LORA Based Forest Fire Monitoring System

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Abstract— The LoRa-based forest fire monitoring method by using wireless type networks is an IoT system designed to detect and prevent forest fires. The system consists of sensor nodes which are deployed throughout the forest to monitor various environmental conditions such as humidity, temperature, wind speed and direction. These sensor nodes are equipped with LoRa radios that enable them to communicate wirelessly with a central gateway. The Gateway gathers the data from the sensor nodes and transmits it to a server in the cloud for processing and analysis. The system utilizes machine learning algorithms to analyse the collected data and detect any anomalies that may indicate the forest fire. In the event of a fire, the system can alert local authorities and fire departments, providing them with real-time information about the location and severity of the fire. This allows for faster response times and more efficient management of the fire. The LoRa-based forest fire prevention system using wireless networks offers several advantages over traditional forest fire detection systems. Its low-power, long-range capabilities enable it to cover large areas, making it ideal for monitoring vast forested areas. Additionally, its wireless connectivity eliminates the need for physical infrastructure such as cables, which can be expensive and time-consuming to install. Overall, the LoRa-based forest fire prevention system using wireless networks is a promising solution for preventing and managing forest fires. Its innovative use of IoT technology and machine learning

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algorithms can help to reduce the impact of forest fires and protect both human life and the environment.
Keywords— LoRa technology, Lora WAN gateway, cloud platform, response time, alert system

1 Introduction

Forest fires are a major environmental hazard that can cause significant damage to natural ecosystems, destroy wildlife habitats, and threaten human lives and property [13]. Traditional methods for preventing and detecting forest fires frequently rely on physical infrastructure, including cables and sensors, which can be costly to establish and maintain. To address these challenges, the use of wireless networks and IoT technology has emerged as a promising solution for forest fire monitoring.
One such solution is the LoRa-based forest fire monitoring system using wireless networks. This system utilizes LoRa wireless technology to enable sensor nodes to monitor environmental conditions like temperature, humidity, and wind speed in real-time. The sensor nodes are deployed throughout the forest and communicate wirelessly with a central gateway, which collects and sends data to a cloud-based server for analysis [15].
Machine learning techniques are used to analyze the collected data in order to look for any anomalies that can indicate the possibility of a forest fire. The system may notify local authorities, fire departments, and hospitals in the case of a fire and provide them with up-to-the-minute details regarding the location and intensity of the blaze. As a result, speedier response times and better fire management are possible [16].
The LoRa-based forest fire monitoring system using wireless networks offers several advantages over traditional systems, including its low-power, long-range capabilities and wireless connectivity. It is a creative approach that could lessen the effects of forest fires, safeguard the environment and human life, and enable quicker and more effective control of the fire [12-17].
Forest fires have several naturally occurring sources, such as lightning that ignites nearby trees. Typically, such fires are put out by rain without any collateral damage. The best conditions for a fire to ignite are high air temperatures and dryness (low humidity)[18].
Man-made causes - Fire may also happen when an ignition source, like a bare flame, a cigarette or bidi, an electric spark, or any other source of ignition, comes into contact with combustible material [19].
Natural or managed forest fire - Forest fires can be started intentionally by locals or accidentally by careless people in the summer when heat is generated in the underbrush and other biomes [20].

Table 1. Statistics showing Variations in Forest Fires over the previous year

Year	Name of the Forest Fires	Increase or decrease in forest fires(over the previous year)
January-June 2017	3,623	-
January-June 2018	11,808	225.92%
November 2019-June 2019	12,965	9.80%
November 2018-June 2020	759	-94.15%

November 2020-June 2021	21,487	2730.96%

The State of Forests Report 2021 states that between November 2020 and June 2021, India reported 345,989 forest fires. This is the most forest fires that have been reported in the nation so far for this time period. This is the most forest fires that have been reported in the nation so far for this time period. The second-highest number of forest fires on record at least 258, 480 was reported during the same period in 2018–19 [14].
We can see the annual increase in forest fires by looking at the table above. We are aware that a rise in forest fires results in an increase in fatalities, a loss of animals, and a loss of land [14].

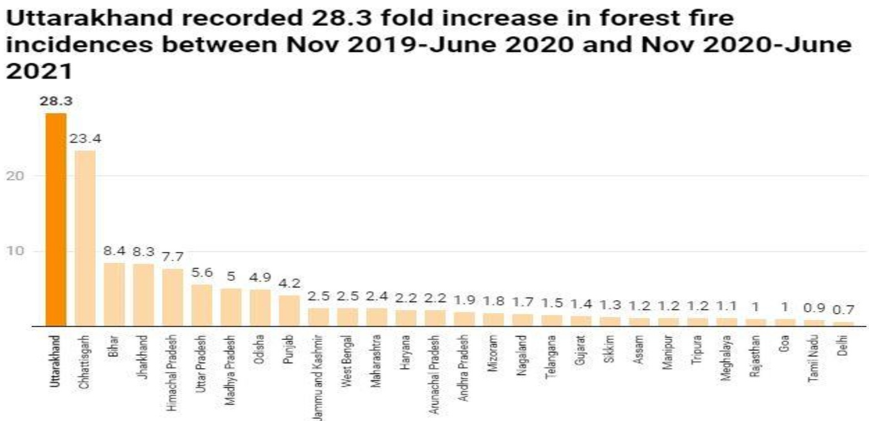

Fig. 1. Statistics of number of forest fires taken place in India from November 2019 to June 2020

We can observe in the table that Uttarkhand recorded 28.3 fold increases in forest fires. It is in the topmost place in number of forest fires when compared to all the other places in India and the second highest state to observe most number of forest fires is Chhattisgarh. The other all states observed a minimum number of forest fires [21].

2 Literature Study

As a consequence of the implementation of the wireless sensor network approach for detecting forest fires, coupled with satellite monitoring, aerial patrolling, and manual observation, a stereoscopic and Omni-bearing pattern of air and ground forest fire detection was discovered. This made it possible for the pertinent government agencies to quickly decide how to put out fires or prevent them from starting. [1] Comparing the wireless sensor network to more conventional monitoring methods like lookout towers and satellite-based monitoring can help determine the likelihood of a forest fire with more accuracy. This framework focuses on the techniques for gathering data using designed systems for data collecting before classifying the data. [2]. The creation of a compact LoRa (Long Range)-based wireless ad hoc network sensor system for environmental monitoring provides a real-time, low-cost long-distance monitoring solution. [3].

The work by Anton Herutomo, et al. breaks down the deployment of Open MTC as an M2M and IoT communication platform into its initial parts. Two Device Application components, or DAs, are housed with the relevant carbon monoxide gas concentration, temperature, and humidity sensors, as well as Zigbee and an Arduino microcontroller, and they are connected to the Open MTC GSCL [4]. In its first phases, using Open MTC as an M2M and IoT communication platform is discussed. The ETSI M2M standard refers to two Device Application components (or DAs) linked to Open MTC GSCL as having sensors for temperature, humidity, carbon monoxide gas concentration, and Zigbee[5]. The ZigBee network is used to gather data, which is then sent over a GPRS network using a GPRS module that was handled by a coordinator node to an FTP server with a public network IP on the internet. To execute obtaining remote data from the monitoring zone, the monitoring centre obtained the information using an FTP server that was made available to crucial specialists and decision makers [6]. Santoshinee Mohapatra's study led to the development of the Pabitra Mohan Khilar algorithm, which can identify faulty nodes and predict the likelihood of a fire. The likelihood of a fire has been determined using fuzzy logic. In an indoor laboratory setting, they carried out an experiment to validate the recommended method. [7]. evaluating the risk of a fire and whether a forest fire is present, Roberto Vega-Rodrguez, et al, employed and explained the low cost Long Range (LoRa) based network[8].

3 Existing System

Several existing systems use LoRa-based wireless technology for forest fire monitoring. These systems typically consist of multiple sensor nodes placed strategically throughout the forest, which can detect parameters such as sound, fire gas, and smoke. The nodes communicate with a central gateway using the LoRa wireless protocol, and the data is then sent to a cloud server for analysis and visualization. Some systems also integrate a mobile application and web platform to provide real-time alerts and insights about the fire. Researchers at the Indian Institute of Technology, Roorkee, the University of Malaya, and the University of Aveiro in Portugal have created several examples of these systems. [9-10].

The capacity to operate in distant locations with minimal infrastructure, low power consumption, and long-range communication are just a few benefits of LoRa-based forest fire monitoring systems. These technologies can enable reliable monitoring and early identification of forest fires, which can reduce the damage wrought by such calamities. In addition, LoRa-based systems are affordable, simple to deploy, and maintain, making them a viable option for managing and monitoring forest fires. [11].

4 Proposed System

1. Lora WAN Gateway: A gateway would be installed in a central location and would act as a bridge between the LoRa devices and the internet. It would receive data from the LoRa devices and send it to a cloud platform for processing.
2. Sensors: Sensors would be placed at strategic locations in the forest to detect temperature, humidity, and air quality. These sensors would be low-power and long-range, allowing them to communicate with the gateway from remote locations.
3. GPS and location tracking: Each sensor would be equipped with GPS and location tracking capabilities, enabling fire fighters to quickly locate the source of a fire.
4. Cloud platform: A cloud platform would receive data from the gateway and process it in real-time. Data would be evaluated by machine learning algorithms in search of abnormalities and trends that might indicate the presence of a fire.
5. Data visualization: The data collected from the sensors would be visualized on a dashboard, allowing fire fighters to monitor the forest in real-time.
6. Alert system: When the system detects a potential fire, it would send an alert to fire fighters with the location and severity of the fire.

7. Fire fighters: Once alerted, fire fighters would be able to respond to the fire quickly, minimizing damage and preventing it from spreading.
8. Response time and damage reduction: With a real-time monitoring system, response time would be significantly reduced, and damage to the forest could be minimized.

5 Methodology

To develop a LoRa-based forest fire monitoring system using a wireless network, you can follow the following methodology:

1. Define System Requirements: The first step is to identify the requirements of the system, such as the area of the forest to be monitored, the number of nodes required, the range of the wireless network, the frequency of data transmission, and the types of sensors to be used.
2. Design the System Architecture: Create the system's architecture based on the system requirements. The sensors, LoRa transceivers, microcontroller, power source, and data storage and processing system should all be a part of the architecture.
3. Choose the Sensors: Select the appropriate sensors based on the environmental factors that contribute to forest fires, such as temperature, fire sensor, gas sensor, sound sensor , and carbon dioxide levels.
4. Select the LoRa Transceivers: Choose LoRa transceivers that meet the range and data rate requirements of the system.
5. Develop the Microcontroller Code: Write the code for the microcontroller that controls the sensor data acquisition and transmission using LoRa.
6. Build the Hardware Prototype: Assemble the hardware components according to the system architecture and test the system prototype to ensure it meets the system requirements.
7. Implement the Wireless Network: Set up the wireless network infrastructure to support the LoRa-based forest fire monitoring system.
8. Test the System: Test the system in a forest environment to ensure it can detect and alert of fire incidents accurately and in a timely manner.
9. Deploy the System: In the forests that will be under observation, install the LoRa-based forest fire monitoring system.
10. Monitor and Maintain the System: Monitor the system performance regularly and maintain the system components to ensure its continuous operation.

Overall, developing a LoRa-based forest fire monitoring system using a wireless network requires careful planning, thorough testing, and on-going maintenance to ensure its effectiveness in preventing forest fires.

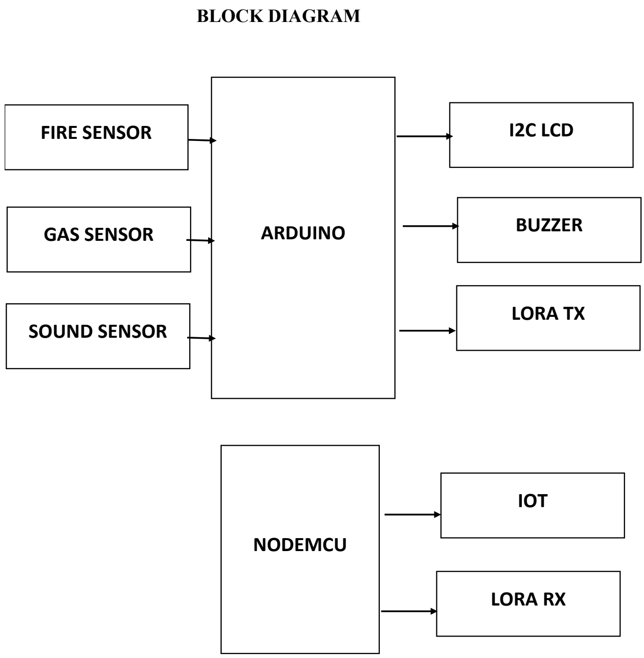

Fig. 2. Block diagram representing our proposed method.

We use LoRa device to transmit and receive data from sensors. All the sensors along with LoRa transmitter present at transmitter side are connected to Arduino and LoRa Receiver is connected to NODEMCU. Thing Speak is used to check data graphs of Gas sensor, Sound sensor and Fire sensor.

6 Working Operation

1. Deployment: Multiple wireless sensor nodes are placed strategically throughout the forest to detect various environmental parameters such as fire sensor gas sensor and sound sensor. These sensor nodes can be either fixed or mobile, depending on the requirements of the monitoring system.
2. Communication: Using the LoRa wireless technology, which permits long-range and low-power communication, the sensor nodes connect to a central gateway. Data from the sensor nodes is gathered by the gateway and sent to a cloud server for analysis and visualisation.
3. Data Analysis: The cloud server processes and analyses the data received from the gateway to detect potential forest fires. The data can also be used to provide insights into the environmental conditions that are conducive to forest fires.
4. Alerting: Real-time alerts can be generated by the system through a mobile application or a web platform. Forest rangers, fire fighters, or other stakeholders may get these notifications so they can take the necessary steps to lessen the harm a forest fire causes.

Overall, a wireless networked LoRa-based forest fire monitoring system provides a low-cost, high-performance, and scalable solution for managing forest fires.

7 Results and Discussion

The result has explained in the following about the variations in Gas value, sound value and fire value with the help of things speak server so that the circuits detects any changes above the limits. Hence at the service station will be alerted, if any changes are recorded.

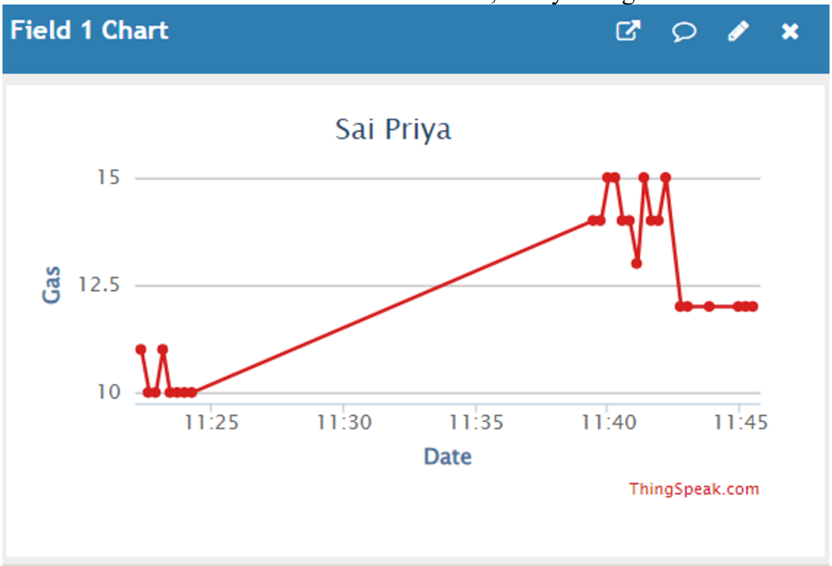

Fig. 3. Graph showing the variations in the gas value.

The variation in Gas level changes the values where Y-axis represents Gas value and X-axis represents date

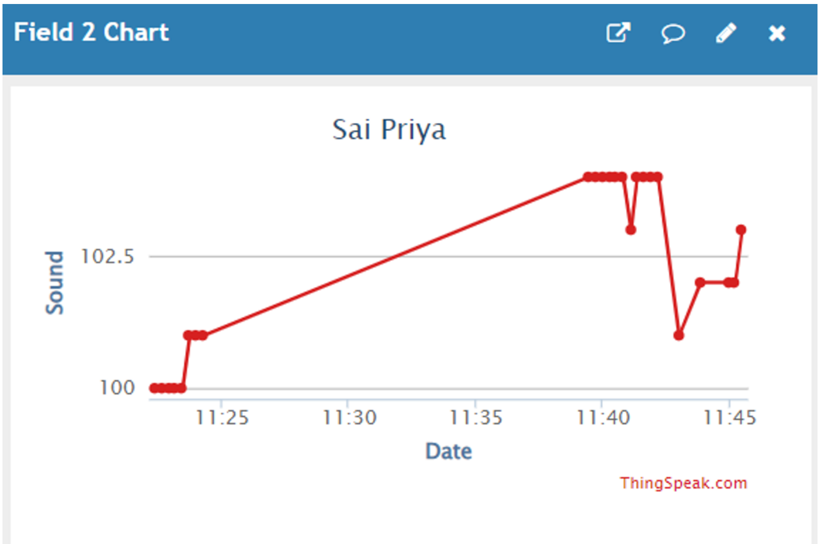

Fig. 4. Graph showing the variations observed in sound value.

The variation in sound changes the values where Y-axis represents sound value and X-axis represents date.

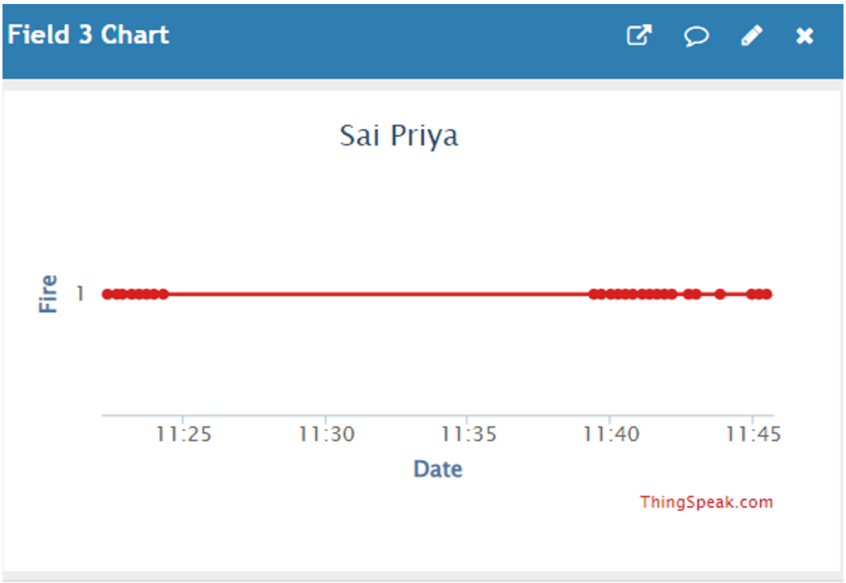

Fig. 5. Graph showing the Fire value as constant.

The variation in fire changes the values where Y-axis represents fire value and X-axis represents date

The above figure shows the result of Thing Speak server. We have three graphs in the above figure.

Gas graph, Sound graph and Fire graph. The variation occurs when the circuit detects any changes above the limit.

LoRa-based wildfire surveillance systems aim to detect and monitor wildfires in remote areas where traditional wired communications infrastructure is limited or unavailable. These systems typically consist of a network of sensors distributed throughout the forest region. The sensors are equipped with fire detection functions such as temperature and smoke sensors and communicate wirelessly using LoRa technology.

When one of the sensors detects a fire event, it transmits the relevant data, including location and intensity of the fire, to a central monitoring station or cloud-based platform. The monitoring station may then examine the information and offer current details on the location, spread, and intensity of the fire. This information can be critical for early detection and timely response to prevent or mitigate the impact of wildfires.

The advantages of using LoRa technology in forest fire surveillance systems include long range, which allows long-distance communication even in demanding environments. LORA'S low-power characteristics allow the sensors to run on battery power for extended periods of time, reducing the need for frequent maintenance or powering in remote areas. In addition, LORA'S ability to penetrate through obstacles and its immunity to interference make it suitable for use in wooded environments.

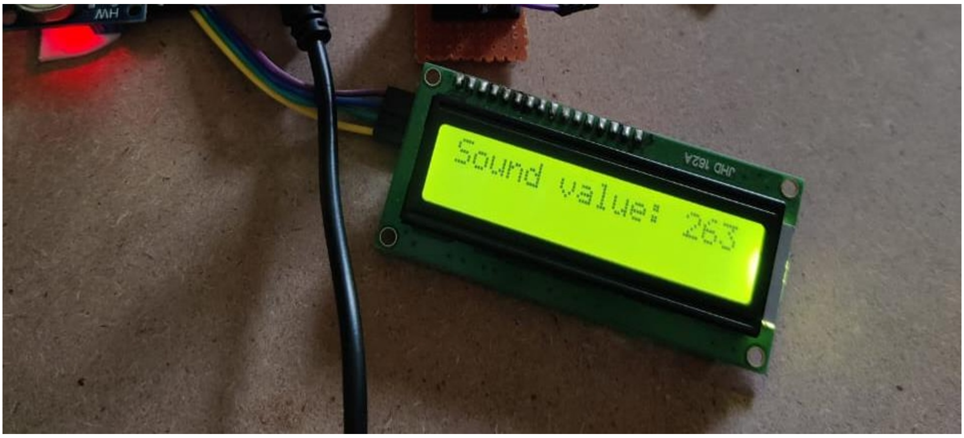

Fig. 6. Realtime sound value in LCD

The above result shows that the sound value of the surrounding of the system shown as sound values 263 decibels

Fig. 7. Realtime Fire value in LCD

The above result shows that the fire value of the surrounding of the system shown as fire values '0'

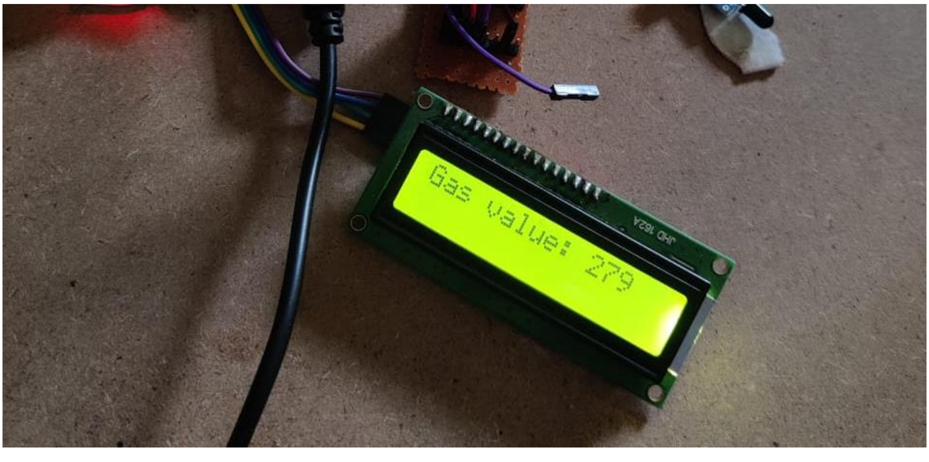

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Fig. 8. Realtime sound value in LCD

The above figure shows the values of the Gas, Sound and Fire in the LCD connected to the prototype model. The LCD shows Normal OR High as per the variations observed.

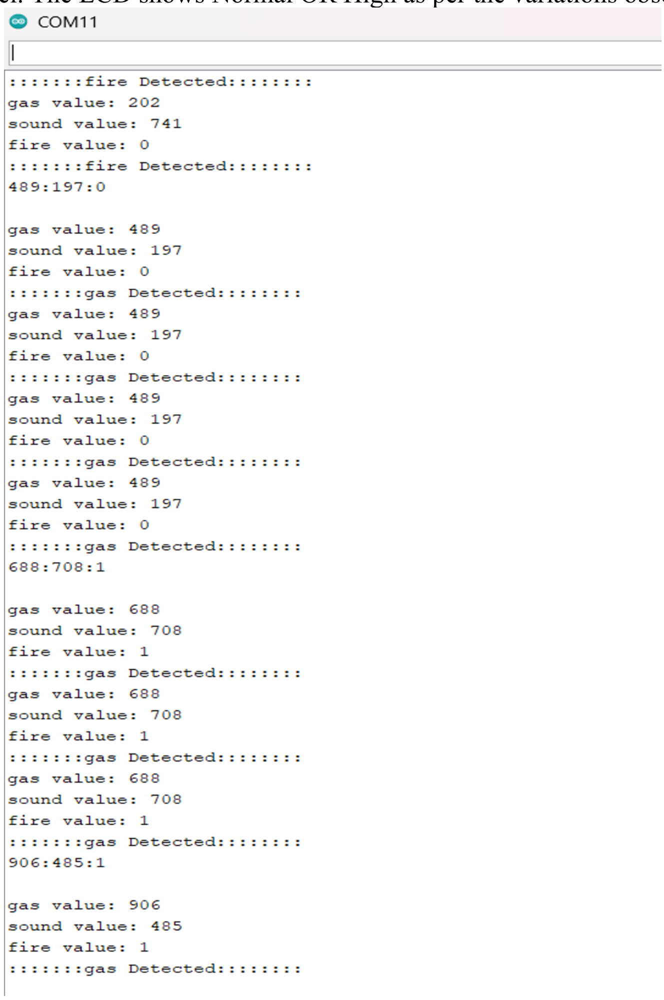

Fig. 9. Values shown in serial monitor

The above figure shows the values given in the Serial Monitor of the Arduino server.

Conclusion

Devices that can communicate over long distances without consuming a lot of energy are more important than ever. Long-Power Wide-Area Networks are currently addressing this problem of the future. There are numerous applications based on LPWA technologies available right now, however the majority of them do not use LoRa modules. The number of flames and the damage they inflict will both continue to rise as a result of global warming. Along with the thousands of hectares of forest that are lost each season, many assets and properties are also negatively impacted. The lives of the citizens and the fire fighters are also in jeopardy. This is the primary issue I want to address in order to reduce and prevent devastating fires.

References

1. J. Zhang, W. Li, Z. Yin, S. Liu and X. Guo, "Forest fire detection system based on wireless sensor network," 2009 4th IEEE Conference on Industrial Electronics and Applications, Xi'an, China, 2009, pp. 520-523, doi: 10.1109/ICIEA.2009.5138260.
2. A. Chauhan, S. Semwal and R. Chawhan, "Artificial neural network-based forest fire detection system using wireless sensor network," 2013 Annual IEEE India Conference (INDICON), Mumbai, India, 2013, pp. 1-6, doi: 10.1109/INDCON.2013.6725913.
3. A. Herutomo, M. Abdurohman, N. A. Suwastika, S. Prabowo and C. W. Wijiutomo, "Forest fire detection system reliability test using wireless sensor network and OpenMTC communication platform," 2015 3rd International Conference on Information and Communication Technology (ICoICT), Nusa Dua, Bali, Indonesia, 2015, pp. 87-91, doi: 10.1109/ICoICT.2015.7231402.
4. Guozhu Wang, J. Zhang, Wenbin Li, Dongxu Cui and Ye Jing, "A forest fire monitoring system based on GPRS and ZigBee wireless sensor network," 2010 5th IEEE Conference on Industrial Electronics and Applications, Taichung, 2010, pp. 1859-1862, doi: 10.1109/ICIEA.2010.5515417.
5. S. Mohapatra and P. M. Khilar, "Forest fire monitoring and detection of faulty nodes using wireless sensor network," 2016 IEEE Region 10 Conference (TENCON), Singapore, 2016, pp. 3232-3236, doi: 10.1109/TENCON.2016.7848647.
6. E. A. Kadir, A. Efendi and S. L. Rosa, "Application of LoRa WAN Sensor and IoT for Environmental Monitoring in Riau Province Indonesia," 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), Malang, Indonesia, 2018, pp. 281-285, doi: 10.1109/EECSI.2018.8752830.
7. J. Wang, S. Yi, D. Zhan and W. Zhang, "Design and Implementation of small monitoring wireless network system based on LoRa," 2019 IEEE 4th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), Chengdu, China, 2019, pp. 296-299, doi: 10.1109/IAEAC47372.2019.8997877.
8. G. Saldamli, S. Deshpande, K. Jawalekar, P. Gholap, L. Tawalbeh and L. Ertaul, "Wildfire Detection using Wireless Mesh Network," 2019 Fourth International Conference on Fog and Mobile Edge Computing (FMEC), Rome, Italy, 2019, pp. 229-234, doi: 10.1109/FMEC.2019.8795316.
9. S. Srividhya and S. Sankaranarayanan, "IoT–Fog Enabled Framework for Forest Fire Management System," 2020 Fourth World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4), London, UK, 2020, pp. 273-276, doi: 10.1109/WorldS450073.2020.9210328.
10. E. A. Kadir, A. Efendi and S. L. Rosa, "Application of LoRa WAN Sensor and IoT for Environmental Monitoring in Riau Province Indonesia," 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), Malang, Indonesia, 2018, pp. 281-285, doi: 10.1109/EECSI.2018.8752830.
11. Saida, Angotu, and R. K. Yadav. "Review on: analysis of an IoT based blockchain technology." Int. J. Educ. Manag. Eng 12 (2022): 30-37.
12. Sagoff, Mark. "Do non-native species threaten the natural environment?." Journal of Agricultural and Environmental Ethics 18.3 (2005): 215.
13. https://fsi.nic.in/forest-fire-activities
14. Apriani, Yosi, Wiwin A. Oktaviani, and Ian Mochamad Sofian. "Design and Implementation of LoRa-Based Forest Fire Monitoring System." Journal of Robotics and Control (JRC) 3.3 (2022): 236-243.

15. Mahdavinejad, Mohammad Saeid, et al. "Machine learning for Internet of Things data analysis: A survey." Digital Communications and Networks 4.3 (2018): 161-175.
16. [17] Zhao, Ming, et al. "Realization of Forest Internet of Things Using Wireless Network Communication Technology of Low-Power Wide-Area Network." Sensors 23.10 (2023): 4809.
17. https://vikaspedia.in/energy/environment/know-your-environment/forest-fires
18. Cunningham, Andrew A., and David L. Martell. "A stochastic model for the occurrence of man-caused forest fires." Canadian Journal of Forest Research 3.2 (1973): 282-287.
19. https://agritech.tnau.ac.in/agriculture/agri_majorareas_disastermgt_forestfire.html
20. https://www.downtoearth.org.in/news/forests/forest-survey-report-2021-forest-fire-counts-up-2-7-times-81123