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An Efficient and Effective Forest Surveillance System to Prevent Malicious Activities using LoRa

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Abstract*: Smuggling of most valuable trees, like sandalwood in a forest, represents great damage to environment assets. It causes critical financial harm and at last, has a significant obliterating impact on the condition everywhere throughout the world. Fire is yet another reason that destroys the forest. Creatures are losing their natural habitat in this manner causing an absolute lose in nature. This paper proposes an IOT based forest surveillance system which employs the benefits of LoRa technology to detect theft of trees in forest by recognizing the sound produced by certain equipments while cutting the trees. And this paper also proposes the use of gas and temperature sensors to calculate the temperature, humidity, carbon monoxide to predict the forest fire well in advance.PIR sensor is used to find the motion of human beings around the forest and protect the device from the animals. The information is transmitted by the Lora technique. The inserted framework engineering and the equipment/programming plans are explained in detail. The exploration results demonstrate that Lora innovation had a decent transmission impact among forest.

***Keywords* : Arduino; LoRa Module ; Microphones;Sensors.**

I. INTRODUCTION

The most valuable types of trees, for example, Axle wood, Sandalwood, Ben teak, Bamboo and Rosewood are wide spread in the large areas of dense forests all over the world. Several measures have been embraced by various social organizations along with the Govt. of India, to alleviate these issues. These incorporate the appointment of special security forces in those areas and installation of surveillance cameras in most critical areas etc.. Strict actions are also taken against the indicted guilty parties. In spite of all these punishments the smuggling cannot be controlled completely. At the same time smugglers continue to cut down these precious resources of our nation. The most encouraging arrangement is -"the usage of an ongoing, remote sensor system and information logging framework" which will be an advanced and a shabby present-day innovation to make checking increasingly powerful and attainable. The issue of forest fire early discovery to confirm their spread rapidly is a critical task even now. The rate of spread of forest fire is unequivocally impacted by various factors like wind speed, types of trees, land spread, and other climatic conditions. However, the rate at which fire spreads is one of the important attribute that permit us to group timberland fires into three categories: ground, crown and surface fires. Surface fires are low to high intensity fires that burn on the surface of the ground and they usually spread at the rate of 0.5 m/min which is comparatively low. On the other hand crown fires are incredibly unsafe and hard to battle and mostly spread at the rate from 100 to 200 m/min. Speed of the wind may even elevate this rate to a certain extent. And so the rate of spread of the surface fire is a major factor to be considered during the battle against forest fires. This component impacts on tasks like arranging woods putting out fires, and even in taking choices for directing endorsed flames and stifling out of control fires. In this manner, it is vital to know the sort of flame when a flame caution is activated whether it is given by an individual or by a mechanized framework for timberland fire location. Here we propose a model which employs sensors and microphones to detect the untoward activities like theft of trees and forest fires in large forest areas. Once any unusual behavior is detected it is communicated to forest officials nearby with the help of LoRa technology. Lora stands for **Lo**ng **Ra**nge. It is a low power wireless communication technology which is widely used in IOT based projects now a day. This technology enables us to communicate in remote areas like forest where internet and power supply is a very big challenge. Our system uses several communication units (transmitter + receiver) employed at random locations in the forest which acts as straight forward extensions. These extensions transfer the messages between those communication units and a remote server nearby the surveillance room. The sensors employed in this system estimates four parameters each one moment: temperature, gas, motion, and sound. If a portion of these deliberate parameters is over the designed limits, the framework examines the data and responds sending an alert to the forest division using Lora module. They will come to know about the incident along with its precise location which can be identified from the fact that each Lora module has a unique id showing its location.

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II. LITERATURE SURVEY

Several studies have been made in understanding the types of forest fires which helped in choosing the appropriate sensors for this system. Forests are the nation's asset. Such abundant resources are disturbed by some factors like forest fire and abnormal natural calamities occasionally. The forest fire is caused by both human and natural disasters [1]. Several technologies have been proposed to address this issue. Here given below a table consists of the comparison of the present communication technologies like Zigbee, Sigfox, LTEM and our Lora module. Compared to other modules like LTEM, SIGFOX, ZIGBEE the data rate to be sent is less in Lora module. In our system only short message is transmitted and so Lora module is implemented as it is a low cost and long range transmission technique.

Table.1.Comparison of different communication technologies

	LoRa	LTEM	SIGFOX	ZIGBEE
Rate of Transmission	21.30 Kbps	<150kbps	<0.1kbps	<250kbps
Range of coverage	5-7km	<8-10km	<3-5 km	<700 m-1km
Cost of module	$5-20	$100	$5-20	$5-20

In the forest there are many factors for the fire. It maybe man made or natural and it is necessary to find the reason for the fire. For that purpose sensors are used. The cost of implementation is reduced because of the usage of small sensors which covers a larger area. [3]. Using cameras to store the level of fire in forest and use of the infrared camera during night times for flame recognition makes it still effective. Camera which even works on thermal covers the area of fire and compares with the data fed for the smoke and identifies it. The scattering of the light due to the particles in smoke identifies the presence of smoke. Infrared has higher accuracy than the other systems [5]. Generally if the infrared level is noted at the receiver side and checked with the threshold value, initially it sends a precaution message; but this methodology has some drawbacks in accurately detecting the fire in that location. Detection capabilities are affected at times if the presence of smoke is under the bush or out of coverage area in camera .The fire would be spread faster before infrared camera detects the smoke in the forest [7].The data collected in the forest need memory to store and process. This process is helpful to identify the output from the data. The various techniques like rough sheet theory and dependency matrix are helpful in the identification of data for the later process.[9].The data and images collected in the system have a high frequency in sending the data from one point to another. It takes one hour to change the meteorological data update, and the change of image data, the factors responsible for the forest fires changes faster. Also prediction system of fire and the collected data is more important. To monitor these changes of factors for fire the images from the IR cameras to be collected in real time. For this purpose a wireless sensor network has to be established which is a challenging task in remote forests where internet facilities are not available.[11].Rather than detecting the occurrence of fire it is most important to frequently check for the factors that initiates the forest fire. Right factor cannot be easily detected because of the large area in the forest. With the low resolution cameras scanning of large area is a challenge. Wireless sensor networks are helpful in providing high accuracy solution. Various technologies are developed in sensor networks which would help in creating a framework to detect forest fire. Currently, many sensors are used to detect various phenomena which are used for fire detection systems [13]. Now, we require an easier solution that can provide high accuracy of the result on the fire detection with the help of the above mentioned sensors.

III. METHODOLOGY

The methodology proposed in this paper is to detect the forest fire in earlier stages and to identify cutting down of trees by incorporating small and low cost sensors. We are not utilizing substantial costly incorporated control hardware which influences framework in such powerless condition. Fire is identified using gas and temperature sensors and cutting of trees are identified using PIR sensors and small microphones. More number of these sensors are fixed across the forest area. These sensors uses Lora technology for communication. Our system is transmitting and receiving using a Lora module that still can cover a vast checking zone. The remote sensor systems are comprised of four sections: sensor hub, receiver and transmission system. The architecture diagram for the Transmitter and Receiver is as shown in Figure 1 and figure 2.

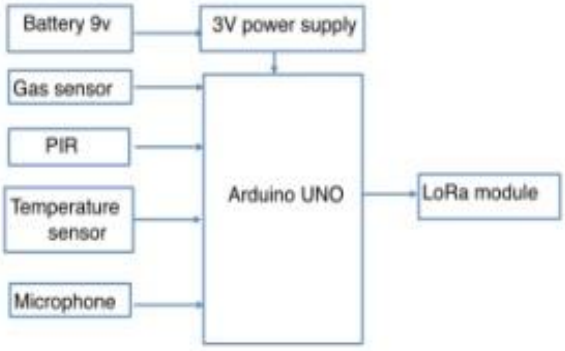

Fig 1. Architecture diagram of transmitter

The forest surveillance system proposed in this paper continuously checks and monitors index value of air, temperature, sound around the area and other environmental parameters in real time. After detecting any untoward activity it can automatically transmit alert signals to the Lora module nearby which in turn transmits to the next Lora transceiver module. This process continues until the signal reaches the control. The signal reaches the control room as follows: At first, various gas and pressure and other sensor nodes widely distributed in the forest areas detect parameters such as index value of air, temperature, the frequency of sound etc in real-time. These values are continuously sent to the transceiver nodes using multi-hop routing technology until it reaches a nearby local server maintained in control room. Then after the data which is received at the nearby control center, is saved depending on the data type in the corresponding database tables.

The data is compared with certain threshold values and if it exceeds the threshold an alert message will be generated in case of emergencies to take appropriate measures. In usual circumstances these data at the server computer can be processed, analyzed and even visualized in the form of charts, graphs and plots which will be further helpful for real time prediction analysis.

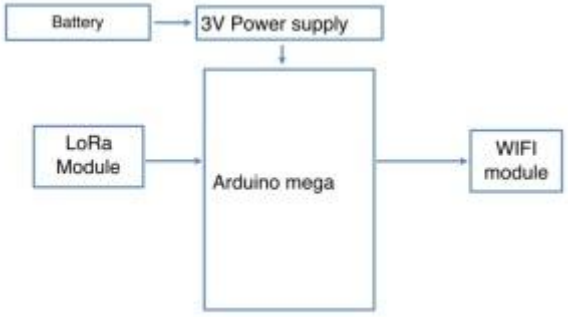

Fig 2. Architecture Diagram of the Receiver

In receiver module communication operations are similar like the transmission module. For the Development such a system the sensors plays a vital role in. At receiver side Hub implementation specifically decides the execution of the whole system. Both transmitter and receiver employs the Lora communication technology which plays a vital role in this system The equipment structure of the whole framework is typically made out of the sensor board, Arduino, microphone, wireless communication module (Lora module) and control module

A. Sensor Board

1. Temperature Sensor

The forest fire is frequently brought about by a wide range of components joined together such as temperature and humidity which is the main factor for the cause of the natural fire. Natural Forest fire is typically caused due to the rise in temperature in the forest environment. As the temperature is the primary factor, in our work, we use the LM35 Temperature sensor to measure the temperature in the surroundings. LM35 measures more accurate than a thermostat. Compared to other thermocouple sensors LM35 sensor generates an output voltage which is very high and so it is not necessary to amplify the output. The LM35 produce a reading of the high voltage value that is a proportional value of the atmospheric temperature (in degree Celsius). The main advantage of the sensor is its low power consumption (around 60 micro amps and it also incorporate the property of low self heating which is essential in our system.

2. Gas Sensor

Secondly, on earlier stages detecting and controlling of fire is easier by the use of gas sensor to measure the gas concentration in the air. In our system, we use the MQ3 gas sensor to detect the air quality index in the environment. This index of air can lie less than 500 units which would be harmless to the people. If the index increases more than 500 units then an alert message is given as per the code in the Arduino. This factor would find the earlier stage of the fire and measures can be taken to control the fire in advance.

B. LoRa Module

The Lora is tiny wireless transceiver modules that offers long range, low power, and secure signal transmission. It is a booming communication technology in the field of IoT. This employs multi hop routing methodology for transmission. The data from the sensor is transmitted from one module to the other. N number of nodes can be connected in the system. The transmitter is coded with a unique id in order to identify its location, along with its network address and bandwidth as same as the receiver. In case of the network availability the messages are uploaded directly to the cloud, and when network is unavailable the message packets are again sent to nearest receiver module and this process continues until it reaches the server or network connection. The bandwidth of Lora module lies between sub-Giga bytes from 100 kHz-1giga hertz. Thus Lora module is the key component here which enables the transmission of alert signals.

C. PIR Sensor

Passive Infrared sensors are used to find the motion of the human around that area. The device mainly measures the IR radiating objects in its field of view. The PIR sensor helps in detecting the human around the area of 10 to 12 m. The main advantage of this device is that is the use of pet-friendly PIR sensor which would discard the animals less than a weight of 80 pounds. They detect the unwanted movement of human and send alert signals to the Lora module. This is helpful in case of deforestation kind of activities.

D. Microphone

Microphones are used to record the sound in the surrounding environment. As nature of the forest has a less sound, In case of using the chainsaw to cut down the trees for smuggling, the sound pitch value increases more than 110db and is recorded in the microphone and compared with the threshold value as per the program in the Arduino. If it exceeds the threshold alert signals are sent to the Lora module.

IV. ALGORITHM AND FLOWCHART

The flow diagram below depicts how the process of forest monitoring and surveillance is done. The data collected from various sensors are compared with the predefined threshold values based on the environment of the forest behavior. If it reaches the threshold value it transmits a message like “the risk factor is high” using Lora module. If it doesn’t reach the threshold value it continues to monitor the environment. The Lora module incorporated in this system is capable of transmitting the messages even in an environment where there is no network coverage.

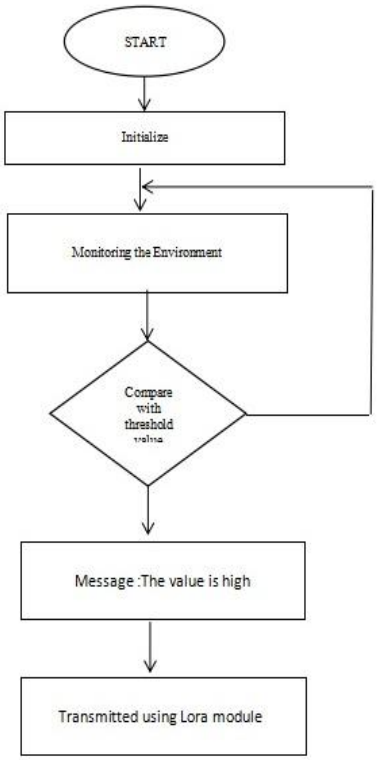

Fig.3.Flow diagram of transmitting data

Flow of the Process:
Step 1: Start the process
Step 2: Monitor the environment behavior like temperature, air index value, noise rate etc.
Step 3: Compare those values with the predefined threshold value.
Step 4.a: After comparison if the particular value is higher than threshold value then the message is sent through Lora module Step 4.b: After comparison if the particular value is lower than the threshold value the process repeats from step 2.

V. RESULTS AND DISCUSSION

In this section the prototype of the Lora transmitter and receiver is explained. The prototype shows the sensors and the transceiver module. Various tests and trials are carried out using sensors to detect the factors causing the fire and cutting down of trees. The sensors are attached to the trunk of the tree. Threshold values are set according to the forest environment.

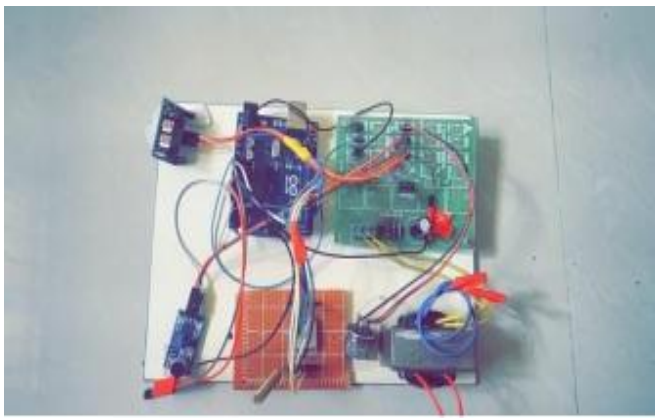

Fig.4.Prototype of Transmitter

The transmitter consists of the gas sensor, temperature sensor, PIR sensor, Lora modules attached to the Arduino Uno. Each sensor collects the information of the environment like temperature, air index value, decibel values and is sent as packets using Lora module. The transmitted message consists of the temperature value, Air Quality Index value, light radiation and amount of noise in decibel noted by temperature sensor , Gas sensor, PIR sensor and microphone receptively. They are formed as packets and the message is sent to the receiver side. (Fig 5)

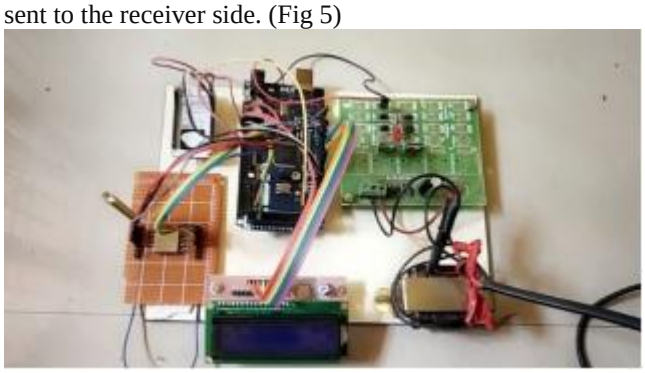

Fig.5. Prototype of Receiver

At the receiver side, the Arduino Mega is connected to the Lora receiver, LCD screen to view the sent messages. The cloud system is also used to upload the information in the cloud in case of availability of network coverage. The messages can be seen when the device is connected to the internet.

Fig.6. shows these packets of messages. The packet consists of the temperature, sound, PIR, air index value which loads for every second and updates its value according to the environment. This value is compared continuously with the threshold values for giving the alert messages.

```
Sending packet: 41
sensor = 686
Temperature = 29
sound1= 30
pir1= 0
Sending packet: 42
sensor = 477
Temperature = 31
sound1= 18
pir1= 0
Sending packet: 43
sensor = 548
Temperature = 31
sound1= 21
pir1= 0
Sending packet: 44
sensor = 642
Temperature = 30
sound1= 27
pir1= 0
Sending packet: 45
sensor = 530
Temperature = 31
sound1= 23
pir1= 0
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Fig.6. Packets of messages from transmitter.

VI. CONCLUSION AND FUTURE WORK

Wireless sensor network had been used in every industry and day to day life. This paper is designed in monitoring the forest fire and smuggling of forest wood. Our system would detect the fire in advance and recognize the pitch value of the sound and recognize the cutting down of trees using the chainsaw and uses Lora communication technology to send alert messages to long distance. This system has an advantage of low power, reliable and long distance message transmission in real time which has a better scope in applications like forest surveillance and monitoring

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