

TREE POACHING AND FOREST FIRE DETECTION SYSTEM USING LORA COMMUNICATION

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Abstract - The rising trend of forest fires and poaching activities poses a serious threat not only to biodiversity but also to the environment and human life. Forests are essential not only for environmental balance, the survival of wildlife species but also for regulating climate patterns. However, conventional systems based on manual patrolling, watchtowers, and camera surveillance systems have some drawbacks such as high maintenance costs, delayed response time and inability to reach some forest areas because of their remoteness. Thus, there is a necessity to develop an advanced automated and cost-efficient system for monitoring forests.

The purpose of this project is to develop the Tree Poaching and Forest Fire Detection System, which will help in providing constant monitoring and sending immediate alerts about any changes that may pose a threat to the ecosystem in the form of poaching and forest fires. This system is built on the use of LoRa (Long Range) communication technology, and it includes two main modules: the transmission module installed in the forest and the receiving module installed in the monitoring center. The transmitting unit comprises Arduino UNO microcontroller with flame and smoke detectors for detecting forest fires and vibration and sound detectors for poaching monitoring.

KeyWords: Arduino Uno, LoRa Module, Flame Sensor, Smoke Sensor, Vibration Sensor, Sound Sensor, LCD Display, Buzzer.

1.INTRODUCTION

Forest surveillance systems have undergone many changes owing to developments in wireless sensor network technology and Internet of Things. Recent researches have concentrated much on devising intelligent solutions that help to monitor environment changes in real time. Such a solution will be able to reduce the effects of fires and other unlawful acts by offering timely alerts for quick responses. Most of the

current studies in forest surveillance systems mainly concentrate on detection of forest fires. The solutions

devised include the use of temperature sensors, flame sensors, and smoke sensors to detect fire as soon as possible and contain it in order to prevent the fire from spreading over extensive areas of forest lands.

Early detection is vital in preventing loss of vegetation, flora and fauna, and human settlements. Traditional forest monitoring methods include manual patrolling, watchtowers, and satellite observation systems. Although these methods have been used for decades, they have several limitations. Manual patrolling needs a lot of manpower and is not practical for large forest areas. Watchtowers offer limited coverage and cannot detect incidents happening far from where they are located. Satellite systems, while helpful, often have delays in processing data and can be costly to set up and maintain. To address these issues, researchers have suggested using wireless sensor network (WSN) systems. In these systems, multiple sensor nodes are spread across forest areas to monitor environmental conditions continuously. These nodes gather data like temperature, humidity, smoke levels, and flame presence. The data collected is sent to a central monitoring station for analysis and alert generation.

1.1.PROPOSED SYSTEM AND METHODOLOGY

Description-The suggested Tree Poaching and Forest Fire Detection System aims at providing instant surveillance and detection of important occurrences such as forest fires and poaching activities. The suggested system utilizes a modular approach for its development, thus ensuring that it is flexible, scalable, and easy to deploy. The complete system is composed of two major components – the transmitting component (Forest Node) and the receiving component (Monitoring Station). The transmitting component operates in forest regions where constant surveillance is needed. This component is built around an Arduino UNO microcontroller that is connected to several sensors like flame sensors, smoke sensors, vibration sensors, and

sound sensors. The function of these sensors is to detect changes in the environment and abnormal occurrences. Flame sensors detect fires by detecting infrared radiations emitted by fires. Smoke sensors detect smoke emissions and harmful gases in the atmosphere. The combination of these two sensors helps in accurately detecting the occurrence of fires. Vibration sensors detect mechanical vibrations caused by vibrations caused by tree cutting activities, whereas the sound sensor is used for sensing noise produced by the cutting process that involves use of chainsaws or axes. The incorporation of both vibration and sound sensors increases the effectiveness of detection of tree poaching. The Arduino UNO serves as the main processor in the transmission unit of the system. The Arduino UNO microprocessor constantly takes readings from the various sensors and compares them to the preset threshold levels. Once any of the sensors produces reading exceeding the preset threshold levels, Arduino determines the occurrence of an anomaly and initiates alert signals. Once the alert is identified, the Arduino formulates the alert message, including the ID number of the sensor that caused the alert, and the type of alert. Subsequently, the formulated message is transmitted using the LoRa module. The transmission unit is designed to operate continuously and can be powered either by battery or solar energy, making it ideal for use in remote forests. The receiving unit of the system is



Figure 1

situated in the monitoring center.

After receiving the data, the Arduino processes the message and extracts important information like the device ID and type of alert. This information appears on the LCD screen, providing a clear indication of the detected event. Along with visual alerts, the system also produces audible alerts using a buzzer. When an alert is received, the buzzer activates to notify authorities right away. This makes sure that alerts are not missed and

allows for a quick response to critical situations. The system uses LoRa communication technology, which allows long-range wireless transmission with low power use. LoRa operates in sub-GHz frequency bands and can send data over several kilometers. This makes it ideal for monitoring forests where internet connectivity is not available. Another key feature of the system design is its ability to scale. Multiple transmitting units can be set up across large forest areas, and all units can communicate with a single receiving station. This supports efficient monitoring of wide regions and improves the overall system's performance.

The system is designed to be cost-effective and easy to implement. All components used, like the Arduino UNO, sensors, and LoRa modules, are affordable and widely available. This makes the system suitable for large-scale use. Additionally, the system is energy-efficient; it consumes low power and can run for long periods without maintenance. This is especially important for remote forest areas with limited power sources. The overall design ensures reliable operation, precise detection, and real-time alerts. By combining multiple sensors with wireless communication, the system offers a solid solution for monitoring and protecting forests. Therefore, the proposed design effectively tackles the challenges of detecting forest fires and illegal tree poaching in remote areas and offers a practical solution for environmental protection.

2.LITERATURE SURVEY

In recent years, LoRa (Long Range) communication technology has gained significant attention for forest monitoring. LoRa is a low-power wide-area network (LPWAN) technology that enables long-distance communication with minimal energy use. It is especially suitable for remote forest areas where internet and cellular networks are not available. LoRa-based systems can transmit data over several kilometers, ensuring reliable communication between sensor nodes and monitoring stations. Several research studies have shown that LoRa is effective in environmental monitoring. Compared to other communication technologies like Wi-Fi and GSM, LoRa offers benefits such as low power use, a wider communication range, and lower operational costs.

These features make it a great choice for deploying sensor networks in large forest regions. Despite improvements in forest fire detection systems, most existing solutions only focus on fire-related events.

Illegal tree poaching, which is another major threat to forests, has received less attention in research. Tree poaching involves unauthorized cutting of trees with tools like axes or chainsaws, leading to deforestation and ecological imbalance.

In order to deal with this problem, some studies have attempted using vibration sensors and sound sensors for monitoring poaching activities. Vibration sensors can sense the disturbance created due to cutting, whereas the sound sensors will be able to capture the sound produced by machines. But the problem with their individual usage is that the environmental disturbance like strong winds or movements by animals might cause false alerts. To solve this problem, several sensors must be used together, which is called sensor fusion. Using multiple sensors, including vibration and sound sensors, will make the system differentiate between natural environmental behavior and poaching activities. In our proposed monitoring system, the forest fire detection as well as the tree poaching detection system will be used. This integration makes the whole solution complete for the surveillance of forests. It allows for timely identification of the occurrence of fire and any unlawful acts, thus allowing prompt actions and reducing negative impacts on the environment. Moreover, the design of the system is such that it can be implemented effectively and economically. Several sensors can be deployed in different parts of the forest area, and all sensors can communicate with the monitoring station using LoRa communication technology.

Alongside LoRa-based solutions, some other communication methods such as GSM, ZigBee, and Wi-Fi have been tested for use in forest monitoring. The use of GSM-based systems allows communication via mobile networks; however, the presence of such networks might be limited in forests. ZigBee is capable of achieving low-power communication; yet, its application is limited to short ranges, rendering it ineffective in covering extensive areas. Wi-Fi-based systems are characterized by high-speed data transmission; however, they have increased power requirements and limited ranges. In comparison to these alternatives, LoRa provides an optimal solution for implementing forest monitoring systems due to its high range, low energy requirements, and cost efficiency. Moreover, due to recent innovations in IoT, cloud-based systems have become possible in which sensors' data is transmitted to remote locations and analyzed there. Nevertheless, the reliance on internet connectivity

renders such systems less suitable for forest monitoring. Thus, standalone systems utilizing LoRa communication will be a better alternative than other communication technologies for real-time monitoring in far off areas. The above comparison demonstrates how significant is choosing suitable communication technology according to applications. LoRa communication technology in the proposed system provides an effective means for communication over a large area. In all, from this literature survey, it can be stated that the significance of an automated monitoring system and benefits of LoRa communication and sensor fusion have been explained.

3.HARDWARE USED

A) Arduino UNO

The Arduino UNO is the most popular microcontroller development board available today using the ATmega328P microcontroller. The Arduino UNO will play a vital part in the proposed system as it is the central processing unit in charge of executing all the processes. The Arduino UNO will be tasked to gather data from sensors, process the data, and manage inter-module communication.

There are 14 digital pins on the board, out of which 6 pins have PWM capability. There are also six analog pins available for taking readings of analog signals from various sensors. The clock speed of the board is 16MHz, while its operating voltage is 5V. The power source of this board can be either a USB port or any external power source, from 7V to 12V.

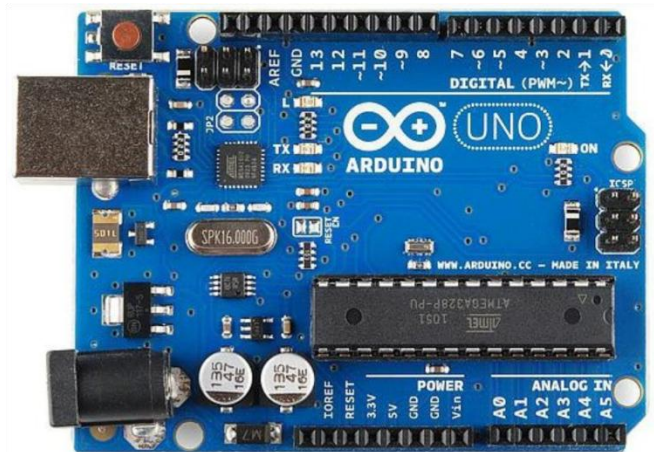


Figure 2. Arduino uno

The Arduino UNO is composed of some key elements, which include a crystal oscillator for clocking purposes,

a USB port to communicate with a computer, a power jack for an external power source, an ICSP (In-Circuit Serial Programming) pin for direct programming, and a reset switch for system restarting. This makes the board flexible and user-friendly. The Arduino UNO is composed of some key elements, which include a crystal oscillator for clocking purposes, a USB port to communicate with a computer, a power jack for an external power source, an ICSP (In-Circuit Serial Programming) pin for direct programming, and a reset switch for system restarting. This makes the board flexible and user-friendly.

B) LORA Module

LoRa module stands for Long Range and refers to a wireless device used for communication over long ranges while consuming low power. It is based on the LoRa technology that falls under the classification of Low Power Wide Area Networks (LPWAN). Such technology is particularly useful where low power long range communication is needed.



Figure 3. LORA Module

LoRa is designed to work in the sub-GHz band at frequencies including 433 MHz, 868 MHz, and 915 MHz. The modulation scheme used by LoRa is referred to as chirp spread spectrum (CSS). This ensures that it works effectively despite noise and interference. It works well outdoors, especially in forested areas.

C) Flame Sensor

The flame sensor is an electronic component employed for detecting fire or flame through the measurement of infrared radiation produced by the fire source.



Figure 4. Flame Sensor

The flame sensor finds extensive application in fire alarm systems because of its fast reaction time and excellent sensitivity to the flame signal. This is achieved using the fact that fires produce infrared light within a certain wavelength range ranging from 760 nm to 1100 nm. The infrared produced by the fire is captured by the fire sensor, and this is converted into an electrical signal by the sensor.

D) Smoke Sensor

The smoke sensor is a vital device that can detect the presence of smoke and toxic fumes in the atmosphere. In this case, the smoke sensor employed is the MQ-2 sensor, which is famous for its ability to detect toxic fumes and smoke.

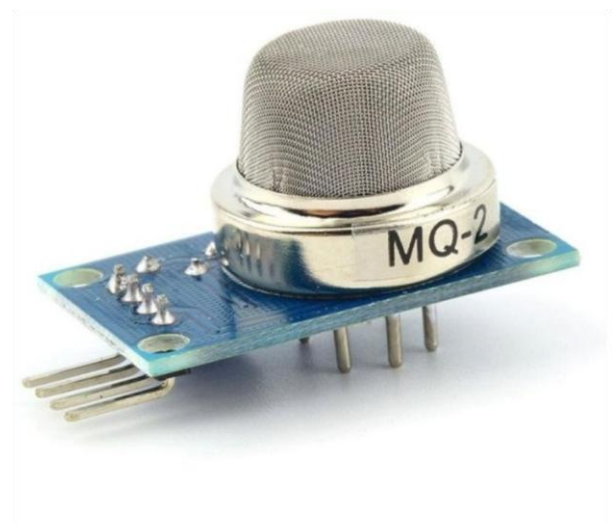


Figure 4. Smoke Sensor

Functionality of MQ-2 Gas Sensor :

MQ-2 works based on the concept of gas sensing via the use of a sensing material that is usually SnO₂. Upon the presence of gases or smoke in the air, there will be resistance changes. Such resistance changes will be translated to an electrical signal that will be analyzed using the microcontroller. This sensor is able to detect many gases including but not limited to LPG, Methane, Hydrogen, Carbon Monoxide, and smoke particles. This particular gas sensor offers two outputs; analog and digital outputs.

E) Vibration Sensor

The vibration detector is an electronic gadget designed to monitor mechanical vibrations or movements around its surroundings. The vibration detector is used to detect any disturbances that occur due to physical activities like tree felling, especially when it comes to monitoring tree poaching.

It works on the principle that it detects changes in vibration or movement. In case of vibration, there is production of an electric current within the sensing

system. The electric current is then relayed to the microcontroller for further action.

F) Sound Sensor

Sound sensors are electronic devices that can measure the sound level in the ambient atmosphere. The importance of sound sensors lies in their ability to sense sounds caused due to activities like chopping down trees, as such sounds need to be measured to detect tree poaching in forests.



Figure 7. Sound Sensor

Most sound sensors provide two types of outputs – one analog and the other digital. While analog output gives information about the intensity of sound, the digital output shows whether the sound level goes beyond a certain limit. The sensitivity of the sound sensor can be varied through a potentiometer.

G) LCD Display

The Liquid Crystal Display (LCD) is the name for the electronic display unit which displays the text and data output from the system. In the project, LCD will be used to display messages for forest fire and poaching alerts. One of the most widely used LCD modules is 16×2 LCD. It can hold up to 16 characters per row in two rows. Such LCDs are widely employed in embedded systems because they are simple, consume less power, and are easy to interface.



Figure 8. LCD Display

4. Software Used

A) Arduino IDE Software

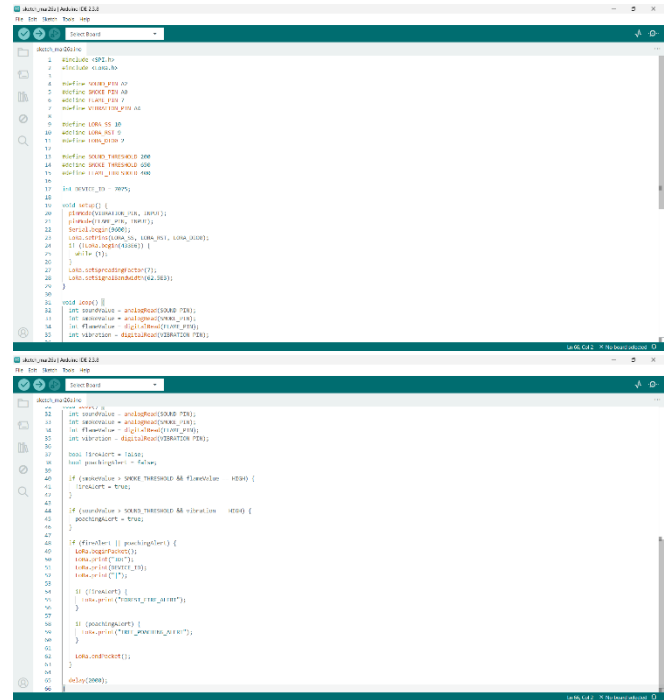
The Integrated Development Environment for Arduino (IDE) is the officially recommended software used for developing programs to be uploaded onto the Arduino boards, for example, the Arduino Uno board. This software makes use of an easy-to-use interface, thus making it convenient for both beginner programmers

and seasoned professionals to develop embedded system applications. Arduino IDE uses the C and C++ programming languages to develop programs capable of controlling various hardware components such as sensors, LED lights, buzzers, and communication interfaces. This project utilizes the Arduino IDE in coding the transmitter and receiver devices.

Regarding the transmitter, the programming of the transmitter will involve collecting information from the sensors (like vibration, flames, or temperature readings), processing the information, and sending alerts using the LoRa module. As far as the receiver, the programming will involve receiving data from the LoRa module, displaying the alert message on the LCD screen, and activating the buzzer if need be. Some of the features offered by the Arduino IDE include libraries that are built into it, in addition to supporting other external libraries (such as LoRa library and LiquidCrystal). After programming, the software goes through compilation in order to check if there are any bugs, and the program is then uploaded to the Arduino board using the USB cable. Once uploaded, the Arduino runs the program continually.

B) Transmitter

The transmitter in the system used for detecting tree poaching and fires includes the device that detects environmental parameters and sends alerts to the monitoring station. The transmitter includes an Arduino Uno board, several sensors including the flame detector, vibration detector, and either the gas/temperature sensor, and the LoRa communication module with the antenna. The sensors detect the environment around the forest area. For instance, the vibration sensor detects any vibrations, such as tree chopping, whereas the flame detector or the smoke sensor detects fire outbreaks.



Arduino Uno serves as the controller that processes all the inputs collected from the sensors via its digital and analog pins. The data obtained from the sensors is compared to a certain threshold value set within the program. In case there is any irregularity found like a fire or tree cutting activity, an alarm signal is generated by the Arduino. This signal is then sent to the LoRa module through the SPI protocol.

LoRa will then convert the data signal into radio frequency signals and transmit them across long distances using its antenna. Hence, the transmitter is very vital when it comes to the real-time surveillance system that alerts immediately upon detection of any abnormalities.

C) Receiver

The receiving unit is responsible for the monitoring and alarms to be raised as it receives the information sent out by the transmitting unit. The receiving unit comprises the Arduino Uno, LoRa module, 16x2 LCD screen, buzzer, and power supply. The LoRa module constantly keeps on receiving any signal sent out by the transmitting unit.

When a signal is captured, it is relayed from the LoRa module to the Arduino board using SPI protocol. The Arduino then processes the signal and determines the kind of alert, which may either be fire detection or poaching of trees. In accordance with the message captured, the alert is displayed on the LCD screen, making it easier for the user to get the message.

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