Advanced Multipurpose Hand Hygiene Dispensary System using IOT

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***Abstract*—This paper proposes an Advanced Hand Hygiene Dispensary system using IOT to reduce the spread of viruses in public places such as hospitals and malls. The system tracks hand washing activities through temperature monitoring and liquid level measuring, which are accurately processed through parallel working sensors. The dispensary system features Ultrasonic and MLX90614 temperature sensors that measure Liquid distance and hand temperature, respectively. These readings are displayed on an LCD screen and stored on a ThingSpeak IOT cloud platform. The system's experimental results are displayed on a data collection dashboard using HTML, CSS and JavaScript with interactive maps generated using the Leaflet.js library. Users can easily find the nearest hygiene node using the maps. Comparison with existing Hand Touch operated dispensers showed that the proposed IOT-based Dispensary system provides an efficient, safe, and reliable option for hand hygiene. It automates processes, visualizes and analyzes live data in real-time.**

***Index Terms*—Non contact dispensing, IOT Technology, ThingSpeak IOT cloud, MLX90614 temperature monitoring, Liquid level monitoring.**

I. INTRODUCTION

During pandemic, use of Handwash has increased drastically especially in hospitals, malls and movie theatres due to effective use of hand touch operated liquid dispensers risk of spreading virus among people is high. For detection of body temperature, sanitization to maintain hand hygiene temperature gun and Hand press operated dispensers are used which increased the cost and time for performing both the tasks separately especially in crowded places like Hospitals and Malls. Thus this automatic and non contact dispensing is designed and developed with integration of features such as to monitor temperature, track hand hygiene activities and measure liquid level accurately.

In [1], the dispenser is equipped with BLE Module, proximity sensors for hand detection, and works on the basis of scanning for BLE signals. As, BLE modules are only provided to the medical staff, people visiting hospital can't have access to the dispensary system instead they have to use the Hand pressable systems.
In [2], the system works on the basis of taking vision input from pi camera using raspberrypi which increases the cost of making more systems for public places and does not include with features such as data analizing, storing and validation, multiple inputs from user etc.

In [3], a solar powered kiosk is made which houses solar panel,hand sanitizing dispenser, Temperature detection system separately which also increased cost and the there is no presence of analizing data of people in an organization.

In [4]-[5], a systematic review has been proposed for determining the improvements and compliance in hand hygiene monitoring technology systems compared to human observations.

In[6], the current state of NB-IOT technology is analyzed and its potential to address challenges faced by smart hospitals, such as limited bandwidth and low power consumption. The use of NB-IOT in smart hospitals is shown to enhance the efficiency and effectiveness of healthcare services.

In [7], hand Hygiene is a critical aspect of infection control in healthcare settings and ensuring adherence to hand hygiene protocols is a major challenge. conventional methods for monitoring hand hygiene such as direct observation, are time consuming and prone to human error. This study examines the current state of video surveillance technology and its potential to address the challenges faced by healthcare facilities in monitoring hand hygiene. The findings of this research have important implications for the implementation of effective hand hygiene protocols and will be valuable to healthcare professionals, researchers andtechnology developers.

In [8], hand hygiene is crucial in preventing the spread ofgerms in healthcare facilities. This study examines the efficacy of touch less dispensers in reducing germ exposure and their impact on hand hygiene practices and outcomes. The findings of this research have significant implications for the implementation of effective hand hygiene protocols. The use of touch less dispensers is shown to improve the safety and hygiene of healthcare facilities.

In [9], A raspberry pi based face mask and body temperature detection system is presented in this study. The system detects face mask usage and measures body temperature in real time. The results demonstrate the potential of Raspberry pi-based systems for screening and monitoring in various settings. The findings have significant implications for the development of effective and affordable screening systems for controlling the spread of infectious diseases.

In [10], the authors proposed an IOT based system for automated health monitoring and surveillance. The system uses wearable devices and sensors to monitor individuals health in real time. The results demonstrate the potential of IOT-based systems for health monitoring, particularly during public health crises. The findings have important implications for the development of effective and efficient health monitoring systems post-pandemic. The system provides a valuable tool for health authorities to monitor the spread of infectious diseases.
An advanced hand hygiene dispensary system using IOT offers touch less operation, real-time monitoring of hygiene compliance, the ability to dispense different types of sanitizers or soaps, and remote management. These features improve hygiene, reduce the spread of germs, and provide a more efficient solution for maintaining a hygienic environment.

II. SYSTEM IMPLEMENTATION

A. System Architecture

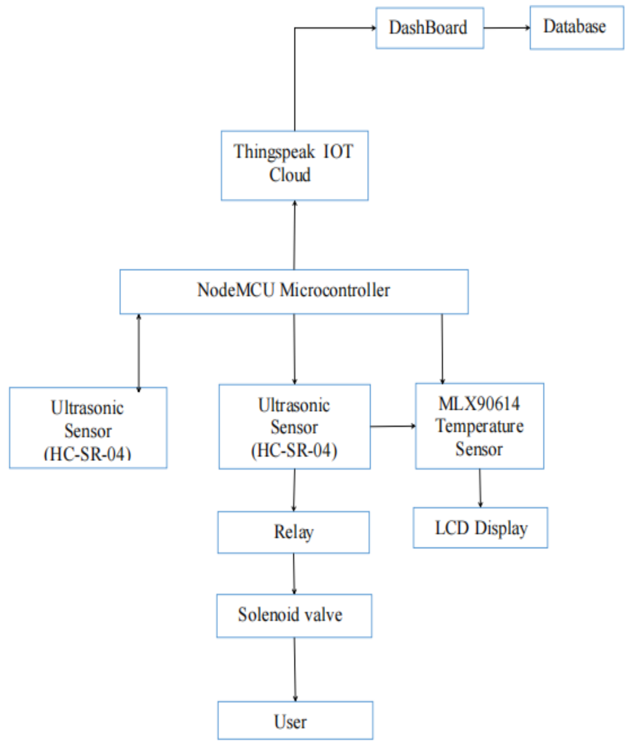


Fig.1 Block Diagram of Hardware setup

The block diagram of Advanced Hand Hygiene system is shown in Fig.1. NodeMCU Micro controller is used in the system for controlling various sensors and Actuators. The ultrasonic sensor is used as a first input which measures thedistance between the sensor and hand. When the user's hand is in the range of ultrasonic distance (placed at less than 15cm) a signal is sent for turning on relay. Relay then turns ON submersible mini pump, which dispenses the liquid to the user. The second input which is taken from theuser is using MLX90614 Temperature sensor. User's hand Temperature is taken when user places his hand beneath thedispensary system and displays it in the LCD Display. Dispensing of Liquid and Temperature monitoring process runs parallel in the system. The third input in this system is Ultrasonic sensor which is placed at the bottom of the lid. This sensor measures the liquid level in the dispensarysystem by passing high frequency sound waves from Triggering part and receives to Echo part when it touches surface of liquid.

III. SENSORS USED

A. Ultrasonic sensor

In Fig.2 Ultrasonic detector is used to measure the distance of an object by emitting sound waves and converting them into electrical signals. An ultrasonic wave is transmitted at a 30-degree angle. Measuring angles should be at least 15 degrees for maximum accuracy.

The distance is calculated by measuring the amount of time it takes for the ultrasonic sound to travel, as well as its velocity.

$$\text{Distance} = \text{Time taken} * \text{Speed of sound} / 2 \qquad (1)$$

To produce the ultrasonic sound, the trigger pin must be activated to a high level for a minimum duration of 10μs. The output of this activation will then be received by the Echo pin, which will measure the time elapsed to determinethe distance.

Fig.2 Ultrasonic sensor

A. MLX90614 Temperature Sensor

In Fig.3 mlx90614 sensor works on the principle of infrared radiation emission. The sensor contains a thermopile, which is a series of thermocouples that detect the temperature difference between the object being measured and the ambient temperature. The thermopile generates a voltage proportional to the temperature difference, which is then amplified and filtered to produce a signal that is proportional to the object's temperature. The MLX90614 has a field of view (FOV) of approximately 90 degrees, the object temperature range can be varied from -70 C to 382.2 C whereas ambient temperature range can be varied from -40 C to 125 C depending on the user requirement.

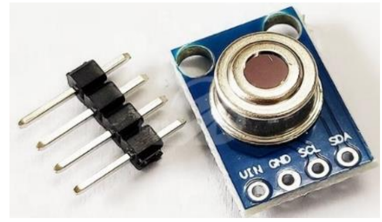


Fig.3 Temperature Sensor

IV. HARDWARE SETUP

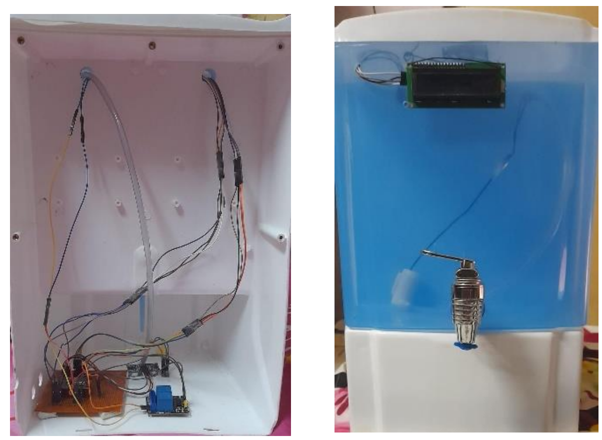


Fig.4 Hardware Setup

Fig.4 shows the prototype of Hand Hygiene Dispensary system is capable of storing 10 Liters of liquid. where the Ultrasonic sensor is attached at the bottom of the dispenser along with temperature sensor. The three pins of the relay vcc, gnd are connected to the NodeMcu while input pin is connected to the pin13 of NodeMcu. Power pin of submersible mini pump is connected to the outpin pin of relay and GND is connected to the gnd of NodeMcu. SDA, SCL pins of temperature sensor is connected to the D1, D2 pins of NodeMcu. The LCD Display is connected on top surface of Liquid storage tank for displaying Temperature monitoring as well as liquid level monitoring. An ultrasonicis connected on the bottom surface of lid with NodeMcu to measure the distance of liquid level and visualization is displayed on the Thingspeak IOT platform.

V. VALIDATION OF EXPERIMENTAL RESULTS

A. Temperature Accuracy Test

TABLE 1. ACCURACY OF TEMPERATURE MEASUREMENT

Ultrasonic distance (cm)	Normal Body Temperature	Sensor based measurement of Body Temperature
4cm	37°C	36.7°C
7cm	37°C	37.1°C
10cm	37°C	38°C
13cm	37°C	33°C
15cm	37°C	32°C

Fig.5(a) and Fig.5(b) shows Temperature data of the User which is uploaded to the Thing speak IOT Cloud platform on April 7th 2023 and May 6th 2023 at 19:25 pm and 12:10 pm. Each time user uses the hand hygiene system, the temperature datagets updated and the visualization of data can be seen as a graph. These results can be downloaded for tracking of their Hand Hygiene Activities.

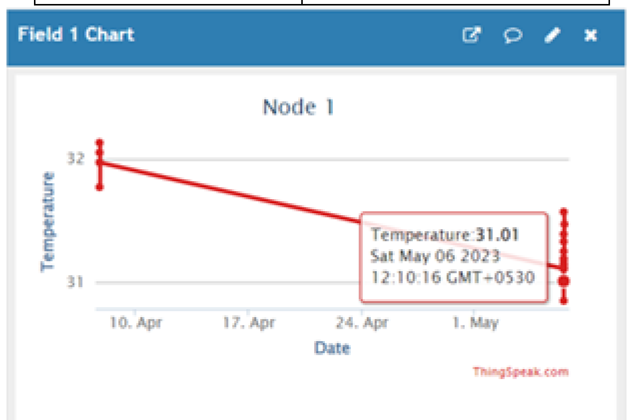
Table 1 results Indicate the accuracy of sensor based measurement depends on Field of View which is used to determine the relationship between object and sensor distance. If the sensor is nearer to the object, then the sensing area is low which increases the accuracy of readings whereas accuracy is decreased when the object is farther from the sensor.
The highest difference between Normal and Sensor measurement is 4°C. So, accuracy of overall measurement is around 95%.

B. Liquid Level Test

The accuracy of liquid level test is calculated by continuous testing of setup. Fig.6(a) shows the data chart of Liquid level on January 13th 2023 at 09:11am. The liquid level in the Hand Hygiene system is recorded as 100% whereas Fig.6(b) shows the percentage value of liquid level on February 6th 2023 at 11:27am which is recorded as 39%. This IOT platform is used due to the ability to store large hand hygiene data such as readings,time and date at which the system has been used. Due to the live monitoring of data the user can find the liquid present in the dispensary system and fill it once its under threshold value. The threshold value is kept as 20%
The results from Table 2 show that when the distance decreases between sensor and liquid (kept as minimum distance as 10cm from the sensor) liquid percentage level is increased (kept maximum percentage level at 28cm)because the nearer the liquid to the sensor, the more the liquid level whereas the liquid percentage is low when the distance increases with the liquid. Each time the user uses the system, the data will be updated in the cloud.

TABLE 2. ACCURACY OF LIQUID LEVEL MEASUREMENT

Ultrasonic Distance (cm)	Liquid Level percentage (%)
10 cm	100
14.25 cm	73
17.02 cm	62
19.52 cm	54
24.76 cm	39
26.21 cm	22
28.84 cm	7



(a)

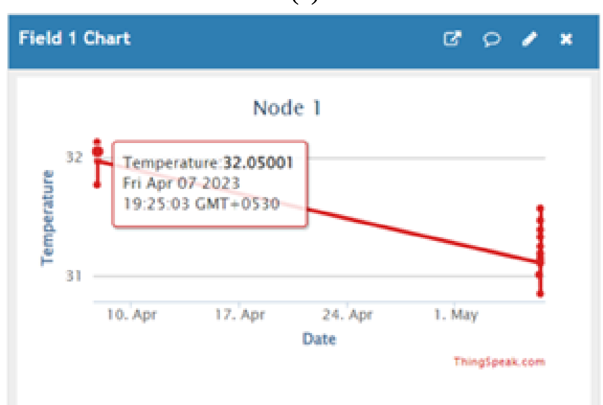


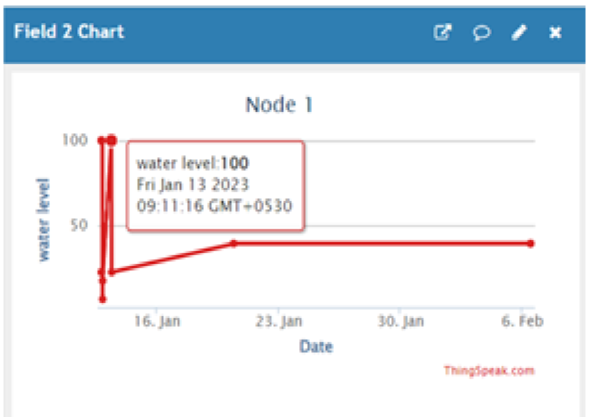
Fig.5 Temperature data in Thingspeak

(a)

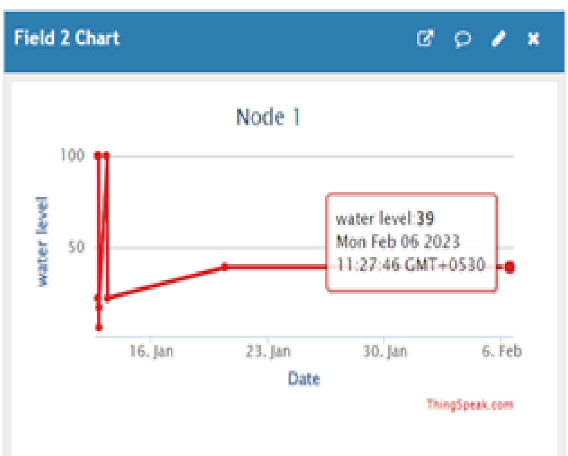
VI. SOFTWARE IMPLEMENTATION

A. Software System Architecture

Fig.7 illustrates the block diagram of the Hand Hygiene System Dashboard. In this system, Thingspeak IOT cloud is utilized to store hygiene readings of both the user and the node. These readings include liquid level data and are updated in real-time during the usage of the node. Subsequently, the readings are stored in a channel and are exported in HTML and CSS format to be displayed in the dashboard. To enhance the visualization of the data, the dashboard also incorporates Leaflet.js, a powerful Javascript library that allows for the deployment of simple and interactive maps.



(b)



(b)

Fig.6 Liquid level data in Thingspeak

The latitude and longitude information of a particular location is included in the Javascript and is displayed in the dashboard. This enables the users to have a better understanding of the hygiene status of different areas and facilitates informed decision-making.

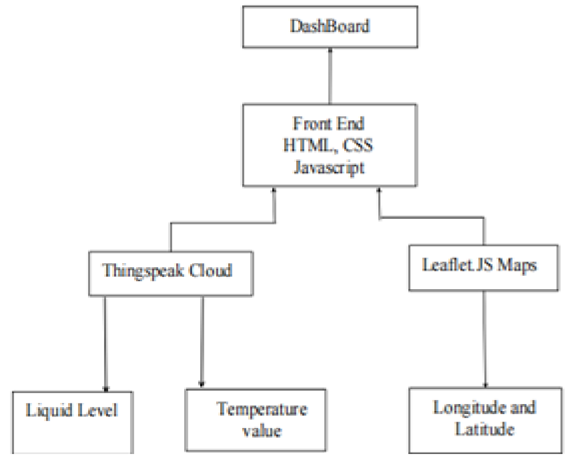


Fig.7 Block Diagram of Hand Hygiene System Dashboard

B. Features of DashBoard

Fig.8 shows the design of a hand hygiene system dashboard that is built with HTML, CSS, and JavaScript. The dashboard was designed to address the limitations of existing systems in the market.

The dashboard includes three features:

Fig.8 Home Page

1) Tracking of the level of liquid present in the nodes: Fig.9 shows the data collection dashboard, which displays the liquid level data of each node exported from the Thingspeak channel. This data is accessible to any user. If the liquid level is below the threshold value (which is 22 cm for this hand hygiene system), the dashboard displays an alert message. This feature allows users to track the level of liquid present in the hand hygiene nodes, which are the devices that dispense hand sanitizer or soap. This information can be used to ensure that the nodes are always stocked with enough liquid, and to improve hand hygiene compliance and reduce the spread of infection.

Fig.9 Data Collection DashBoard

2) Tracking of individual hand hygiene data:

Fig.9 shows the data collection dashboard, which displays the body temperature data of users. The Readings of the user is first gets stored in Thingspeak and then it is exported from the Thingspeak channel and displayed in the Node1 feature of the dashboard. This allows users to track their own body temperature data. This information can be used to monitor their health and identify any potential health problems.

3) Locating the nodes easily using map:

Fig.10 shows the map feature, which allows users to easily locate the hand hygiene nodes in a facility. This can be helpful in large facilities, such as hospitals, malls, and colleges, where there may be many nodes located throughout the building and in public areas. The map feature uses Leaflet.js, an open source library, to deploy simple, lightweight maps in the dashboard. Users can click on a node on the map to see its location and a small description. This information can be used to quickly and easily find the nearest hand hygiene node.

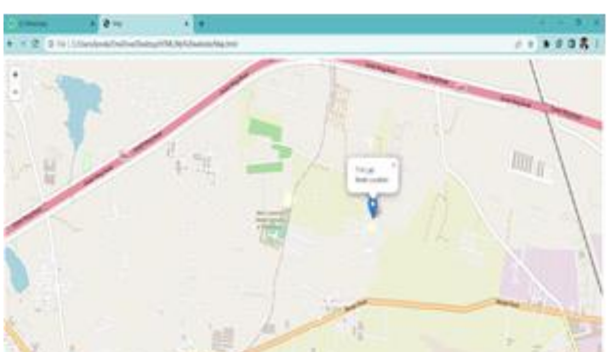


Fig.10 Leaflet.js Map

CONCLUSION

Majority of Existing Dispensers in the market are Hand pressable. Due to this, Spreading of virus will be increased. The existing Dispensers does not Integrate with features such as Tracking of Hand Hygiene Activities, Analysis of Data of people in an organization for the health protection of employees. Majority of people in public places can’t access and locate the node to maintain their Hygiene system. Maintaining Hand Hygiene tracking is necessary especially in the post pandemic period. This data can be used for research purposes in the primary (Medical sector) to prevent the future pandemics and to track the hand hygiene activities of employees within an organization. This is benefited to the society with the use of IOT Technology.

In a large scale, manufacturing of these IOT devices can provide employment opportunities to the rural people in terms of manufacturing, processing and shipping the devices.

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