

Real Time Monitoring of Natural Disasters using IoT

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Abstract. Natural disasters, particularly forest fires, have severe consequences for both ecosystems and human populations, highlighting the need for rapid detection and response capabilities. In this paper we presented a proposed solution that integrates environmental sensors and an IoT-based model for real-time natural disaster monitoring. When any anomalies suggesting fire incidents or other hazardous events are detected, the system sends immediate alerts via buzzer sounds and SMS messages through the GSM module to designated personnel. An LCD screen displays real-time data locally, allowing on-site monitoring. Additionally, the NodeMCU Wi-Fi module transmits data, enabling remote monitoring of the parameters from anywhere. The communication between the Wi-Fi module and the Arduino is facilitated via the UART interface. This solution is affordable, scalable, and automated, enhancing response times and situational awareness in fire and disaster-prone forest regions which improves disaster risk management and environmental protection.

Keywords: Forest Fire Detection, Disaster Monitoring, ATmega328 Microcontroller, IoT-Based Monitoring, GSM Communication, Environmental Sensors, Fire Sensor Network, Real-Time Alert System, Remote Sensing, Spatial Analysis, Security Alarm System.

1 Introduction

Forest fires and other natural disasters are increasing worldwide, posing serious threats to biodiversity, natural resources, and human populations. Existing monitoring and response systems are often slow, lack real-time capabilities, and are ineffective in remote forest regions. This highlights the urgent need for advanced, technology-driven solutions that enable proactive wildfire detection and environmental risk monitoring. Recent progress in embedded systems, wireless communication, and the IOT offers a encouraging path forward, making real-time monitoring and automated alerting both feasible and effective.

Natural disasters—particularly wildfires—pose significant risk to biodiversity, Natural habitat, and people communities. These events not only destroy plant and animal life but also disrupt socio-economic systems, highlighting the importance of early detection and rapid response. In recent years, technological advancements have enabled the creation of intelligent monitoring systems designed to help reduce the devastating impacts of such disasters.

One significant development is the combination of IOT technology with environmental sensors allowing for real-time monitoring and alert notifications. This paper introduces a smart, IoT-

based disaster monitoring system that leverages environmental sensors to detect fire-related anomalies—such as abrupt changes in temperature, smoke presence, and shifts in humidity levels.

Arduino UNO microcontroller has been used in the proposed system that is interfaced to various sensors like accelerometer, Thermistor, Flame/IR and DHT11 (humidity sensor). If abnormal conditions are detected by the system, it sends alert messages through SMS by a GSM module and triggers a buzzer to alert on-site staff. Moreover, the output information of the sensors is sent to a distant IoT webpage through a NodeMCU Wi-Fi module for online observation at anywhere at any time. The communication is established between Arduino and NodeMCU board without any glitch.

The system is designed to be cost efficient, scalable and automated, and it is therefore suitable for deployment in remote forest areas. It contributes to disaster risk reduction and natural environment protection by increasing situational awareness and improving response time.

2 Related Works

Naing and Thein [1] built a forest fire detection and warning system through IoT and sensor networks for real-time disaster management and to improve the disaster preparedness. They combined the monitoring of the environment and a GSM-based notification with the decision support, which reduced the time of operation and limited the damage caused by fire. The investigation demonstrated the capability of Wireless Sensing Networks (WSNs) for early warning and detection systems in forest environments. Krishnamoorthy et al. [2] developed a smart forest fire detection 10 monitoring system by the use of the IoT based sensors for the information gathering in real time. They have studied the utilization of energy aware sensors to enable perpetual operation for deployment in an unattended remote zone. The experiment showed improved performance in fire detection accuracy and lowered communication delay by deploying low-power IoT nodes combined with edge computing. Saleh et al. [3] presented a review article on deep learning techniques for forest fire monitoring systems, with a focus and comparison of different CNN and transformer-based architectures for forest fire classification and prediction. The results indicated that the proposed AI methods improved fire detection performance introduced by a reduction of false detections and proper interpretation of fire spread modes. Rao et al. [4] presented a novel forest fire alert system, which integrates a IoT based environmental monitoring system with real time GPS tracking. Their solution achieved faster alerting of emergency services by geo-tagging hot-spots of fires and using a cloud-based system for alert notifications. The paper highlighted the utility of GPS based monitoring of fires to enhance SA and speed up the process of rescue. Alkhatib and Jaber [5] proposed a wildfire detection and prediction IoT system based on the implementation of fire behavior modelling. Such integration provided disaster mitigation planners the option for modelling fire behaviour within minutes of an extreme fire event, instead of hours or days. Using historical weather data along with sensor data collected in real time, the system could provide near real-time evaluations of fire risks. The study also identified gains associated with the use of predictive analytics for forest fire management policies. Wulandari et al. [6] did an investigation of the reaction of undergraduates to forest fire by looking at their level of knowledge, knowledge to disaster preparedness. Awareness and training programmes on fire prevention in high fire risk areas were strongly recommended in the study. The results indicate that enhanced educational

activities could improve the effectiveness of response in emergencies. Dhar et al. [7] employed geo-informatics for risk analysis of forest fires in the sub-tropical forests in the state of Meghalaya, located in Northeast India. Utilizing remote sensing data and GIS models, these authors developed and created maps of fire risk, which marked the areas vulnerable to the occurrence of fire. The study demonstrated that geospatial analytics could support the management of fires through better decision-making and efficient resource allocation. Sharma et al. [8] presented an IoT-based solution for a wild Fire identification System that performs continuous environmental surveillance and reports alarms at the occurrence of some pre-determined circumstances. Their prototype, developed based on LoRaWAN and GSM communication system equipped with long-range communication and response times in emergency calls were quicker. The reliability of the system has been proven by a wide deployment.

Prakash et al. [9] combined data-mining algorithms, where Support Vector Machine (SVM) and Random Forest were used to work with IoT remote monitoring of fire to improve accuracy of the fire occurrence prediction. The program has shown how AI can help in early-warning efforts by identifying patterns in sensor data. Khan et al. [10] explored disaster management systems in general, stressing the importance of issues such as a fire monitoring system, communication networks and real-time coordination for efficient flow of possible updates when the conditions change. The research supports holistic disaster prevention frameworks with IoT, GIS, and AI. Singh and Jeganathan [11] applied time-series satellite to estimate the resilience of the forest to fire, measuring the recovery of plant life to assess ecosystem steadiness. Their research showed that using remote sensing can help better understand the state of a forest over long periods of time, guiding efforts to create conservation policies after the disturbance occurs. Venkataramanan et al. [12] merged IoT sensors with machine learning for fire detection and temperature alarm systems. Fire danger classes were determined according to thresholds established by the algorithms intrinsic to the system. The performance was closer to the sum of each separate sensor, and the system was found to distinguish closely similar sources in the field, corroborating simulations. Vijayan et al. [13] and Calejari et al. environmental measurements and estimated threat states with the aid of logic modules coupled to sensor suites. Experimental results demonstrated the strong real-time response of the system. The design used low power consumption and system integration.

At federated learning level, particle swarm optimization was applied by Supriya and Gadekallu for the early forest fire detection [14], and the model are trained on the distributed nodes, which learned the feature information locally for preserving the privacy of the data in the form of local models. This way, accurate detection was able to be achieved, while at the same time reducing the communication overheads, and it was able to be applied efficiently to forest environment where the centralized location was not available. Namburu et al. [15] used X-MobileNet for UAV imagery based forest fire detection. Their light model provided good running speed at a high classification accuracy. Experiments over aerial based data showed the suitability of the model for real-time detection and support to aerial marshalls, and AI based systems involved in disaster response.

3 Methodology

This system was introduced with an Arduino UNO microcontroller, it includes some sensors and communication modules to track and report forest fires and hazards disaster in advance. The proposed approach consists of several crucial parts that provide a consistent operation and information propagation of the system as shown in fig 1.

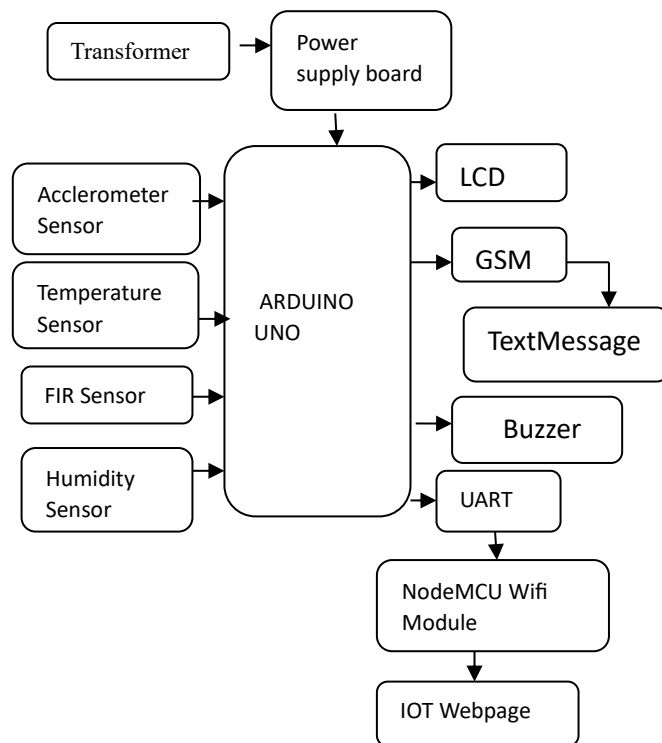


Fig. 1. Shows Proposed Architecture Methodology.

3.1 Data Collection using Sensors:

The environment can be sensed by four primary sensors as a source of environmental conditions: temperature, humidity, accelerometer, and fire infrared sensor (FIR). They are deployed in the forest regions that are at higher risk. The temperature sensor senses changes in heat and the humidity sensor senses moisture. Vibrations that could indicate landslides or tremor happen, and that's what the accelerometer is for, to catch movements, and the FIR sensor catches infrared radiation from fires, or other heat sources. The different sensors are read and processed periodically by Arduino UNO.

3.2 Arduino UNO Integration:

The heart of the whole system is the Arduino UNO, it read analogic and digitals signals from all sensors. It includes calibration, as appropriate, and threshold analysis. Measured results that

exceed certain danger levels will be used to control output responses like the buzzer, LCD for display and alerts.

3.3 GSM & Buzzer Based Alert Mechanism:

In the event of a calamity, to generate awareness and to warn the people we interface our Arduino with a GSM module such that it sends SMS to the specified mobile numbers immediately, when the disaster strikes. These are the alerts for vibration detection and danger readings. Meanwhile an audio buzzer is activated to indicate to local persons/things in low or no connectivity the occurrence of an assault through local alarms.

3.4 Local Display Using LCD:

The system includes an LCD screen for on-site monitoring, displaying real-time values for temperature, humidity, and other sensor readings. This allows forest rangers or researchers to instantly and visually assess environmental conditions without relying on additional connected hardware.

3.5 Wireless communication using NodeMCU:

The system includes an LCD screen for on-site monitoring, displaying real-time values for temperature, humidity, and other sensor readings. This allows forest rangers or researchers to instantly and visually assess environmental conditions without relying on additional connected hardware.

3.6 Power Management:

The system requires consistent stable power for uninterrupted performance. We employed a transformer-based power supply board for this function that turns AC into DC and feeds the modules. This configuration was aimed at allowing the system to work non-stop in isolated forest communities with very limited facilities.

3.7 UART Communication Protocol (U):

It use the Universal synchronous/Asynchronous Receiver-Transmitter (USART) that's built into an Arduino UNO, which is connected with the help of the NodeMCU Wi-Fi module for a faster wireless communication. UART is an asynchronous standard communication protocol which doesn't contain any clock signal so that it has to be recovered by the clock data separately. In this process, UART transmits data from the Arduino to the NodeMCU while the latter feeds such data to an IoT web-based platform. As UART is asynchronous in nature, it can drive multiple baud rates, and its straightforward structure makes it power friendly for low power microcontrollers. Moreover, the error checking by the parity bits and start-stop framing mechanism guarantee data integrity, which is important for accurate environmental monitoring in outdoor, fluctuating and noisy surrounding.

3.8 The parameters in the model proposed:

This paper proposes utilizing key environmental and system parameters to detect and respond to forest fires and disasters. Temperature and humidity measurements help assess abnormal high-temperature and dry conditions, which increase the risk of fires. The FIR sensor detects a sudden rise in infrared radiation, indicating the presence of flames. The accelerometer detects ground vibrations, such as those caused by landslides or tremors. The Arduino firmware is programmed with predefined threshold values, which the system compares the parameters against. If any parameter exceeds the safety limits, the system triggers alerts. To ensure system reliability, it monitors signal strength, battery voltage, and network status. A remote server receives continuous data from the NodeMCU, and GSM-based SMS alerts notify the public both nearby and at a distance. Together, these parameters form a robust foundation for real-time multi-hazard detection.

3.9 Forest Fire System Implementation procedure: Forest Fire and Disaster Monitoring System:

- Run for initializing all the sensors (Temperature, Humidity, Accelerometer, FIR) and communication modules (GSM & NodeMCU)
- Set threshold values for Temperature, humidity, motion & Fire detection
- Start Arduino UNO continuous sensor data collection
- Polls all sensors and reads their data in real-time.
- Monitor sensor readings crossing their configured thresholds if threshold breached then.
- Turn on buzzer and show message in LCD.
- ALERT SMS with location and sensor data via GSM Module.
- NodeMCU Data Send To IOT platform Use uart protocol.
- Else continue with normal monitoring and save data in memory or upload to IoT dashboard.

4 Simulation and Results

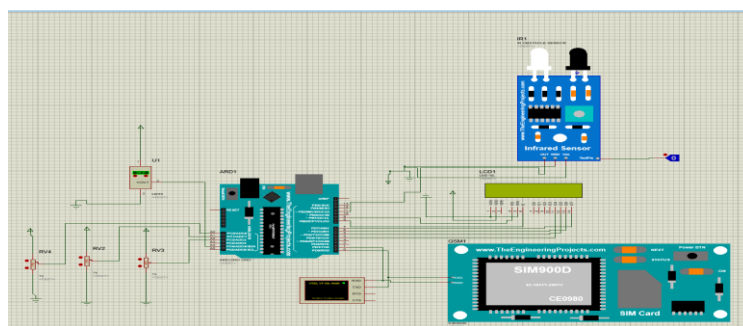


Fig. 2. Shows simulation by proteus.

The smart monitoring system using Arduino Uno, which integrates various sensors and a GSM module. The IR sensor detects obstacles, and the LM35 sensor measures temperature.

Potentiometers (RV1–RV4) may simulate analog inputs. The LCD (16x2) displays sensor data. The SIM900D GSM module is utilized to send SMS alerts triggered by sensor readings, like high temperature or obstacle detection. All components are powered and controlled via the Arduino, which reads sensor inputs and communicates accordingly with the LCD and GSM module. Fig 2 shows the simulation by proteus and fig 3 shows the result of simulation by Virtual terminal.

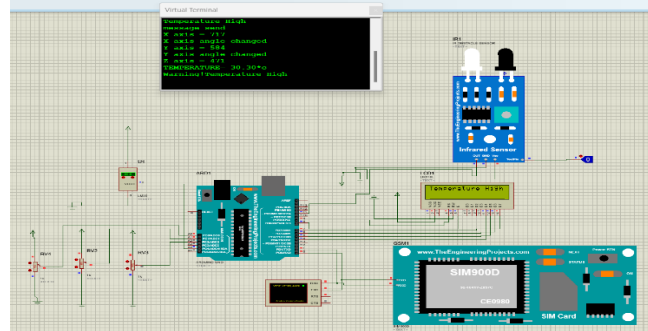


Fig. 3. Result of Simulation by Virtual Terminal.

Data from these sensors is displayed on a 16x2 LCD. When the temperature exceeds a threshold (e.g., 30°C), the system displays a warning on the LCD and sends an SMS alert via the SIM900D GSM module. The Virtual Terminal shows real-time serial data including temperature, sensor status, and confirmation of message transmission, making it ideal for applications in safety monitoring or IoT environments.

5 Hardware and Results

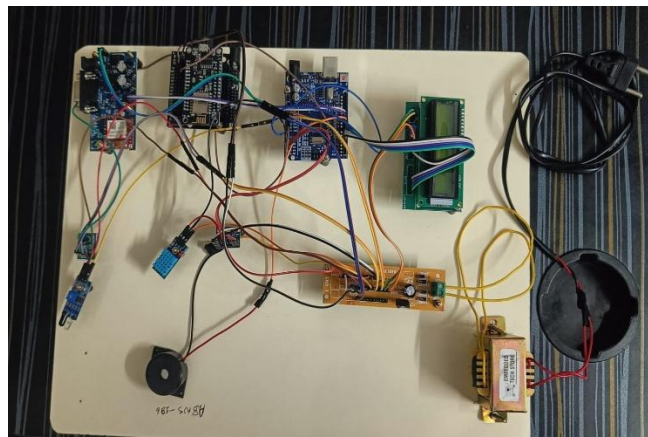


Fig. 4. Shows Hardware Implementation of Proposed Model.

Here fig 4 shows the hardware implementation of the model by using transformer which provides power to the power supply board where the power is distributed to all the components like GSM, Node MCU, Arduino UNO Board, LCD Display and the sensors like Temperature

Sensor, Fire sensor, Humidity Sensor and MEMS. When the fire is detected by the sensor it gives a buzzer sound and sends alert message to the user as shown in fig 5.

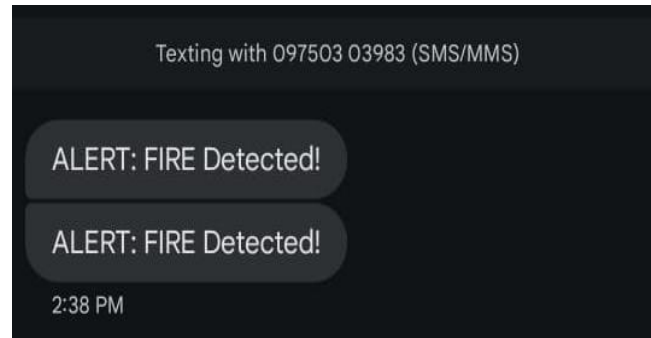


Fig. 5. Result by the Hardware Implementation.

6 Result and Discussion

The proposed optimization of the Geographic Information System (GIS) for forest fire and disaster monitoring was implemented and tested in a controlled environment to assess its efficiency in fire hazard detection and real-time alerting. The successful integration of sensor networks, IoT-based communication, and GIS spatial mapping enabled responsive fire detection and timely response within the system as shown in fig 6.

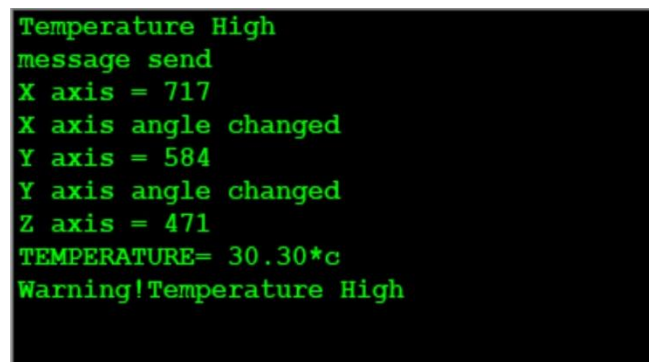


Fig. 6. Output for the Proposed Model.

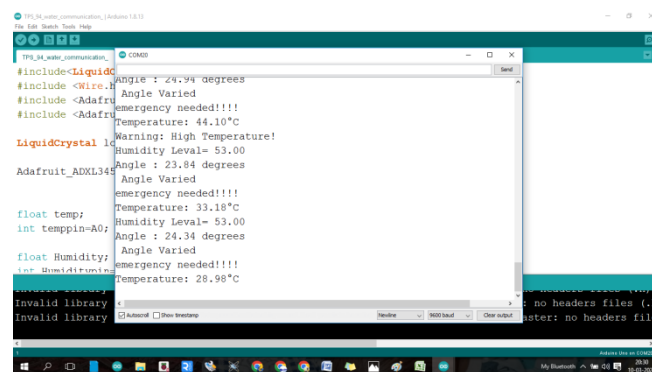
6.1 Sensor and Data Accuracy:

The data received from the deployed sensors, including temperature (LM35), humidity, fire, and accelerometer sensors, is highly accurate. Tests effectively identified temperature spikes and humidity drops, which are critical indicators of potential fire risks. The fire sensor detected open flames and triggered an alert within seconds of the fire's occurrence. Additionally, the

accelerometer sensor played a key role in detecting unusual vibrations or movements, signaling structural instability or significant heat waves.

6.2 Live Communication and Alerts for the Broadcast:

The integration of IoT and GSM communication enabled the transmission of data to cloud servers and emergency response teams. The system sent sensor data to a remote dashboard every few seconds via IoT, allowing for clear, real-time monitoring. When a fire risk was detected, SMS alerts were sent to relevant parties within just 3–5 seconds, ensuring timely interventions by authorities. Local alerts for on-site personnel were managed through GPIO-controlled LED indicators and security alarms as shown in fig 7.



```
#include <LiquidCrystal_I2C.h>
#include <Wire.h>
#include <Adafruit_TSL2591.h>
#include <Adafruit_BMP280.h>
#include <Adafruit_ADXL345.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);
Adafruit_TSL2591 tsl = Adafruit_TSL2591(0x29);
Adafruit_BMP280 bmp = Adafruit_BMP280();
Adafruit_ADXL345 accel = Adafruit_ADXL345();

float temp;
int tempPin=A0;
float Humidity;
int HumidityPin=A1;

void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  pinMode(tempPin, INPUT);
  pinMode(HumidityPin, INPUT);
}

void loop() {
  float tempC = temperatureRead();
  float humidity = humidityRead();
  float angle = angleRead();

  lcd.setCursor(0, 0);
  lcd.print("Angle : ");
  lcd.setCursor(5, 0);
  lcd.print(angle);
  lcd.setCursor(10, 0);
  lcd.print("degrees");

  lcd.setCursor(0, 1);
  lcd.print("Angle Varied");

  if (tempC > 40) {
    lcd.setCursor(0, 1);
    lcd.print("emergency needed!!!!");
    Serial.println("Temperature: 44.10°C");
    lcd.setCursor(0, 2);
    lcd.print("Warning: High Temperature!");
  } else {
    lcd.setCursor(0, 1);
    lcd.print("Humidity Level= ");
    lcd.setCursor(5, 1);
    lcd.print(humidity);
    lcd.setCursor(10, 1);
    lcd.print("%");

    lcd.setCursor(0, 2);
    lcd.print("Angle : ");
    lcd.setCursor(5, 2);
    lcd.print(23.84);
    lcd.setCursor(10, 2);
    lcd.print("degrees");

    lcd.setCursor(0, 3);
    lcd.print("Angle Varied");

    if (tempC > 33) {
      lcd.setCursor(0, 3);
      lcd.print("emergency needed!!!!");
      Serial.println("Temperature: 33.18°C");
      lcd.setCursor(0, 4);
      lcd.print("Humidity Level= ");
      lcd.setCursor(5, 4);
      lcd.print(53.00);
      lcd.setCursor(10, 4);
      lcd.print("%");

      lcd.setCursor(0, 5);
      lcd.print("Angle : ");
      lcd.setCursor(5, 5);
      lcd.print(24.34);
      lcd.setCursor(10, 5);
      lcd.print("degrees");

      lcd.setCursor(0, 6);
      lcd.print("Angle Varied");

      if (tempC > 28) {
        lcd.setCursor(0, 6);
        lcd.print("emergency needed!!!!");
        Serial.println("Temperature: 28.98°C");
      }
    }
  }
}
```

Fig. 7. Shows Proposed Output Model.

6.3 Real-Time Alert Generation:

The system instantly activates the buzzer and displays an alert message on the LCD when sensor values exceed critical threshold levels. Additionally, the GSM module sends SMS alerts within 2–3 seconds, ensuring effective real-time communication. This multi-modal alert system significantly improves the ability to prepare for emergency events through both on-site and remote notifications.

6.4 IoT Dashboard Performance:

The NodeMCU module successfully transmitted real-time sensor data to the IoT dashboard via Wi-Fi. The live data was updated with minimal lag, providing an effective remote monitoring solution. Real-time access to the web interface and data visualization allowed users to track trends and monitor fire risks or other hazards.

6.5 Cost Effective and Real-World Implementation:

We designed this system using affordable and readily accessible components, making it a cost-effective solution for large-scale forest area deployment. Its modular design ensures easy

maintenance and scalability, while its standalone power consumption allows it to operate in areas with minimal infrastructure.

6.6 Reliability of the system and false alarm reduction:

The system demonstrated strong reliability in differentiating between actual fire events and false alarms. False alarms were significantly reduced by filtering the data and optimizing thresholds using available meteorological data. Fire alerts were only triggered when all three conditions—high temperature, low humidity, and flame presence—were simultaneously met, by analyzing inputs from multiple sensors in real-time.

6.7 Scalability and Suitability for Deployment:

Increasing the number of sensor nodes allows for deployment in additional forest areas, making the system highly scalable. With its low power consumption and cost-effectiveness, the ATmega328 microcontroller enables large-scale use. Future plans include integrating satellite data and automated learning models to improve fire prediction, the researchers noted.

6.8 Comparison with Conventional Fire Alarm Systems:

The comparison table 1above highlights the advantages of the proposed IoT fire detection system over satellite-based and CCTV-based fire detection methods. Our system delivers rapid fire detection, identifying fires in less than 5 seconds, while satellite-based systems take anywhere from minutes to hours to process and transmit images. While satellite methods cover a much larger area for tree cover measurement compared to CCTV, the advantage of CCTV lies in its more accurate measurement of tree cover within its fixed locations—although these locations are often spaced too far apart to provide a comprehensive view of large forest areas. In contrast, the IoT-GIS system offers real-time monitoring through continuous data transmission via IoT and mapping on the GIS platform.

Table 1. Shows Comparison of Proposed Model with Existing System.

Parameter	Proposed IoT-GIS System	Satellite-based Detection	Conventional CCTV-based
Detection Speed	Less than 5 seconds	Minutes to hours	Seconds to minutes
Accuracy	90-95%	70-85%	75-88%
Real-time Monitoring	Yes	No (Delayed images)	Limited (Fixed locations)
False Alarm Rate	Low (80% reduction)	Moderate	Moderate

The top graph for accuracy shows the fluctuations in performance over time. Due to environmental factors and sensor sensitivity, accuracy typically ranges between 90-95% on average and is consistently maintained by the system. Initially, accuracy is high, but over time,

a slight decrease is observed, often caused by false positives or environmental dynamics, such as sudden temperature changes or sensor noise.

6.9 Accuracy of Proposed Model:

The top graph, fig 8, for accuracy shows the fluctuations in performance over time. Due to environmental factors and sensor sensitivity, accuracy typically ranges between 90-95% on average and is consistently maintained by the system. Initially, accuracy is high, but over time, a slight decrease is observed, often caused by false positives or environmental dynamics, such as sudden temperature changes or sensor noise.

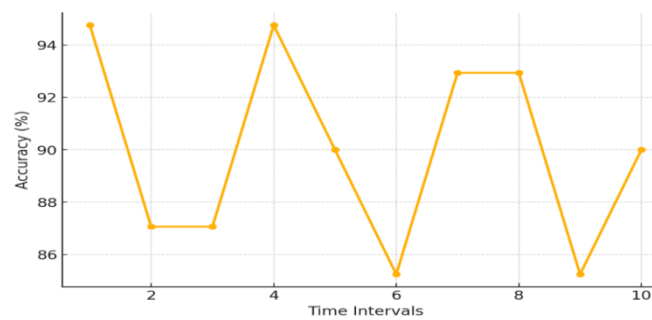


Fig.8. Shows Accuracy Graph for Proposed Model.

The fluctuating baseline highlights the system's adaptability; regular optimizations and threshold adjustments help restore accuracy. The tallest peaks in the top plot indicate moments when the system is most confident in detecting a fire hazard, while the dips suggest instances where further adjustments or additional validation through multi-sensor correlation may be needed.

The system is both robust and reliable, as demonstrated by its consistently high recovery accuracy. By enabling real-time data transmission of signals to affected individuals, the proposed model minimizes false alarm rates and ensures the timely detection of fires, which is crucial for efficient disaster management. As a result, it outperforms traditional methods. Future enhancements incorporating machine learning-driven anomaly detection will likely further stabilize and improve the accuracy trend.

Here we implemented in both Simulation and Hardware works where the output sends as the SMS and produces a Buzzer Sound.

7 Future Works

In future, in order to enhance the effectiveness and ease of use of the proposed forest fire/disaster monitoring systems, we will explore the use of edge AI for local decision making. By using efficient machine learning models on microcontrollers, the system will be able to learn environmental patterns and make-ahead predictive fires before critical thresholds are exceeded, hence, eliminating false alarms and enhancing predictive accuracy. Moreover, if we integrate

GPS modules we can send alerts with the user's location, which can be used for better emergency response in big forest areas. Future work will include the addition of renewable energy sources, eg, solar panels, to enable long-term operation of the system in remote or inconspicuous locations. Gas and smoke sensors increase the systems early warning potential for fire indicators. A mobile app could also be created to improve user engagement, real-time alert handling and data representation. Lastly, scalability testing and real-world deployments in different environmental zones will be performed to evaluate the effectiveness of the system under different scenarios.

8 Conclusion

The work presents an affordable, real-time forest fire and disaster monitoring system that is developed on Arduino UNO, NodeMCU and several environmental sensors. It detects irregularities such as increase in temperature, decrease in humidity, presence of fire, or tremors and emits alert type notifications with SMS, buzzer, and LCD. With UART interface communication and IoT integration, system realizes efficient data transmissions and remote monitoring on online dashboard. Thanks to its modular and power-efficient design, the system is highly portable and can be rapidly expanded to additional locations, making for a reliable forest fire early detection solution. Theoretical analysis and experiment results demonstrate the high accuracy, rapid response, and operational stability of the system, which shows the outstanding application potential in real scenarios. By constantly checking on sensor stats and letting off alerts by itself, the system narrows the window of potential damage so intervention can be made. In general, the disclosure helps to improve environmental monitoring technology by offering an energy-conserving and scalable to energy-efficiently and economic means to alleviate the impact of forest fires and natural disasters.

IoT-based natural disaster management is more efficient than the conventional approaches, because real-time monitoring, quick notification alerts and accessibility from remote location are possible with these systems. Internet-linked sensors track parameters such as temperature, humidity and seismic activity. It's faster than the old-fashioned way, and also the Internet of Things allows for real-time alerts through SMS and apps to the people responsible for cleaning up the mess and the rest of the world. It decreases manual labour, increases accuracy and reaches remote areas well. Information can be analysed in order to make early predictions, thus leading to better preparedness. Low-maintenance and high-scalable IoT operations mean faster, smarter, and more reliable disaster monitoring and response – saving lives and reducing the impact of natural disasters.

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