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Forest Fire Detection Using Lora Communication

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Abstract-The need for efficient fire detection systems is highlighted by the substantial threats that forest fires pose to both human lives and the ecosystem. Limited coverage, high false alarm rates, and delays in signal transmission are just a few of the problems traditional methods for detecting forest fires sometimes encounter. This research study suggests a unique strategy that uses long-range (LoRa) communication technology for forest fire detection to address these problems. LoRa allows for long-range, low-power wireless communication, making it appropriate for installation in sparsely populated, off-the-grid forest areas. This study investigates the development, application, and assessment of a LoRa-based forest fire detection system. The suggested system includes a network of sensor nodes outfitted with LoRa transceivers and fire detection sensors. The sensor nodes send real-time data to a centralised control centre while continuously monitoring environmental variables like temperature, humidity, and smoke. Complex algorithms are used by the control centre to analyse the data it receives and identify probable fire issues. When a fire is discovered, the system immediately creates notifications and sends them to the appropriate authorities and local communities. Numerous field tests were carried out in various forest settings to gauge the success of the suggested strategy. The outcomes show the system's capacity for precise fire detection, minimal false alarm rates, and quick response times. A viable option for early forest fire detection and prevention, the LoRa-based system also shown its benefits in terms of broad coverage, long-range communication, and energy economy. This study advances forest fire management systems by laying the groundwork for the creation of reliable, scalable, and affordable fire detection technologies that can lessen the devastation caused by forest fires. This research paper's main goal is to offer a thorough analysis of the development, use, and evaluation of a LoRa-based forest fire detection system.

Keywords: LoRa communication, environmental monitoring, early warning systems, wireless sensor networks.

I. Introduction

Forest fires are a major cause for concern on a global scale since they harm ecosystems severely, threaten biodiversity, and endanger people's lives and property. The deadly impact of these fires can be lessened with prompt discovery and action. The breadth, accuracy, and response times of conventional forest fire detection techniques, such as human observation and satellite photography, are constrained. As a result, there is an increasing demand for creative solutions that can get around these obstacles and improve forest fire early warning systems.

Wireless sensor networks (WSNs) have become a promising technology for disaster management and environmental monitoring in recent years. WSNs are made up of a large number of autonomous sensor nodes that can monitor different environmental conditions, gather information, and wirelessly transfer it to a centralised control point. This research focuses on the integration of Long Range (LoRa) communication technology into forest fire monitoring systems by utilising the capabilities of WSNs.

LoRa technology allows for long-distance, low-power communication, making it especially well-suited for deployment in harsh, outlying areas like woods. LoRa's increased range makes it possible to build out a widespread coverage network, guaranteeing that even vast forest regions may be properly monitored. Additionally, LoRa's low power consumption makes it possible for sensor nodes to run on battery power for an extended period, which eliminates the need for regular maintenance and power supply in isolated forest sites.

The suggested system consists of a network of sensor nodes that are deployed strategically across the forest and are outfitted with LoRa transceivers and fire detection sensors. By continually monitoring environmental variables including temperature, humidity, and smoke levels, these sensor nodes allow for the early identification of possible fire issues.

Real-time transmission of the sensor nodes' collected data to a centralised control centre allows for the real-time analysis of the data to look for indicators of fire. When a fire is discovered, the system quickly creates alerts and distributes them to the appropriate authorities and adjacent populations, enabling quick reaction and evacuation procedures.

Extensive field experiments were carried out in various forest ecosystems, mimicking various fire scenarios, to evaluate the performance of the proposed system in terms of accuracy, false alarm rates, and response time. The test results demonstrate the effectiveness of the LoRa-based forest fire detection system by showing that it can effectively detect fires, reduce false alarms, and send out quick alerts for efficient fire management.

The proposed system holds significant promise for improving early warning systems and boosting the effectiveness of forest fire detection and prevention by utilising the benefits of LoRa communication, including long-range coverage, low-power consumption, and robustness in challenging environments.

II. LITERATURE SURVEY

A wireless sensor network (WSN)-based forest fire detection system utilising the Internet of Things (IoT) is presented in the paper [1] where the authors discuss the necessity of an effective system for detecting forest fires to lessen the harm caused by wildfires. The WSN architecture they suggest consists of sensor nodes containing temperature, humidity, and smoke sensors. A central server receives the data gathered by the sensor nodes and transmits it for immediate processing. Through experimental evaluations, the authors show how successful their system is and contrast it with more conventional fire detection techniques. By highlighting the potential of WSNs and IoT in enhancing forest fire monitoring systems for prompt reaction and mitigation, this research adds to the body of previous knowledge.

The paper [2] explores the integration of Internet of Things (IoT) devices and deep learning algorithms for accurate and timely forest fire detection. The authors emphasize the need for advanced technologies to improve fire management systems. They present a system architecture that combines IoT sensors with a deep learning-based algorithm for real-time monitoring and swift alert generation. Extensive experiments validate the system's high accuracy, low false alarm rates, and fast response times in detecting forest fires. This study highlights the potential of combining IoT and deep learning for effective forest fire management.

The study [3] examines the drawbacks of conventional forest fire detection techniques and the possibility for incorporating LoRa communication technology into the system. The literature review demonstrates the inherent limitations of traditional methods, such as human surveillance and satellite imaging, which highlights the necessity for new technology. Due to its long-range coverage, low power consumption, and appropriateness for deployment in distant and difficult situations, LoRa communication technology emerges as a feasible alternative. LoRa-based wireless sensor networks (WSNs) have been successfully used in environmental monitoring applications in earlier studies, demonstrating its potential for detecting forest fires. While WSNs have been used to detect forest fires in previous studies, this work focuses exclusively on the integration of LoRa technology, with the goal of shedding light on the viability and efficacy of this strategy for enhancing forest fire early warning systems.

The literature review for the publication [4] examines the body of work on wireless communication technology and forest fire detection methods. According to the survey, wireless sensor networks (WSNs) have been carefully examined for their potential to monitor environmental variables and transmit real-time data for the detection of forest fires. The survey also emphasises the benefits of Long Range (LoRa) communication technology, such as its extensive coverage, low power requirements, and adaptability for installation in isolated forest locations. The combination of several sensor types, including temperature, humidity, and smoke sensors, has also been investigated in earlier studies as a way to improve the precision and dependability of forest fire warning systems. The literature review also highlights the value of early warning systems in the management of forest fires, highlighting the relevance of swift detection, accurate data interpretation, and rapid alert transmission to lessen the severe effects of forest fires.

III. METHODOLOGY

A. Hardware Part

The components we are using for our proposed system are LoRa module, ESP32 Microcontroller, Fire Sensor, Buzzer, Soil Moisture Sensor, Humidity Sensor, LCD, Smoke Sensor, Power Supply and Temperature Sensor.

We have made 2 circuit diagrams (Fig. 1 & Fig. 2) for this project and the explanation of working of the system is given below.

There are 2 sections of the hardware, one is the sender module (circuit 1) and other is the receiver module (circuit 2). Both the sections communicate with each other with the help of the LoRa module. LoRa module will get 3.3V DC from the ESP32 module. 12V adapter is connected to the electrical socket and the circuit 1.

Both the circuits have their own ESP32 module. Both ESP32 module is connected with the laptop using microUSB cable. The program is loaded into the ESP32 module.

Once the buzzer beeps, we must switch on the electric connection in circuit 1. When switched ON, 256V AC from the socket will be taken by the adapter, which will transfer it to DC voltage of 12V and the power supply will convert 12V DC to 5V DC. The sensors connected in the circuit 1 will start working. The sensors will send all information to ESP32 module, which will send all information through LoRa module to the Google Firebase. Even the same information will be displayed on the LCD i.e., in circuit 2.

After all the data is transferred to the firebase cloud, then it will send those data to the UI application through its API.

The fire sensor will be getting 5V DC from the power supply and the fire sensor will detect flames along with sending signal to the ESP32 module which will send an alert message to the application and the buzzer will make sound.

The smoke sensor will get 5V DC from the power supply. It will detect whether the smoke is present or not and accordingly it will send signal to the ESP32 module which itself will send an alert message to the application and the buzzer will make sound.

The temperature sensor will get 5V DC from the power supply. If the temperature sensor detects high temperature of the area, then one alert signal will be sent to the application from the ESP32 module.

The soil moisture sensor will be getting 5V DC from the power supply and the soil moisture sensor will detect moisture content in the soil along with sending signal to the ESP32 module which will send the soil moisture value to the application.

The humidity sensor will be getting 5V DC from the power supply and the humidity sensor will detect humidity along with sending signal to the ESP32 module which will send the humidity value to the application.

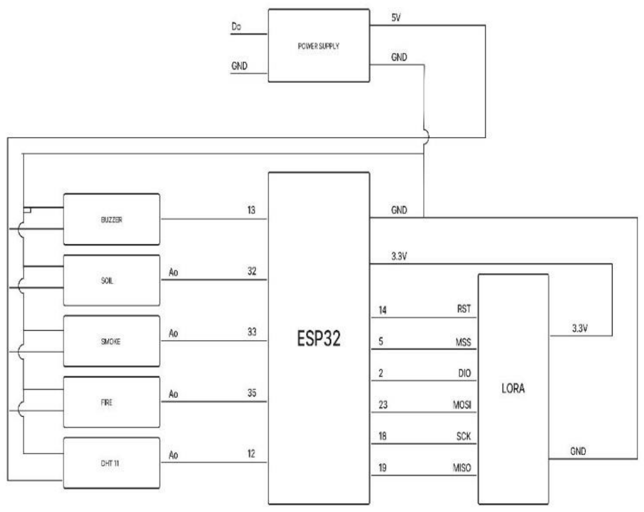


Fig. 1: Circuit diagram of the Transmission Module

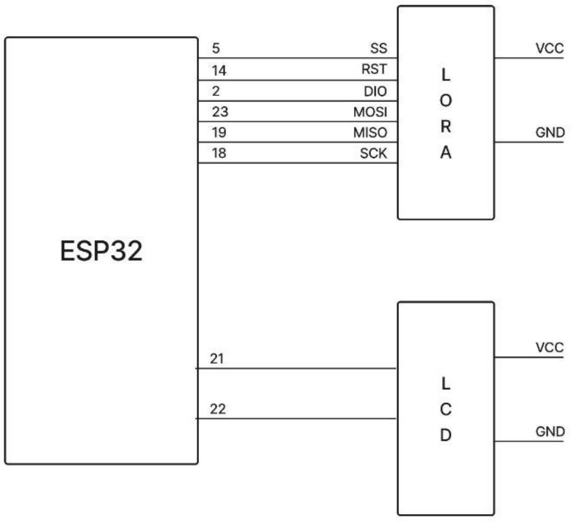


Fig. 2: Circuit diagram of the Receiver Module

A. Software Part

After hardware, comes the software part of the project (Fig. 2). The program is done in Arduino IDE using Embedded C language.

- The sensors will start collecting data from the forest area.
- And for the backend, we have used google firebase cloud to connect with the UI application.
- If the fire value is lower than the threshold value (i.e., 3000), then an alert message will be sent to the UI application and the buzzer will beep.
- If the smoke value is lower than the threshold value (i.e., 3000), then an alert message will be sent to the UI application and the buzzer will beep.
- If temperature is higher than the threshold value, then an alert message will be sent to the UI application.
- The humidity and soil moisture content value will be sent to the UI application.

IV. ADVANTAGES

Our suggested solution has several benefits that make it a promising strategy for enhancing early warning systems. Here are some few advantages: -

- Long-Range Coverage: Because LoRa communication technology has a long range, it makes it possible to build a network with broad coverage in forests. This minimizes the possibility of fires being unnoticed and guarantees that even vast forest zones can be efficiently monitored for fire events. Low
- Power Consumption: LoRa is built to be energy-efficient, enabling sensor nodes to run for long periods of time on battery power. This capability is especially helpful in isolated woodland areas where access to power sources may be difficult or nonexistent. It increases the fire detection system's durability by lowering the requirement for frequent maintenance and power source changes.
- LoRa communication is renowned for being resilient in difficult situations, such as forests with dense vegetation and barriers. The signals can pass through foliage and trees, allowing for dependable data transmission from sensor nodes to the central control station. The fire detection system's continuity and dependability are guaranteed by this strong connectivity.
- Real-Time Monitoring: Systems for detecting forest fires using LoRa offer real-time monitoring of environmental variables like temperature, humidity, and smoke concentrations. Because of the ongoing monitoring, potential fire occurrences can be identified early, allowing for an immediate response and the implementation of mitigation measures.
- Cost-Effectiveness: Compared to conventional techniques or alternative wireless communication technologies, LoRa technology offers a cost-effective solution for forest fire detection. LoRa is an economical option for installing sensor nodes across a large region in forests, ensuring thorough coverage for fire detection. LoRa's low-cost infrastructure needs and minimum power consumption make it an affordable option.

V. LIMITATIONS

Even though the solution we've proposed is quite reliable, it still has significant limitations. Those are described below: -

- Limited bandwidth: LoRa communication uses unlicensed frequency channels, which have a little amount of available space. The volume of data that can be sent over a particular period of time may be impacted by this restriction. The low bandwidth of LoRa communication may place restrictions on the amount of data that can be communicated frequently from the sensor nodes to the control center in a forest fire warning system, where real-time data transmission is essential.
- Latency: LoRa communication has a rather significant latency despite being effective for long-distance transmission. When compared to other communication systems, the time it takes for data packets to reach the control centre can be much longer. This latency may cause a delay in the detection and

response to fire occurrences in the context of forest fire detection, which can be crucial in halting the fire's rapid spread.

- Data speeds are constrained since LoRa communication is designed for long-range, low-power communication at the expense of speed. The speed at which data is transferred and processed may be impacted by this restriction. The low data rate of LoRa communication may provide problems in situations when significant volumes of data must be delivered quickly, such as high-resolution photography or video feeds for fire detection.
- Signal deterioration and interference: Other wireless devices using the same frequency range as LoRa communication can cause interference. The existence of interfering signals can reduce the performance of the LoRa network in highly inhabited areas or locations with strong radio frequency activity, which can impact the dependability and accuracy of fire detection.
- Network scalability issues: LoRa communication networks have scalability issues. The performance of the entire network may be impacted as the number of sensor nodes rises, which could result in decreased effectiveness and a higher chance of data collisions or network congestion. Due to this restriction, the deployment of numerous sensor nodes throughout broad forest regions may be constrained, thus reducing the coverage and efficacy of the fire detection system.

VI. RESULTS

- **Starting of the System**:
  - The ESP32 model is connected with the laptop using USB cable where type A is put in the laptop and the micro type is inserted in the port of the module.
  - The codes are loaded into the ESP32 module and the laptop is connected to the Wi-Fi.
  - The serial monitor is switched on and is kept at 115200 baud.
  - The serial monitor will start displaying (Fig. 3).

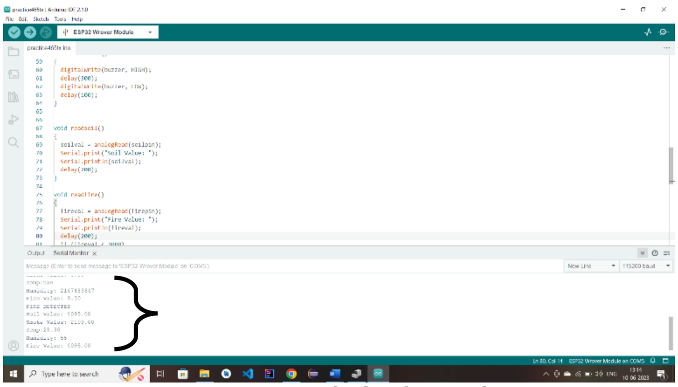


Fig. 3: Starting message displayed on serial monitor

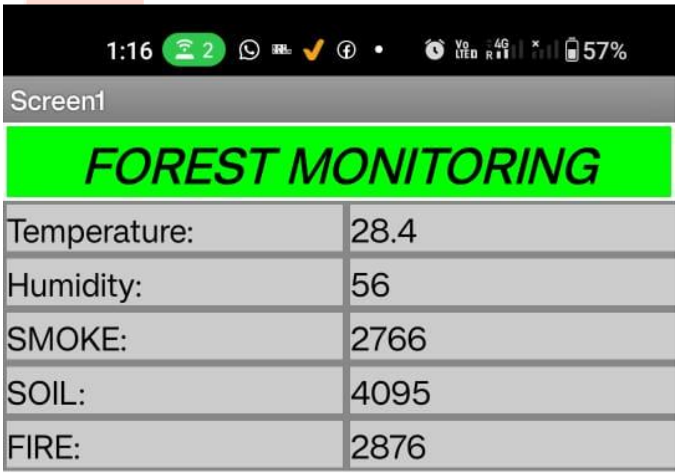
  - Within the first 4 seconds of hearing beep sound from the buzzer, the system needs to be connected to the power supply using 12V adapter.
  - Again, beep sound will come and the LCD will start glowing, showing “WELCOME” message (Fig. 4).

Fig. 4: LCD displaying WELCOME message

  - The first sensor data given in the message will be 0, NaN or some garbage value. But from the next messages, proper data will be displayed.

- **Connection to Network**:
  - Both the ESP32 modules are connected to the laptop.
  - The modules need to be connected with the same Wi-Fi which is being used for the laptop / desktop system.
  - In Arduino coding, we have given a common Wi-Fi id and password, which will be used for the system along with the ESP modules.

- **Data Generation**:
  - In Arduino uno serial monitor, the data will get generated and will be displayed as follows.
  - In UI application, the messages will pop up displaying the status of temperature, soil moisture content, fire value, smoke value, and humidity of the surrounding (Fig. 5).
  - The LCD connected to the system will start displaying messages if fire is getting detected or not, if there is any smoke detected or not. It will also display the temperature, humidity, and soil moisture content values.



Fig, 5: Data generated in UI application

- **Fire Detection**:
  - If flame is detected, the green light of the fire sensor will glow continuously, and the LCD will display that the fire is detected, along with the serial monitor of the Arduino IDE and an alert message will be displayed in the UI application (Fig. 6).

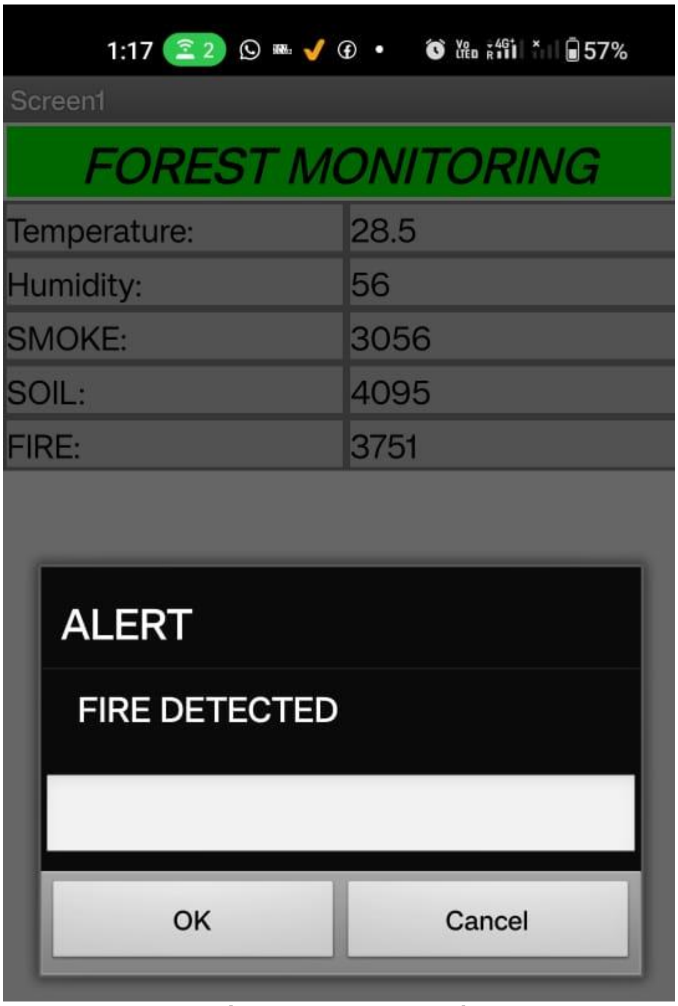


Fig. 6: Alert message sent in UI application

– If fire is not detected, LCD will just display some numerical value, along with the serial monitor of the Arduino IDE and no alert message will be displayed in the UI application (Fig. 7).

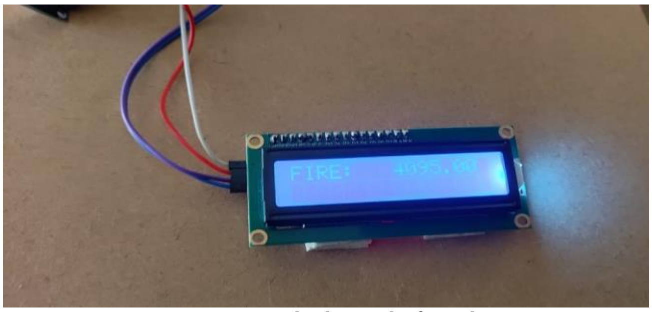


Fig. 7: LCD displaying the fire value

- **Smoke Detection**:
  – If smoke occurs in the area, the smoke sensor will detect the smoke, the yellow light of the smoke sensor will glow, and the LCD will display that the smoke is detected, along with the serial monitor of the Arduino IDE. An alert message will be displayed in the UI application (Fig. 8).

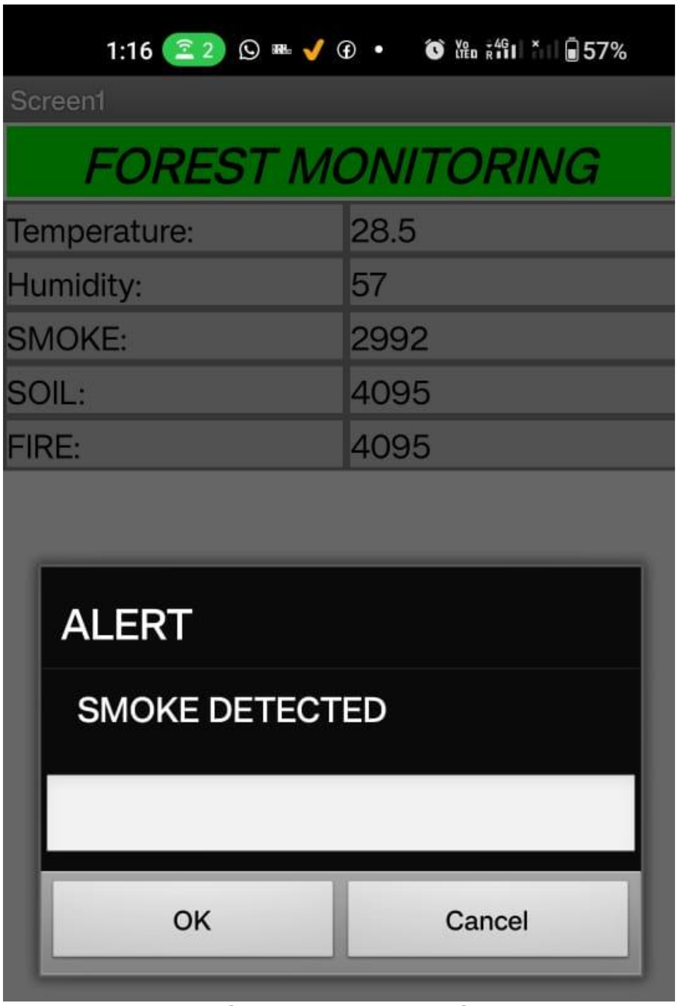


Fig. 8: Alert message sent in UI application

– If smoke is not detected, LCD will just display some numerical value, along with the serial monitor of the Arduino IDE and no alert message will be displayed in the UI application. (Fig. 9).

Fig. 9: LCD displaying the smoke value

- **Soil Moisture Detection**:
  – The soil moisture sensor will continuously detect the moisture content of the soil and will give the readings constantly.
  – The LCD will display the soil moisture content of the soil.
  – Along with that real time soil moisture content will be displayed in the UI application. (Fig. 10).

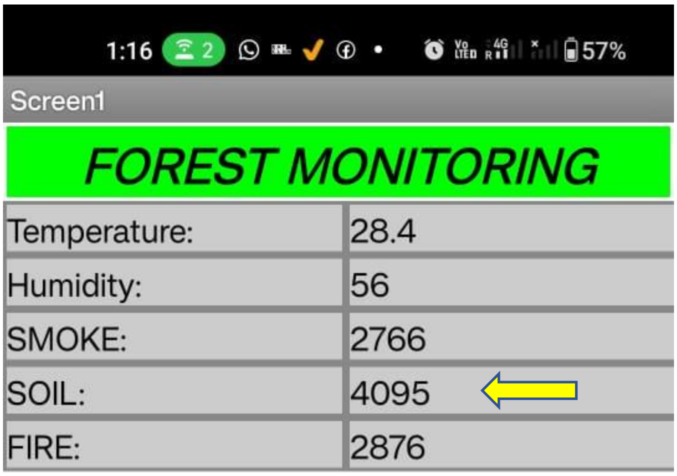


Fig. 10: UI application displaying the soil content value

– LCD will display the soil content value, along with the serial monitor of the Arduino (Fig. 11).

Fig. 11: LCD displaying the soil content value

- **Temperature Detection**:
  – The temperature sensor will continuously detect the temperature of the surrounding and will give the readings constantly.
  – The LCD will display the temperature of the surrounding.
  – Along with that real time temperature value will be displayed in the UI application. (Fig. 12).

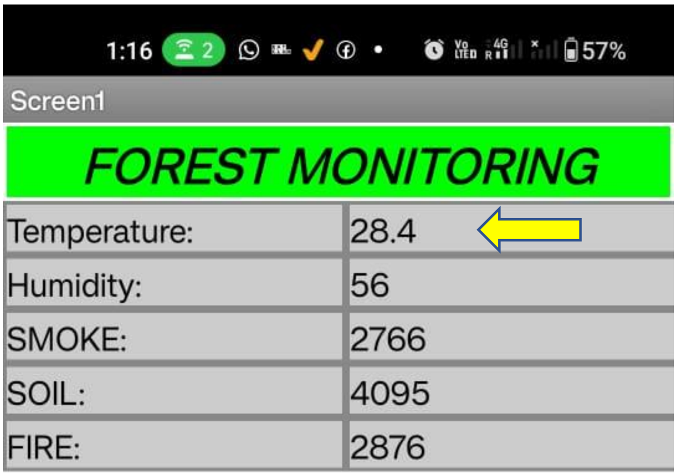


Fig. 12: UI application displaying the temperature value

– LCD will display the temperature value, along with the serial monitor of the Arduino (Fig. 13).

Fig. 13: LCD displaying the temperature value

- **Humidity Detection**:
  – The humidity sensor will continuously detect the humidity of the surrounding and will give the readings constantly.
  – The LCD will display the humidity readings of the surrounding.
  – Along with that real time humidity value will be displayed in the UI application. (Fig. 14).

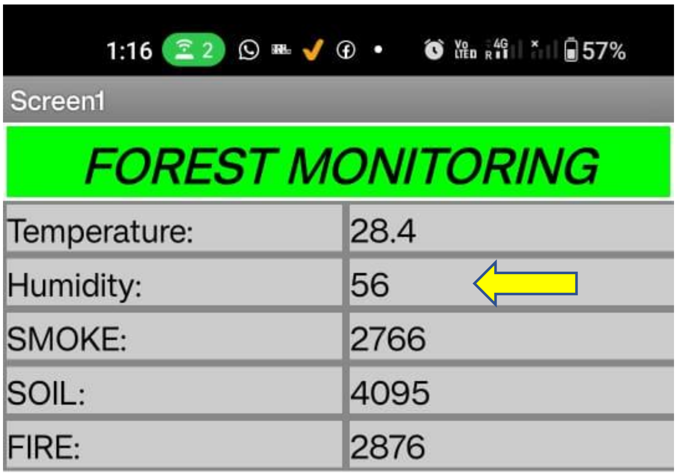


Fig. 14: UI application displaying the humidity value

– LCD will display the humidity value, along with the serial monitor of the Arduino (Fig. 15).

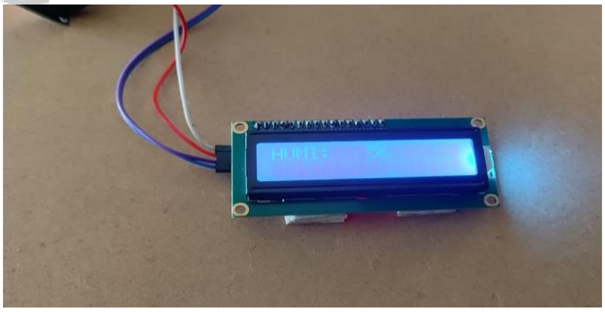


Fig. 15: LCD displaying the humidity value

- **Backend connection**:

  – The Arduino uno serial monitor will send the data to google firebase cloud server, and from their it will send the data to the UI application (Fig. 16).

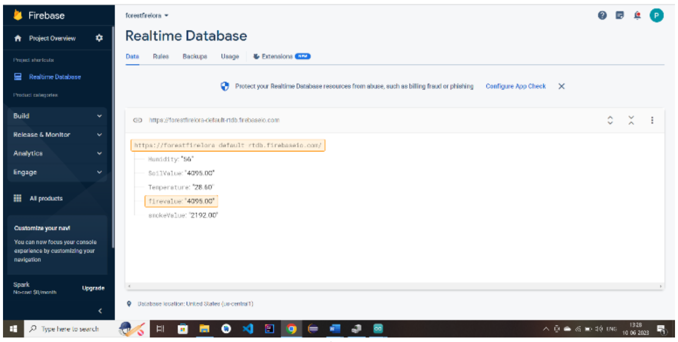


Fig. 16: Google firebase connection

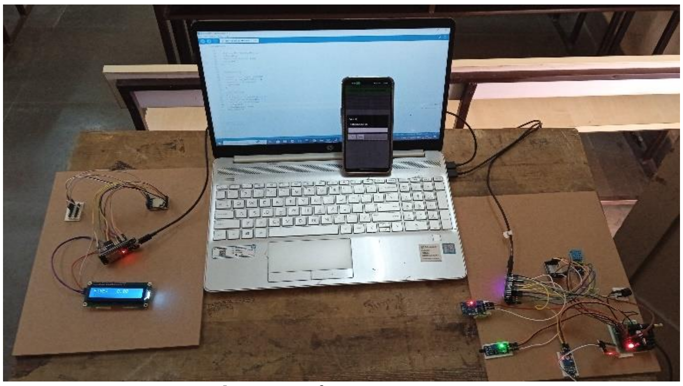


Fig. 17: Complete view of Forest Fire Detection System

TABLE 1
OVERALL RESULTS

Features	**Conditions**	**Message on Application**	**Message on LCD**
Fire	If flames are detected	“ALERT… Fire is detected”	“Fire Detected”
	If flames are not detected	No alert message displayed	No alert message
Temperature	If temperature is high	“ALERT... Temperature is High.”	“High Temperature”
	If temperature is normal	No alert message displayed	No message displayed
Smoke	If smoke is detected	“ALERT… Smoke Detected.”	“Smoke Detected”
	If smoke is not detected	No alert message displayed	No message displayed
Soil Moisture	If soil is wet	“Soil is Wet”	“Soil is Wet”
	If soil is dry	“Soil is Dry”	“Soil is Dry”
Humidity	Checks humidity of the area	Will display the real time humidity value	Will display the real time humidity value

VII. References

[1] Adnan, d A. Ejah Umraeni Salam, Arham Arifin, Muhammad Rizal, " Forest Fire Detection using LoRa Wireless Mesh Topology", The 2nd East Indonesia Conference on Computer and Information Technology (EIConCIT), 2018, Article ID 978-1-5386-8050-6/18.

[2] Mrs. S. Sandhya, Nivedha A. P., Kavitha T. S., Bhuvanehwari R., Nirmala M., “Forest Fire Detection using Lora By Extension of IoT”, International Research Journal of Engineering and Technology (IRJET) Vol. 07, Issue 08, May 2020.

[3] Nicoleta Cristina GAITAN , Paula HOJBOTA, " Forest Fire Detection System using LoRa Technology", International Journal of Advanced Computer Science and Applications (IJACSA), Vol. 11, No. 5, 2020.

[4] K.Mahesh Babu, R. Priyakanth, G. Roshini, V. Saisri, BH. Keerhi priya, N. Srujana, M. Taruni, “Forest Fire Detection Using Lora”, Journal of Emerging Technologies and Innovative Research (JETIR), May 2020, Volume 7, Issue

[5] Evizal Abdul Kadir, Hitoshi Irie, and Sri Listia Rosa, "Fire Detection System in Peatland Area Using LoRa WAN Communication", 2020, 2nd International Conference on Science, Engineering and Technology (ICoSET 2019), DOI: 10.5220/0009145101300134.

[6] Roberto Vega-Rodríguez, Sandra Sendra, Jaime Lloret, Pablo Romero-Díaz , Jose Luis Garcia-Navas, "Low Cost LoRa based Network for Forest Fire Detection",https://doi.org/10.1109/IOTSMS48152.2019.8939193.

[7] Dr. N. N. Ghuge, Adesh Chavan, Rajeshree Gaikwad, Kalyani Kale, " Forest Fire Detection Using Arduino Based WSN", 3rd International Conference on Communication & Information Processing (ICCIP), 2021.

[8] Murugaperumal Krishnamoorthy, Md. Asif, Polamarasetty P. Kumar, Ramakrishna S. S. Nuvvula, Baseem Khan, Ilhami Colak, "A Design and Development of the Smart Forest Alert Monitoring System Using IoT" in 2018 Hindawi Journal of Sensors, Volume 2023, Article ID 8063524.

[9] BS Nikhil Koushik, Akash S., Adithya S., Chirag Sai, Shruthi K. R., " Lora Based Forest Monitoring System", March 2023, IJIRT, Volume 9, Issue 10, ISSN: 2349-6002.

[10] Mounir Grari, Mimoun Yandouzi, Idriss Idrissi, Mohammed Boukabous, Omar Moussaoui, Mostafa Azizi, Mimoun Moussaoui, "Using Iot and Ml For Forest Fire Detection, Monitoring, and Prediction", Journal of Theoretical and Applied Information Technology, 15th October 2022. Vol.100. No 19.

[11] Diwakar Chintha, D.Vishnu Vardhan Reddy, K.Srilatha, “Survey On Fire Detection In Forest Using Wireless Sensor Networks”, 2020, International Journal of Scientific & Technology Research Volume 9, Issue 03, Issn 2277-8616

[12] A.Divya, T.Kavithanjali, P.Dharshini, “Iot Enabled Forest Fire Detection And Early Warning System”,

2019, International Conference of System Computation, Automation & Networking, IEEE 978-1-7281-1524-5

[13] I. Akyildiz, F. Su, W. Sankarasubramaniam, and Y. E. Cayirci, "Wireless sensor networks: A survey," Comput. Netw. (Elsevier) J., vol. 38, no. 4, pp. 393–422, Mar. 2002.

[14] J. Apcar, "Routing in the Internet of Things/M2M Networks," presented at the Ciscolive365, Melbourne, VIC, Australia, 2013, BRKSPG-1661.

[15] G. Fodor, E. Dahlman, G. Mildh, S. Parkvall, N. Reider, G. Miklós, and Z. Turányi, "Design aspects of network assisted device-to-device communications," IEEE Commun. Mag., vol. 50, no. 3, pp. 170–177, Mar. 2012.