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A Novel Approach for an IoT based Saline Bottle Level Monitoring System

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Abstract: **The lack of care for people with sufficient skill in hospitals and their heavy duty has become a social problem in the modern world. Development of low-cost health monitoring systems is an essential need for every hospital in the days to come. Various engineering designs are carried for the benefit of hospital facility enhancement. Several health monitoring sensors for humans in bed have been developed. Several sophisticated techniques and equipment have been evolved for treatment of patients in hospitals. However, management and monitoring of the level of saline bottles becomes the fundamental need for good patient care. For patients who require continuous saline, assessment and replacement of saline bottles require manual interface which may not be accurate sometimes i.e., due to the busy schedule, observers may tend to forget to change the saline bottle at the appropriate time. In this paper, a saline monitoring system is designed and prototype is developed which continuously monitors the level of saline in the absence of any hospital staff. The main purpose of this system is to automatically track the saline level of a patient using Arduino UNO R3 and a load cell with HX711. The whole system is remotely controlled by an Android OS smartphone based on Internet of Things (IoT). When the load of the saline bottle reaches a very low level then an alert message will be sent to the nurse and doctor.**

Index Terms: **Internet of Things (IoT), Arduino UNO R3, Load cell, Saline monitoring**

I. Introduction

There is a continuous growth in the world population, in accordance to this the need for smart health care also becomes essential. Due to the advent of new sensors, microcontrollers and computers, medical care has made tremendous progress. A culmination of medicine and engineering has led to the growth of the medical care stream. This paper elaborates on the design of a low cost indigenously developed sensor which includes a GSM (Global system for mobile communication) modem. This will enable easy monitoring of saline flow from different places. The Arduino microcontroller is used for providing coordination action. The level of the saline bottle is directly proportional to its weight and in order to measure it a LOAD SENSOR and HX711 are placed at the neck of the saline bottle. The weights are categorized as high, medium and low and the output obtained from the sensor is processed to check the same. This information is further transmitted through GSM technology to a distant mobile cell for other actions.

The main objective of the setup is to create an easy, low cost, accessible and authentic method for monitoring saline levels. As the saline goes below the threshold level, it is necessary to change the saline bottle.

The motivation of this novel technique is from the aspect of automating the whole system with minimal human intervention. The main advantage is during the peak hours or nighttime when the need for the nurses to visit the patient's bed frequently reduces drastically as alert notifications will be received periodically. Apart from saving the lives of the patients, the stress of continuous monitoring by the nurses or doctors gets reduced.

This system can automatically monitor the saline flow rate by using an Arduino UNO R3 microcontroller. Wireless data is sent to nurses or doctors' computers or a mobile using GPRS SIM800L and display the results. The hardware devices include - Power Supply, GSM module, Load Sensor, HX711 etc. All these devices are fixed into Arduino to monitor saline. Here a load cell is used, which measures the weight of saline and then generates analog signals, later converted to voltage that can be transmitted to HX711. HX711 receives analog signals from the load cell and it amplifies those signals and transfers them to the microcontroller. GSM module is used when the level of saline goes below threshold value immediately the information including the weight of the saline bottle is sent to the receiver section through this module. An Arduino UNO micro controller is attached to the saline stand so that it can easily monitor the level of saline. When the level of saline goes below threshold then the information will be displayed on LCD and Android App by fetching all the information from the server. It also informs nurses or doctors via generating alert messages on application. The main hardware parts are described as follows.

A. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

B. Load Cell

A load cell is a transducer which transforms force or pressure into electrical output. The magnitude of this electrical output is directly proportional to the force being applied. Load cells have strain gauge, which deforms when pressure is applied on it. And then strain gauge generates electrical signal on deformation as its effective resistance changes on deformation. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells come in various ranges like 5kg, 10kg, 100kg and more, here we have used Load cell, which can weigh up to 40kg.

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C. HX711

HX711 module is a Load Cell Amplifier breakout board for the HX711 IC. It permits the user to easily measure weights by reading the load cell. This module uses 24 high precision A/D converter chip HX711. It is specially designed for the high precision electronic scale design, with two analog input channels, the internal integration of 128 times the programmable gain amplifier. The input circuit can be configured to provide a bridge type pressure bridge (such as pressure, weighing sensor mode), is of high precision, low cost is an ideal sampling front-end module.

Figure 1 shows the block diagram of the saline system.

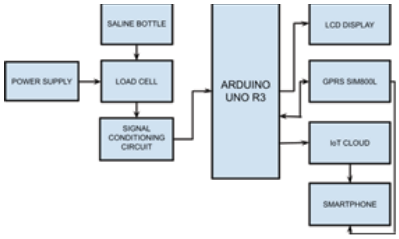

Figure 1. Block Diagram of Saline system

II. Literature Survey

A. Literature Survey 1

International Journal of Pharmaceutical Applications Volume: 3, Issue 1, 2017. “Design and Development of Versatile Saline Flow Rate Measuring System and GSM Based Remote Monitoring Device”. The paper [1] elaborates on an automatic saline monitoring system. This uses a low-cost indigenous sly developed sensor. It also uses a GSM (Global system for mobile communication) modem. This facilitates the doctor or nurse to monitor remotely. The coordinating action is provided by the 8051 microcontrollers.

B. Literature Survey 2

The 4th Joint International Conference on Information and Communication Technology, Electronic and Instrumentation Engineering (JICTEI) “Saline Level Monitoring System Using Arduino UNO Processor”. This paper [2] describes that ECG sensor based advanced wireless patient monitoring system the concept is a new innovative idea. This system aims to provide health care to the patient. The ECG of a patient is sensed with the help of a 3 lead electrode system. A AD8232 helps in amplifying small bio signals and is sent to the Arduino which later processes it along with saline level. The level of the saline bottle is detected through IR sensors. The outputs are displayed through a mobile application.

C. Literature Survey 3

International Journal of Engineering Applied Sciences and Technology (IJAST), Volume: 5, issue: 05, 2020. “Design and development of saline monitoring system using flow sensor”. This journal [3] explains how weight or force sensors can be used for monitoring of saline water level and it prevents backflow of the blood into the saline bottle which doesn’t cause any harm to the patient’s health. The main aim of this journal is to overcome drawbacks in manually controlled saline system and to provide greater accuracy than manual saline flow rate control system.

D. Literature Survey 4

International Journal of Research in Engineering and Technology; Volume: 04 Issue: 09, September-2015 “Low-Cost Saline Level Monitoring System Using Wireless Bluetooth Module and Cc2500 Transceiver". This paper [4] describes how the medical field is integrated with engineering technologies to solve this problem. Using sensors, PLC, microcontrollers interfacing is made easy. This paper mainly focuses on providing advanced saline level monitoring systems.

E. Literature Survey 5

Journal of Mechanical and Mechanics Engineering, MAT Journals 2020 Volume-6, Issue-3 (September-December 2020). This paper [5] highlights the basic information regarding strain gauge-based load cells, classification of these load cells and throws light on some of the new ways of designing these load cells. The force measurement system and its salient features have been briefly discussed. So, from this paper we got to know the usage of load cells and we used load cells as the weight sensor in this project.

F. Literature Survey 6

Paper on Patient Health and Saline Level Monitoring System using IoT, Devendra P Gadekar, Dr. Y P Singh, Efficiently Identification, Volume & Issue: Volume 08, Issue 11 (November 2019). The anesthesiologist can monitor several patients in parallel. In case of any anomaly in the measured data, the doctor is alerted by a notification sent by the Android app. In this proposed system [6], it is possible to automatically monitor the salt flow rate using the microcontroller. Wireless data is transmitted to nurses or doctors. The results are displayed in the form of saline droplet rate, number of droplets coming from the saline bottle.

G. Literature Survey 7

General Application Research on GSM Module, published in 2011 International Conference on Internet Computing and Information Services, Date Added to IEEE Xplore: 01 November 2011. This research paper [7] describes that the GSM network is the most worldwide mobile communication network nowadays. Based on the SIEMENS MC35 GSM module, general techniques of communication with GSM network are depicted, including the initialization of terminal equipment, sending and reading short messages (SMS), sending SMS to group users, and the management on phonebook of SIM card, furthermore, a flexible solution on real-time reading SMS is proposed. Finally, application cases are given for the GSM module. So, we are using the GSM module in our project to send messages to the end user.

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H. Literature Survey 8

Working principle of Arduino and using it as a tool for study and research, International Journal of Control, Automation, Communication and Systems. This paper [8] explores the working principle and applications of an Arduino board. This also explores how it can be used as a tool for study and research works. Main advantages are fast processing and easy interface. Today, with an increasing number of people using open-source software and hardware devices day after day, technology is forming a new dimension by making complicated things look easier and interesting. These open sources provide free or virtually low costs, highly reliable and affordable technology. This paper provides a glimpse of the type of Arduino boards, working principles, software implementation and their applications.

I. Literature Survey 9

Online Integrated Development Environment (IDE) in Supporting Computer Programming Learning Process during COVID-19 Pandemic, IJID (International Journal on Informatics for Development), Volume: 9, No. 1, 2020. In this journal [9] they described that they should install a text editor called Integrated Development Environment (IDE) to support it. There are various online IDEs that support computer programming. However, students must have an internet connection to use it. After all, many students cannot afford to buy internet quotas to access online learning material during the COVID-19 pandemic. According to these problems, this study compares several online IDEs based on internet data usage and the necessary supporting libraries' availability. In this study, we only compared eleven online IDEs that support the Python programming language, free to access, and do not require logging in. Based on the comparative analysis, three online IDEs have most libraries supported. So, we thought of using IDE software and code on this platform.

J. Literature Survey 10

International Journal of Internet of Things and Web Services. Nuba Shittain Mitu, Vassil T. Vassilev, Myasar Tabany (2021). Low Cost, Easy-to-Use, IoT and Cloud-Based Real-Time Environment Monitoring System Using ESP8266 Microcontroller. This paper [10] proposes a low-cost, Easy-to-use, IoT and cloud-based system solution for environmental data monitoring in real-time through the combination of Internet of Things (IoT) and Cloud Computing technology via Arduino IDE. This paper presents a low implementation cost Data Collection Circuit (DCC) using AT-Arduino commands-based microcontroller ESP8266 and custom IoT device for environment data collection from any physical circumstances. This paper has the scope to introduce the NoSQL, scalable, serverless, real-time database that is Google's firebase, to store the sensor data for real-time monitoring and management of the database.

III. Working

In the proposed system saline is automatically monitored by using the Internet of Things. The hardware devices include a Saline bottle, Load Sensor, signal conditioning circuit, power supply, LCD display, GPRS SIM800L, Arduino UNO R3 etc. Here a load cell is used to measure the weight of saline which generates analog signals that can be transmitted to signal conditioning circuit. A signal conditioning circuit receives analog signals from the load cell, and it amplifies those signals, converts the analog signal to digital and transfers them to the Arduino UNO R3 microcontroller. When the weight of saline goes below threshold value then this value is sent over the receiver section of the Arduino UNO R3 then it transmits the signal to GPRS SIM800L. Here weight is directly proportional to level. GPRS SIM800L will receive commands from the microcontroller and transmit alert messages accordingly to the user's smartphone. The information about the saline level will be displayed on LCD and graphical representation is seen in the Android App by fetching all information from the IoT cloud. Figure 2 indicates the flowchart of the saline system.

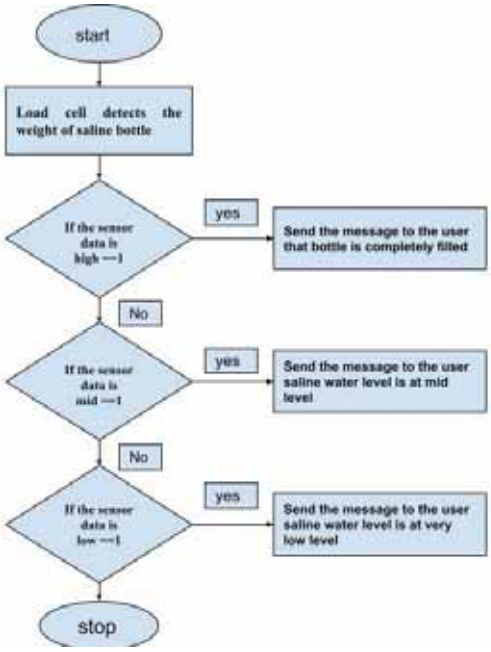

Figure 2. Flow chart of Saline system

IV. Prototype

The prototype model is built with the following set up. It consists of a power supply which is given to the hardware components by the transformer which converts 220V AC to 0-12V AC. A fully activated Micro SIM card in the socket is inserted. The Tx pin and Rx pin are connected on the Arduino. It will be using software serial to talk to the module. Once the system gets connected to the server or a network the push button of the Arduino UNO R3 must be pressed. The input to the load cell is given through the weight of saline bottle. As the saline weight varies, the signals generated from the sensor will get amplified and converted into digital signals due to HX711 which works as a signal conditioning circuit. The digital signal is transferred to the Arduino UNO R3 microcontroller. When the weight of saline goes below threshold value then the level is low as they both are directly proportional, this value is sent over the receiver section of the Arduino UNO R3 then it transmits

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the signal to GPRS SIM800L. GPRS SIM800L will receive commands from the microcontroller and transmit alert messages accordingly to the user's smartphone. The information about the saline level will be displayed on LCD, Continuous data about the level of saline bottle can be seen in the excel sheet and graphical representation is seen in the Android App i.e., ThingSpeak by fetching all information from the IoT cloud. Figure 3 shows the prototype of the system.

Figure 3: Prototype of the saline system

V. Results

The weight of the saline bottle indirectly indicates the amount of saline present in it. Three levels (HIGH MEDIUM and LOW) are fixed to indicate the level of the saline present in the bottle. When the weight of the saline bottle is between 350 g – 500 g then the condition is considered HIGH. When the level of the saline bottle is between 200 g – 350 g then the condition is considered as MEDIUM. The weight below 200 g is considered LOW. The above-mentioned conditions are explained clearly in the following sections.

A. Condition 1

The weight of the saline bottle is well above the set threshold level (424.08 g) indicating HIGH condition. Figure 4 shows the case of weight of the saline bottle is high hence the level of the liquid in the saline bottle is high as they both are directly proportional.

Figure 4. Level of the liquid in the saline bottle is HIGH.

Figure 5 shows the alert message which has been sent to the user's phone saying "**ALERT, SALINE STATUS IS HIGH LEVEL, WT:424.08 g**". Figure 6 indicates the graphical representation of weight of saline bottle and time.

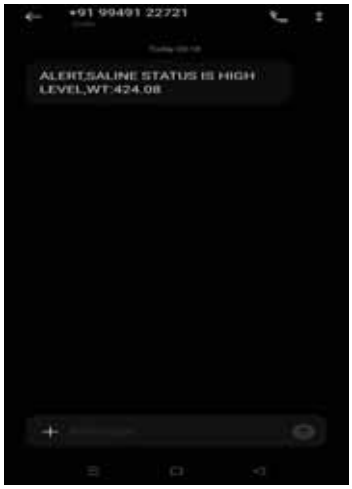
- 

Figure 5. Alert message indicating the liquid in the saline bottle is HIGH.

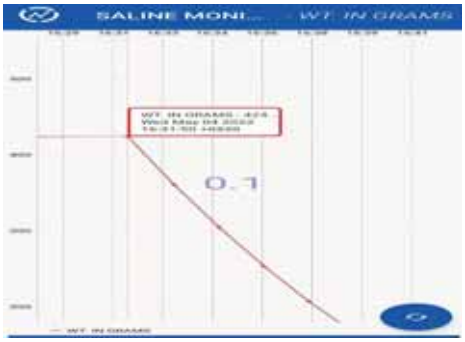


Figure 6. Graphical representation of the weight of the bottle in HIGH condition

B. Condition 2

The weight of the saline bottle is medium (254.08 g) hence the level of the liquid in the saline bottle is medium as they both are directly proportional. Figure 7 shows the level of Saline bottles. Figure 8 indicates the corresponding alert message indicating "**ALERT, SALINE STATUS IS MEDIUM LEVEL, WT:254.08 g**" and Figure 9 indicates the graphical representation of the same.

Figure 7. Level of the liquid in the saline bottle is MEDIUM.

Figure 8. Alert message indicating the liquid in the saline bottle is MEDIUM.

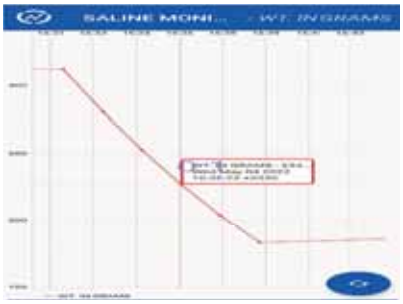


Figure 9. Graphical representation of the weight of the bottle in MEDIUM condition

C. Condition 3

The weight of the saline bottle is low (143.56 g) indicating the LOW condition. Figure 10 indicates the corresponding alert message indicating **"ALERT, SALINE STATUS IS LOW LEVEL, WT:143.56 g"** and Figure 11 indicates the graphical representation of the same.

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Figure 10. Alert message indicating the liquid in the saline bottle is LOW.

Figure 11. Graphical representation of the weight of the bottle in LOW condition

Continuous data indicating the level of saline bottle can be seen in the excel sheet which is taken from the ThingSpeak application as shown in figure 12.

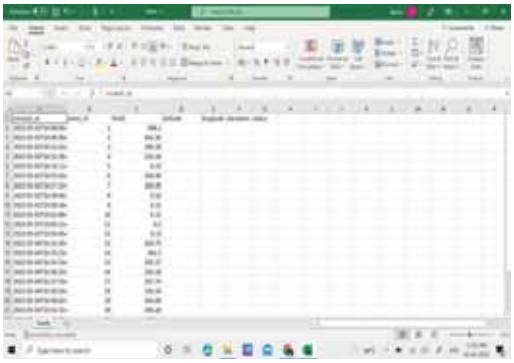

Figure 12. Excel sheet indicating the data.

VI. Conclusions

IoT based saline level monitoring system, makes the efforts on the part of nurses minimal. Human intervention is reduced as the system is automated. As the saline reaches different levels, alert notifications are sent to the mobile of nurses or doctor; this enables them to visit the patient less frequentlyto check the level of saline in the bottle since an alert notification will be sent to the nurses, doctors, caretakers when saline reaches the critical level. It will save the life of the patients. This will reduce the stress in continual monitoring by the doctor or nurse at an affordable cost. This automatic saline level monitoring system provides more flexibility to doctors, thereby the patients care is enhanced. Hence it saves lots of time for a doctor or nurse who is on duty. This proposed system can automatically monitor the saline flow rate by using an Arduino UNO R3 microcontroller. It can wirelessly send the data to nurses or doctors' computers or a mobile using GPRS SIM800L and display the results. The system is loyal, remunerative and comfortable for nurses. It can be reused for the next saline bottle. It is beneficial for nurses as well as doctors at rural hospitals. Nurses can easily monitor saline levels from a distance.

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