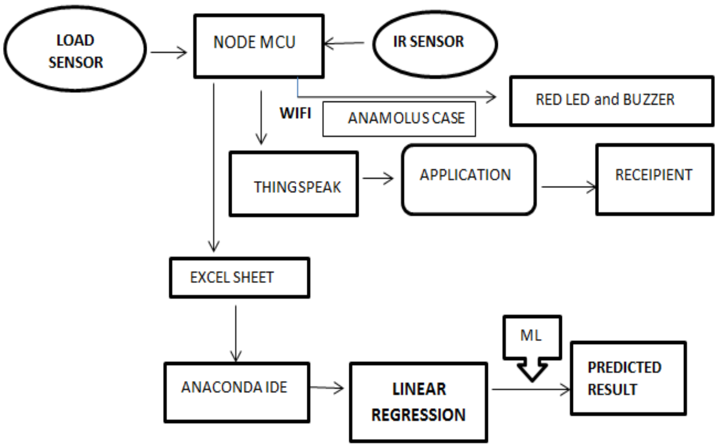

Fig.1. Block Diagram of the system

The architectural diagram of the system is shown in Fig.2

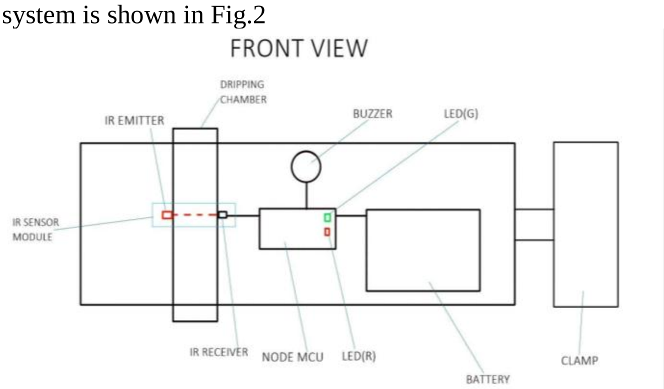

Fig.2.1. Architectural Setup (Front view)

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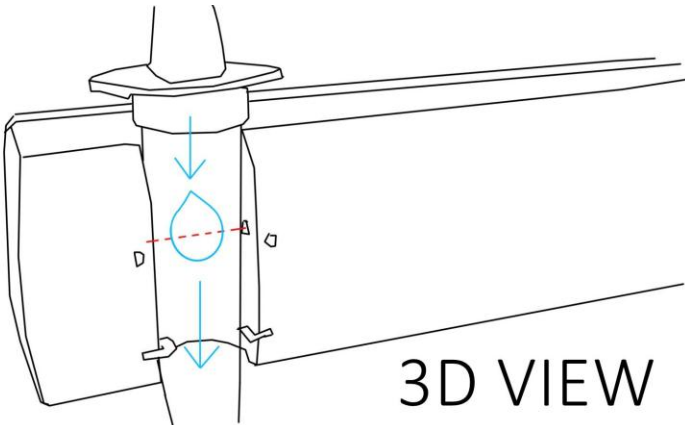

Fig.2.2. 3-Dimensional view

B. Hardware Requirements –

Node MCU - It is an open source environment for creating IoT projects. A ESP-8266 chip is mounted on it which enables the ending of data to cloud servers through WiFi. The firmware is based on Lua scripting language. It comprises of 128kb RAM and 4mb flash memory. Node Mcu is shown in Fig.3 , was developed by Espressif systems.

IR Sensor – An infrared sensor is a sensor which emits or detects radiation by the help of the emitter and receiver LEDs. It is widely used to detect nearby objects. It works on the principle that when an infrared radiation is sent from a source, the signal is reflected back when an obstacle is detected and received by the receiver LED. The sensor is shown in Fig.4.

Load Sensor – It is a sensor which converts a load applied on it to a signal which can be measured. This signal is amplified and further converted into suitable value of voltage using conversion factors.The load sensor amplifier used here is HX-711. The sensor is shown below in Fig.5.

Fig.3. Node Mcu

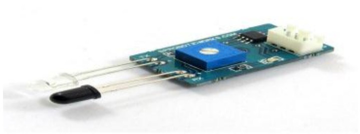

Fig.4. IR sensor

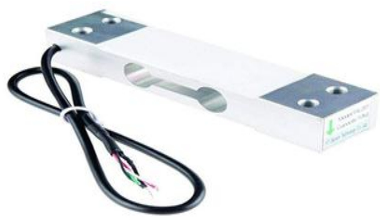

Fig.5. Load cell

The load cell along with the amplifier is shown below in Fig.6.

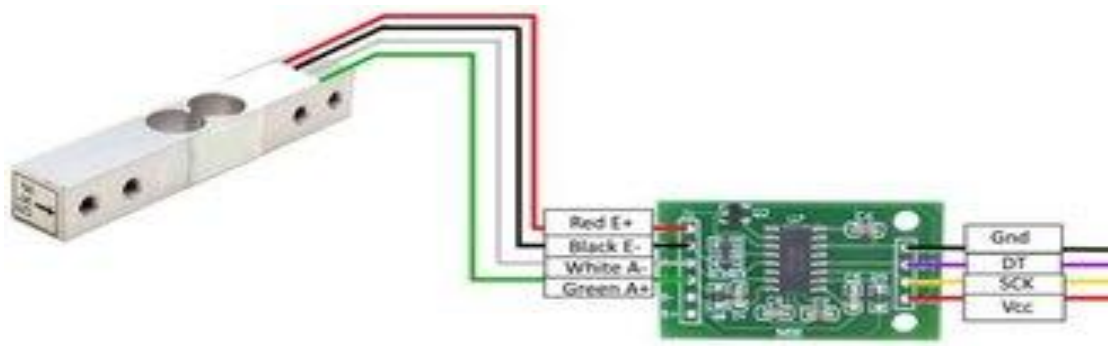

Fig.6. Load cell with HX-711 amplifier

C. Software Requirements

ThingSpeak **-** It is a cloud server developed by Mathworks which provides easy access to share and exchange data. Widely used by many as an IOT development platform ThingSpeak offers visualization plotted data from the sensors. It also has an ability to send notifications to people whenever any anomaly arises via the ThingHTTP protocol present in it. The home page of ThingSpeak is shown in Fig.7

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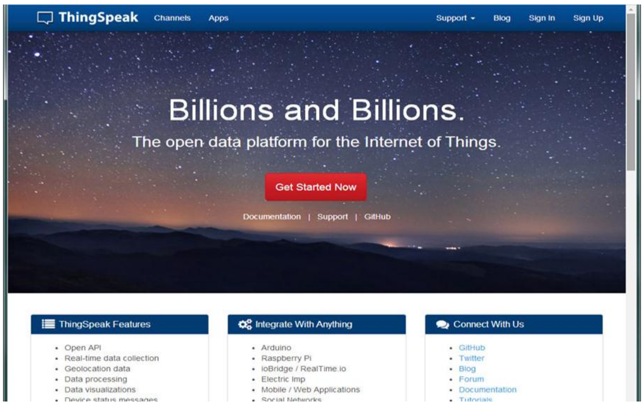


Fig.7. ThingSpeak home page

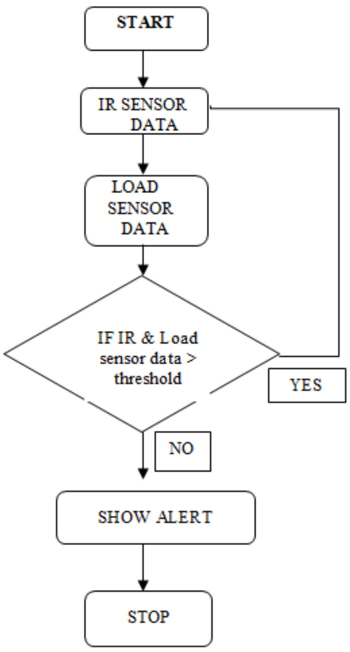
Anaconda Navigator: It is a hub for machine learning and artificial intelligence. Comprising of 7 different studios to work with it, Jupyter Notebooks being the most popular, offers a simple way for programming with python to solve ML problems. MIT App Inventor: Developed by MIT it offers a simple way of designing an application by just dragging blocks from the console. It can easily be interfaced with Google Firebase or ThingSpeak to retrieve data from the servers for constant monitoring and visualization. Both way communications is possible, i.e. between server and app and vice versa.

D. Machine Learning Algorithm- Linear Regression

Linear Regression algorithm is one of the most popular algorithms due to its simplicity. This machine learning algorithm is based on supervised learning and has two variables, a dependant one and an independent one. The independent variable is used to find the value or forecast the value of the dependant variable. This model follows a linear equation hence that combines a specific set of values to give the predicted value. The equation governing this model is: $y = \Theta 0 + \Theta 1*x$, where ‘y’ is the dependant variable and ‘ x’ is the independent one. ‘ϴ1’ is the coefficient of ‘x’ and ‘ϴ0’ the intercept. Here the dependant variable is the predicted hour of changing the saline bottle and the independent value is the level of fluid. The training data and the testing data are made available based on our readings obtained from the sensors. The training data is used to make the algorithm learn or train. It includes the input data as well as the corresponding output. Testing dataset involves only the input part and is used to determine how well our model was trained.

III. FLOWCHART AND ALGORITHM

Flow Chart:



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Algorithm:
Step 1. Start
Step 2. Connect the sensors to Node MCU.
Step 3. Connect the IR sensor and load sensor to Node MCU
Step 4. Setup Wifi connection in both
Step 5. Connect with ThingSpeak using WIFI in both
Step 6. Send data over Wifi to ThingSpeak and visualize
Step 7. Send notification to medical staff whenever anomaly rises
Step 8. Collect the data and store it into excel sheet and then into Jupyter notebooks.
Step 9 . Clean the data obtained and arrange it in format.
Step 10. Implement linear regression algorithm
Step 11. Display the predicted data
Step 12 . Plot the data
Step 13. Stop.

IV. RESULTS

The hardware implementation using the IR sensor, load sensor and the Node MCU are shown in the circuit diagram below in Fig.8.

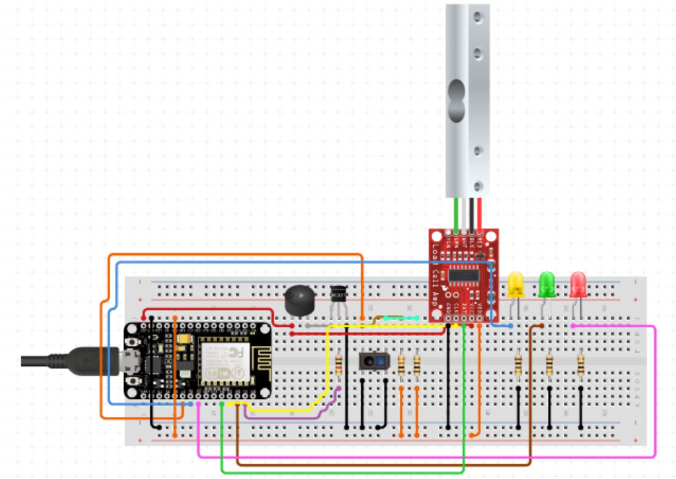

Fig.8. Circuit Diagram

The forecasted data is obtained using the linear regression model. The dataset made from the fluid level measured give the output with respect to the hour of changing the salinebottle. The graph obtained is shown below in Fig.9.

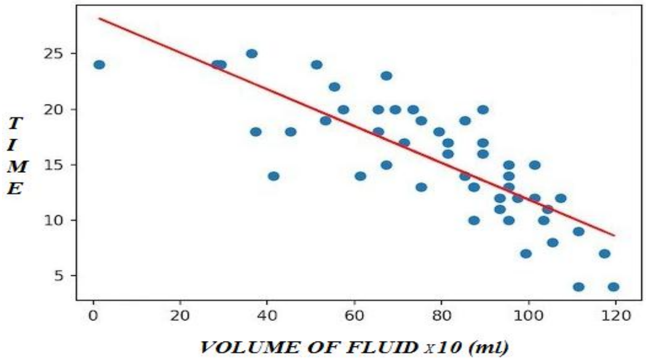

Fig.9. Graph of predicted output

As shown in the graph in Fig.9 the amount of fluid present decreases with time. The hospital staff can easily know at what point of time the saline bottle needs to be changed. As seen here there is high amount of fluid present in the initial hours of setting up the saline bottle which gradually reduces and because of this the graph is of negative gradient. The graph is a perfect fit and the problems of over fitting are overcome by using properly sorted data. Also, Fig.11 shows the display of the fluid level data in the app through which the levels can be easily monitored anywhere anytime, provided there is proper network availability.

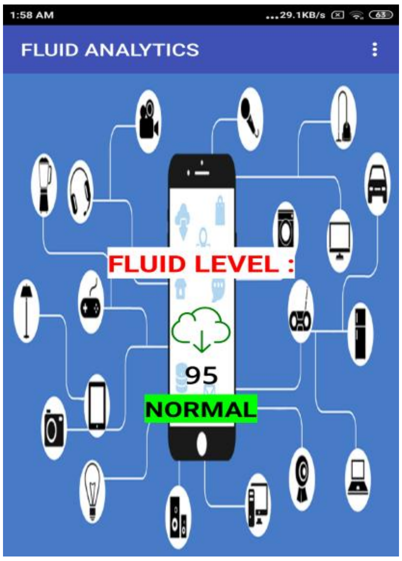

Fig.10. Data diplay in App

V. CONCLUSION

Health monitoring is one of the key issues concerning the medical facilities. This paper incorporates a system through which one of the very important issues of saline level monitoring is resolved. This method can be further applied to specific patients and the data can be segregated based on the type of diseases the patients are having and then stored in a database. It would be a very flexible and automated system in terms of health monitoring thereby reducing the amount of human involvement and also the errors and casualties.

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