Feasibility Analysis of Health Monitoring Using IOT Enabled Automated Saline Infusion

S. Ayisha ,Assistant professor, Electronics and Communication Engineering , Shree Venkateshwara Hitech Engineering College,Gobi,Erode-638455, TamilNadu,India
ayishaecesvhec@gmail.com

V. Vanipriya, Electronics and Communication Engineering , Shree Venkateshwara Hitech Engineering College, Gobi, Erode-638455, TamilNadu, India.
Vanivelli0310@gmail.com

V. Poovika, Electronics and Communication Engineering , Shree Venkateshwara Hitech Engineering College, Gobi, Erode-638455, TamilNadu, India.
Poovi9520@gmail.com

S. Resika ,Electronics and Communication Engineering ,Shree Venkateshwara Hitech Engineering college,Gobi,Erode-638455,TamilNadu,India
resins@gmail.com

Abstract — **With the global population on the rise, there's a growing imperative for proactive healthcare measures. Recent years have witnessed remarkable progress in clinical care, propelled by technological advancements in sensor and microcontroller technologies. These advancements aim to expedite patient recovery in hospital settings. A critical aspect of patient care is ensuring each individual receives optimal treatment and continuous monitoring, alongside timely administration of essential nutrients. Saline solution stands out as a cornerstone therapy for many hospitalized patients, serving to alleviate inflammation in various bodily systems such as the lungs, heart, kidneys, and skin. However, despite its widespread use, administering saline to patients requires constant oversight by nurses or caregivers. Regrettably, instances occur where a patient's blood flow reverses into the saline tubing system, posing potential risks. To address this challenge, this study proposes a system for monitoring saline levels and issuing automatic alerts. This system aims to enhance patient safety during saline administration, mitigating risks associated with inadvertent complications. By implementing such a system, hospitals can ensure more reliable and secure patient care protocols, ultimately contributing to improved healthcare outcomes.**

Keywords— Saline solution,. Inflammation,. Automatic alerts Monitoring system, Mitigate.

I. Introduction

The Internet of Things (IOT), often hailed as the next frontier in technology, is poised to witness a significant expansion, with projections estimating the presence of approximately 30 billion connected devices by the decade's end. This network encompasses physical objects embedded with programming, sensors, and various technologies, enabling communication and data exchange with other interconnected devices and systems via the internet. Essentially, IOT represents the interconnection of tangible items with online connectivity. In numerous instances, IOT facilitates the linkage of specialized gadgets with restricted programmability and adaptability.

IOT stands out as a prominent player among the burgeoning technological advancements, finding applications across diverse domains such as Machine Learning, Embedded Systems, Smart Homes, Smart Cities, Autonomous Vehicles,
Agriculture, Data Analytics, Aviation Services, Healthcare, Traffic Surveillance, Home Automation, E-commerce, and more.

Individuals are vulnerable to respiratory ailments triggered by coronaviruses. Amidst the COVID-19 pandemic, hypertonic saline solution is administered to patients to alleviate inflammation in various bodily organs like the lungs, heart, kidneys, and skin. Additionally, it serves to replenish fluids in individuals who are unable to consume them orally, either for hydration or meeting their daily salt and water requirements. However, the usage of hypertonic saline carries potential adverse effects, such as elevated body temperature, diminished oxygen saturation, and decreased pulse rate in patients.

In this procedure, ongoing surveillance is imperative. The infusion rate of saline is regulated using the drip chamber, which dispenses the solution in the required dosage into the patient's system. Whenever saline is being administered, it necessitates personnel to monitor the blood glucose levels, with checks performed at regular intervals. The patient under consideration requires meticulous observation. In this scenario, healthcare professionals must consistently assess the saline levels being administered to the patient. Following the depletion of saline, two potential issues may arise: retrograde blood flow from the patient's body into the saline container due to a pressure differential, and the introduction of air bubbles from the saline container into the bloodstream, halting blood flow and jeopardizing patient safety. To mitigate these risks, healthcare providers must maintain constant vigilance over the patient. However, amidst the current pandemic, the demanding schedules of nurses and doctors may pose challenges to their ability to maintain continuous monitoring.

Therefore, an automated monitoring system for saline fluid is proposed in this study, aiming to safeguard patient lives and alleviate the burden of constant fluid monitoring in hospitals where a limited number of nurses are tasked with numerous patient assignments. This system also incorporates sensors to assess the patient's temperature, oxygen saturation, and pulse rate, offering comprehensive monitoring capabilities. Such technology enables medical staff to remotely observe saline levels, reducing the need for continual on-site monitoring by doctors and nurses. Upon depletion of the saline bottle, a stepper motor is employed to regulate fluid flow by compressing the capillary tube, preventing the backflow of blood and the introduction of air bubbles into the patient's bloodstream.

The sensors detect the body temperature and heart rate of the patients, with the results being presented on a display. Additionally, the medical history of each patient will be stored on the internet server, allowing doctors to access pertinent information remotely, eliminating the necessity for their physical presence.

The remainder of the document is structured as follows: Section two delves into the relevant literature, Section three outlines the proposed methodology, and Section four contains the reference list.

II. Related Works

Kriti Ojha and colleagues [1] introduced an IOT-enabled solution for monitoring saline levels. The system incorporates a level sensor to ensure precise measurements. When the saline level falls below a predefined threshold, notifications are dispatched to nurses via Bluetooth-enabled devices. However, this notification process has the drawback of gradually depleting the battery life of the mobile phones utilized for receiving alerts. The system devised by Kalaivani and co-authors [2] introduces a monitoring solution for cardiac patients, integrating an ECG sensor alongside saline level monitoring. Patient information is presented on an LCD display for easy viewing and assessment.

Mansi G. Chidgopkar and collaborators [3] introduced an automated and cost-effective solution for monitoring saline levels, employing a wireless Bluetooth module and the cc2500 transceiver. This system tracks the flow of saline and provides an estimation of the time remaining until the saline is depleted. Additionally, a buzzer is installed near the patient's bedside, activating an alert when the saline is nearing empty. Sagnik Ghosh [4] presented the creation of an intelligent and advanced saline container. Within this setup, a linear regression algorithm is employed to anticipate the upcoming instance when medical staff must replace the saline bottle.

Anusha Jagannathachari [5] introduced a saline level gauge. This setup oversees the flow of saline, and in the event of depletion, utilizes a DC motor and spring mechanism to obstruct any backward movement of blood within the tubing. Sanjay. B [6] introduced a hospital-based monitoring system for drips utilizing IOT technology. This setup oversees saline levels using a distinct component known as a load cell, while also dispatching alert notifications in the event of saline depletion. Karthik Maddala [7] introduced a system that tracks the flow of saline and showcases its level on a 16*2 LCD display. In the event of saline depletion, an alert message is dispatched to the nursing or medical staff. Ashika A. Dharmale [8] introduced an IOT-based system for monitoring saline levels and issuing automatic alerts. Within this setup, three infrared (IR) sensors are employed to signify the saline level. Additionally, the system halts the saline flow through the utilization of a micro servo motor. Furthermore, all pertinent patient and saline information is stored in a database for subsequent utilization.

Vyankatesh Gaikwad [9] introduced a system for monitoring saline levels, employing an ultrasonic sensor, and facilitating notifications to nurses through a WiFi module. Furthermore, patients can be accessed via a mobile application within this framework. Pooja Pandit Landge [10] introduced a Smart Saline Level Monitoring and Control System. This setup employs an IR sensor to oversee the saline level, and a DC motor is engaged to cease the saline flow. Additionally, patient information is showcased in an Android application within this system. B. Kiruthiga [11] introduced a system designed to monitor both the saline level and the patient's heart rate. To halt the saline flow, a relay driver and a solenoid valve are employed. Additionally, an alert message is transmitted to nursing or medical staff through a GSM module within this setup.

S. Velmurugan [12] introduced a system utilizing a flow sensor and a level sensor to oversee both the flow rate and level of saline, respectively. Within this framework, four solenoid valves are employed to automatically halt the saline flow, facilitated by a UART WiFi module.N. Y. Suma keerthi [13] introduced an Intravenous infusion monitoring system. This setup is designed to oversee the saline level and monitor the rate of saline droplets. Sensor data collected from the Raspberry Pi is stored in the Firebase realtime database, facilitating the transmission of alert messages. Sakshi D. Ambadkar [14] introduced an NRF Transceiver based system for monitoring saline levels, health parameters, and controlling functions. This setup oversees the saline level, as well as the patient's heart rate and temperature. A servo motor is employed to cease the saline flow, and the system is capable of sending alerts in case of any abnormalities in the patient's health.

Zeng Chen [15] introduced a framework titled "Enhancing Healthcare through Detection and Prevention of COVID-19 Using Internet of Things and Mobile Application". This system aims to monitor the level of saline, as well as the heart rate and temperature of the patient. Sensor data is transmitted to the Firebase database, and patient information can be accessed through the Android application. Md. Milon Islam [16] introduced a system designed to monitor both the patient's body temperature and the temperature of the patient's environment. Utilizing the ESP32 module, the patient's data is transmitted to Thingspeak, enabling access to patient information from any location. Mustafa A Al-Sheikh [17] introduced a system to oversee the temperature, heart rate, oxygen saturation level, and ECG of patients. The health monitoring application on Android smartphones allows for the monitoring of all patient details.

III. PROPOSED WORK

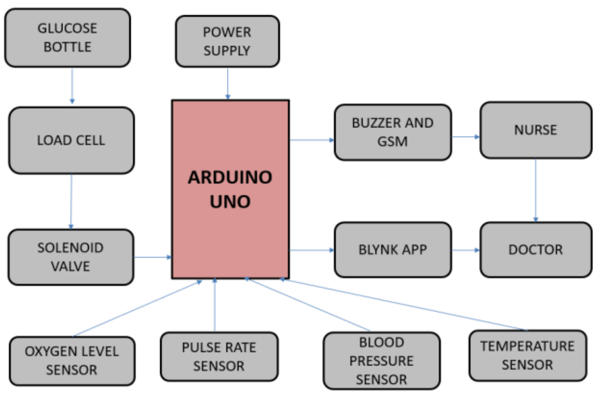

Figure 1: System Diagram

A) Assemble the hardware components

The hardware elements employed in this project include the load cell and the MAX30100 Pulse rate Sensor.

B) Saline level prediction

The saline solution level is determined using the load cell, which indicates whether the saline bottle contains a sufficient or insufficient amount of fluid. This sensor is equipped with an LED light that illuminates when the saline bottle is filled and extinguishes when it is empty. It is interfaced with an Arduino microcontroller. The Arduino software, an open-source platform, facilitates sensor data acquisition, with results accessible through the Arduino's serial monitor. Patient records are stored in a database, and their information is also accessible via a web application.

The system incorporates a DHT11 Temperature Sensor, Arduino ATMEGA328, Arduino Mega, GSM Module SIM900A, solenoid valve, pulse rate sensors, oxygen level sensor and pressure sensor. These sensors are linked to the Arduino board. Whenever an anomaly in the patient's health is detected, the GSM module sends alert notifications to mobile devices.

Additionally, a load cell is engaged to halt the saline flow, mitigating the risk of blood reflux from the patient's body to the saline bottle or the introduction of air bubbles into the bloodstream from the saline bottle. The interconnections of these components are illustrated in Figure 1.

Utilizing a load cell within the glucose container, determine the saline exhaustion point. Upon detection, promptly dispatch a notification and trigger an alarm to the designated mobile device. Employing a solenoid valve, cease the liquid flow, and seamlessly transition to the subsequent glucose reservoir. Ensure continuity by activating the succeeding glucose bottle while deactivating the previous one.

Algorithm for forecasting saline fluid:

1. Establish connection between the sensor and Arduino.
2. Set initial saline level to zero.
3. Position the sensor inside the saline bottle.
4. If (saline level equals zero):
   Display "The saline bottle contains fluid." 6. Else if (saline level equals one):

Dispatch alert message to the nurse.
Display "The saline bottle is nearing depletion."

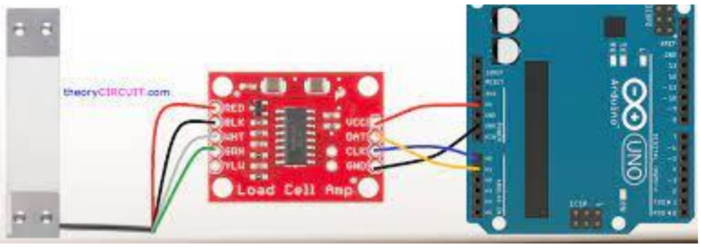

Figure 2: Arduino UNO connected with Wireless water level sensor and servo motor

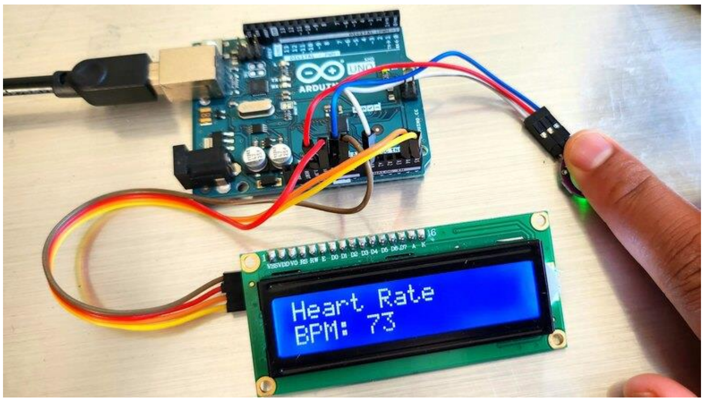

Figure 3 : Arduino connected with heart rate sensor

C) Effects of saline fluid detection

The primary effects of administering saline fluid typically include a rise in the patient's body temperature and an elevation in heart rate. The aim of this module is to detect the patient's temperature, oxygen level, blood pressure rate and pulse. Figure 3 illustrates the connection setup of the wireless water level sensor, temperature sensor, and heart rate sensor to the Arduino.

To monitor the patient's temperature, the DHT11 (Digital Temperature and Humidity Sensor) is employed. This sensor contains a thermistor for temperature measurement, along with a humidity sensing component. Placed on the patient's hand, the DHT sensor gauges body temperature to determine whether it falls within normal ranges or indicates an anomaly.

Another effect of saline administration is an increase in heart rate, which can pose risks to patients. To monitor this, the Pulse Oximeter MAX30100 sensor is utilized. This sensor facilitates real-time monitoring of heart rate and blood oxygen levels. Connected to Arduino, it can be conveniently clipped onto a patient's fingertip or earlobe. The pulse sensor, tailored for Arduino use, includes a 24-inch color-coded cable with header connectors. Positioned with its heart logo in contact with the skin, the sensor's LED emits light through a small hole on its backside. If the heart rate falls between 50bpm and 90bpm, it is considered normal; otherwise, an alert message is dispatched to the nurse.

Algorithm for forecasting patient temperature:

1. Establish connection between the sensor and Arduino.
2. Set initial temperature reading to zero.
3. Position the temperature sensor on the patient.
4. If (temperature reading equals zero):
5. Display "The temperature sensor is not detecting any reading."
6. Else if (temperature reading is greater than zero):
7. Dispatch alert message to the nurse.
8. Display "The patient's temperature is abnormal."

Algorithm for predicting patient pulse rate and oxygen level:

1. Establish connection between MAX30100 and the Arduino.
2. Position the sensor on the patient's finger.
3. Retrieve and display the heart rate and blood oxygen level.
4. If (heart rate is between 50 and 90 and oxygen level is between 95 and 99):
   Display "NORMAL".
6. If (oxygen level is less than 95):
   Dispatch alert message to the nurse.
   Display "OXYGEN LEVEL IS ABNORMAL".
7. If (heart rate is greater than 100 or less than 50): Dispatch alert message to the nurse.
   Display "HEART BEAT IS ABNORMAL".

Hardware implementation

A. Hardware Model

An Arduino board is interfaced with a load sensor , DHT11 sensor for temperature and humidity monitoring, a pulse rate sensor, a GSM module for communication, and a Servo motor for control. These components are integrated to create a network of sensors that gather data, which is then stored in a database. This system enables the monitoring of saline levels remotely and in real-time.

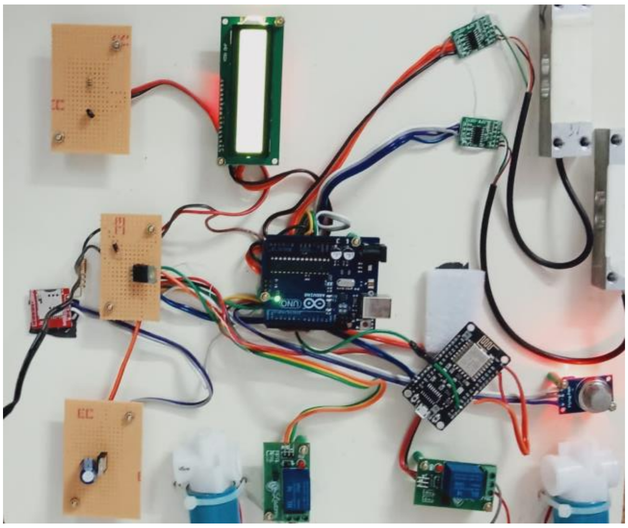

Figure 4 : IOT based saline monitoring system

Table 1 displays the sensor types employed in the system along with their corresponding outputs.

SENSORS	Saline Level	Body Temperature	Heart Rate	Oxygen Level
Load Cell	Present			
Temperature Sensor		Present		
Pulse Rate Sensor			Present	Present

Table 2 outlines the iterations for measuring saline level, temperature, heart rate, and humidity.

Iteration	Saline Level	Temperature	Heart Rate
1	1	32.2	36
2	1	33.7	48
3	1	34.5	75
4	1	36.3	83
5	0	37.4	98

SOFTWARE IMPLEMENTATION

A) Blynk App

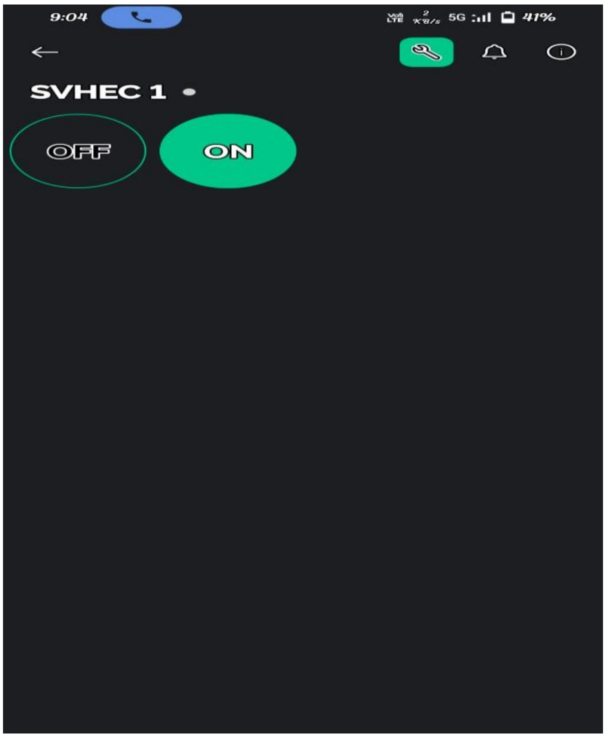

Figure 5: Blynk App

B) Alert messages to doctor

Figure demonstrates the alert notification system designed to inform nurses and doctors in case of emergencies. This includes alerts triggered by an empty saline bottle, fluctuations in patient health such as temperature increase, and changes in heart rate.

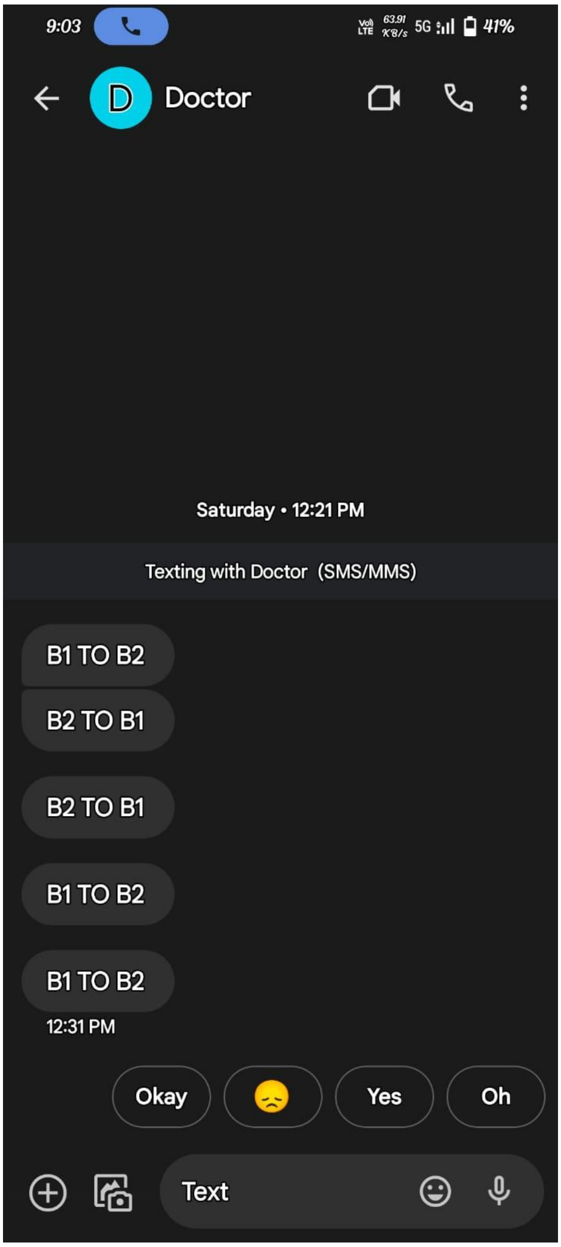

Figure 6 : Messages to doctor

C) ThinkSpeak Results

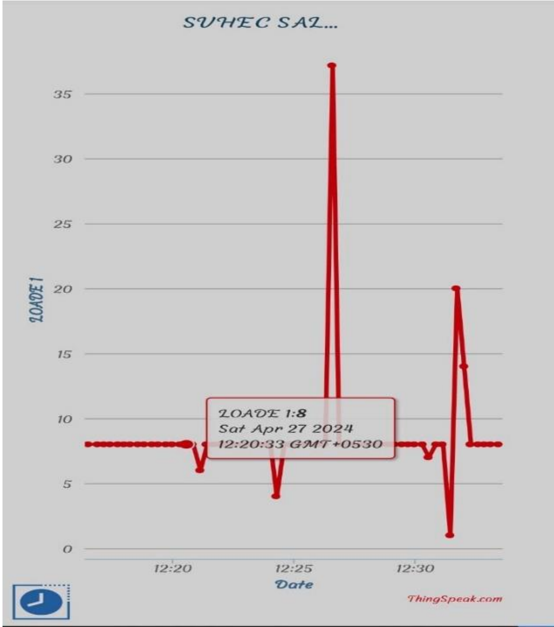

Figure 7 : Load cell 1

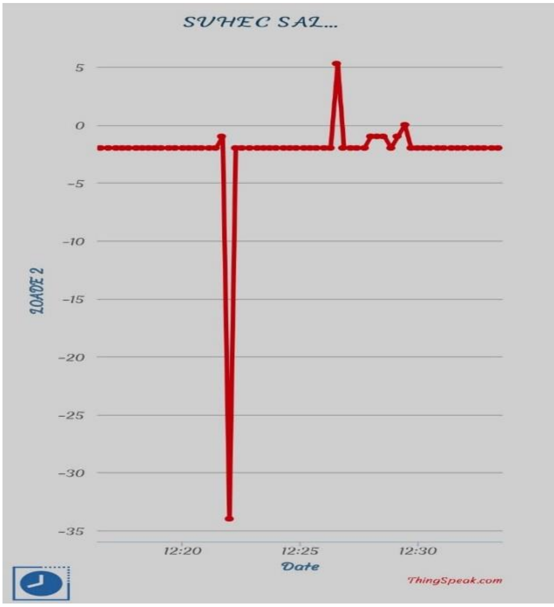

Figure 8 : Load cell 2

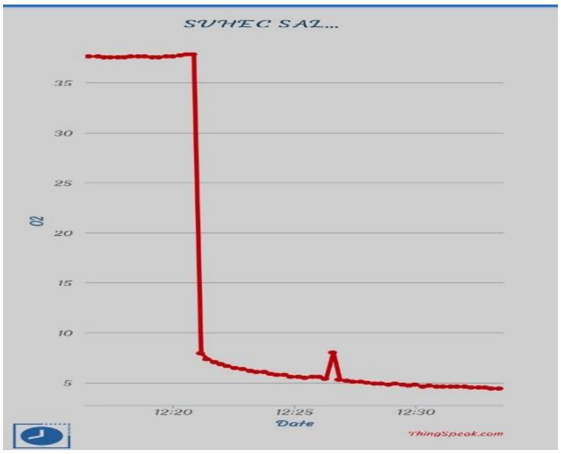

Figure 9 : Oxygen (O2)

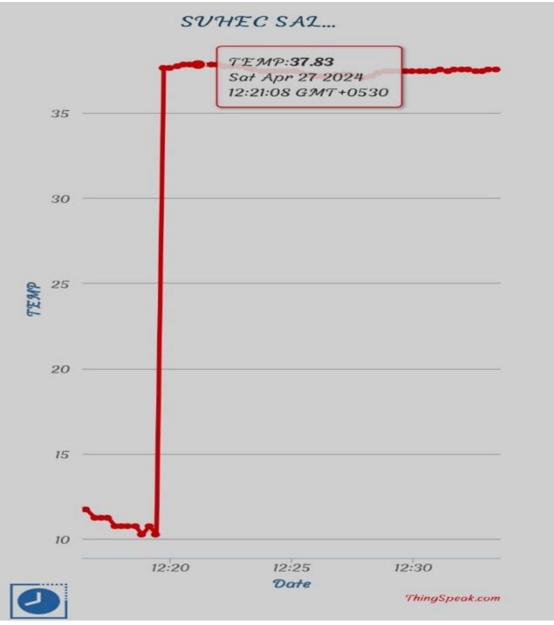

Figure 10 : Temperature

V CONCLUSION

This paper introduces an automated method for monitoring saline fluid levels in bottles, along with the capability to halt saline flow using a solenoid valve. The proposed system is well-suited for hospital environments and can be accessed via computer or smartphone, enabling doctors or nurses to monitor saline levels, temperature, blood oxygen levels, and patient heart rates remotely and at any time. With minimal human intervention due to its automated nature, this system proves particularly beneficial for nurses managing multiple patients in busy hospital settings.

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