DAYANANDA SAGAR COLLEGE OF ENGINEERING

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Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru-560078.

A Mini-Project Report On

"Forest Fire Detection System"

Submitted in the partial fulfillment of requirements for the award of the degree of

BACHELOR OF ENGINEERING
IN
INFORMATION SCIENCE AND ENGINEERING

Submitted by

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Department of Information Science and Engineering
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CERTIFICATE

This is to certify that the Mini-Project Work entitled **"Forest Fire Detection System"** is a bonafide work carried out by **Nandini Poddar [1DS19IS063], Neha S Shetty [1DS19IS064], Pankaj Garg [1DS19IS066], Saquib Ameer Khan [1DS19IS089]** in partial fulfillment for the 6th semester of Bachelor of Engineering in Information Science & Engineering of the Visvesvaraya Technological University, Belgaum during the year 2021-22. The Mini-Project Report has been approved as it satisfies the academic requirements prescribed for the Bachelor of Engineering degree.

Signature of Guide [Prof. Vaidehi M]	Signature of HOD [Dr.Udaya Kumar Reddy K R]

Name of the Examiners	Signature with Date

1. ______________________

2. ______________________

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ABSTRACT

Fire, as one of the world's biggest calamities, must be identified at the right moment before it can do significant damage to the atmosphere, living beings, and resources. In one way or another, these renewable resources are very essential to mankind. Forest fires are the most common hazards in forests which lead to serious destruction of forest wealth, biodiversity, and natural habitat. According to a study, 75-80 percent of the various casualties caused by fire might have been prevented if the misfortune was detected quickly. Particularly in the case of a forest fire, this results in a significant loss to the environment and makes it extremely dangerous for the wildlife habitat. To avoid such losses, an automated system is needed that can provide early detection of any fire situation via any of the alarm systems.

Traditional methods of human surveillance are directly through human observation and through distant video surveillance. This requires 24/7 continuous monitoring.

The automated fire alert detection system by which one can achieve surveillance through the automation approach of detection proposed in this project comprises three sensors, namely flame, temperature (DHT), and CO2 MQ135. These sensors detect changes in a measurable physical quantity and intimate the nearest fire-extinguishing station.

Internet of Things (IoT) technology has brought a revolution to each and every field of common man’s life by making everything smart and intelligent. IoT refers to a network of things that make a self-configuring network. The development of IoT based Forest Fire Detection System will be helpful in mapping emergency plans and making them more effective during the occurrence of any disaster.

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Chapter 1

Introduction

1.1 Overview

A wildfire, forest fire, bushfire, wild-land fire, or rural fire is an unplanned, uncontrolled fire in an area of combustible vegetation starting in rural and urban areas. Of late, forest fires have captured the attention of people worldwide. Over the last few years, there have been devastating fires in the forests of Southeast Asia, the Amazon, and the Rocky Mountains of the USA. Such fires have not only led to threats to the biological diversity of these forests but have also caused large-scale human suffering in neighboring lands, due to pollution of the environment.

Forests play an important role in the global, ecological, environmental, and recreational systems. It greatly impacts the number of greenhouse gasses, and atmospheric carbon absorption, and reduces soil erosion. Forests contain many essential resources for human survival and social development that protect the balance of the Earth's ecosystem. Forest fires are a recurrent phenomenon, natural or man-made, in many parts of the world. Global warming contributes to the increase in its number in recent years and the importance of these disasters. In this scenario, the frequency of forest fires has increased considerably due to climate change, human activities, and other factors.

The detection and monitoring of forest fires have become a global concern in forest fire prevention organizations. This system can monitor real-time related parameters, e.g., temperature, and relative humidity, and send the data immediately to the computer of the monitoring center. The fire alert system has low power utilization and quicker handling capacity at a lower cost and maintenance.

The Forest fire detection system uses advanced technology which will help in tracing out the forest fire in its initial stage.

1.2 Problem Statement

Lately, the world has seen many occurrences of wildfires which have caused a lot of damage to our biodiversity. These fires have caused damage to wildlife, human life, property, and the environment. It could be avoided if a robust system could be deployed in forest areas to detect the fire in its initial stage and alert the concerned authority to take appropriate and immediate action.

Hence our approach addresses the need for early detection of the forest fire before it spreads to a large scale and causes a number of casualties. As a result of this automated system, a lot of lives, as well as natural resources, could be saved. The approach ensures a more reliable and accurate result and is cost-effective at the same time.

1.3 Objective and Scopes of Project

The main objective of this proposed model is to predict the developing trend of the fire by building a Forest fire detection system using IoT and the cloud which would detect the fire and send an emergency fire alert to the authority and analyze the growth of the fire for future study.

The objective is to detect the fire as fast as possible and its exact localization and early notification to the fire units are vital. This is the deficiency that the present invention attempts to remedy, by means of detecting a forest fire at the very early stage, so as to enhance or ensure the chance to put it out before it has grown beyond control or causes any significant damage.

There are a number of detection and monitoring systems used by authorities. These include observers in the form of patrols or monitoring towers, aerial and satellite monitoring, and increasingly promoted detection and monitoring systems based on optical camera sensors, and different types of detection sensors or their combination.

The scope of the proposed model is

- To detect the forest fire at its early stages.
- To determine the intensity of the forest fire.
- To intimate the respective authority along with the GPS coordinates of the location.
- Alert the surrounding ecosystem with a fire alarm.
- Then analyse the change in measurable physical quantity.

Millions of hectares of forest are destroyed by fire every year. Areas destroyed by these fires are large and produce more carbon monoxide than the overall automobile traffic. Monitoring of the potential risk areas and early detection of fire can significantly shorten the reaction time and also reduce the potential damage as well as the cost of firefighting. The objective is to detect the fire as fast as possible and its exact localization and early notification to the fire units are vital. This is the deficiency that the present invention attempts to remedy, by means of detecting a forest fire at the very early stage, so as to enhance or ensure the chance to put it out before it has grown beyond control or causes any significant damage.

1.4 Motivation of the Project

Dixie: California's Dixie fire was the largest wildfire of 2021. It burned more than 960,000 acres before being contained. More than 7.6 million acres burned in the US in 2021 due to wildfires. That's about 2.6 million fewer acres than in 2020.

Black Summer: Australia's "Black Summer" bushfire was another devastating incident. More than 24 million hectares (59 million acres) burned during the bushfire season of 2019-2020, which formed part of a confirmed climate change-driven trend of worsening fire weather and larger, more intense forest fires.

One of the most dangerous aspects of wildfires is their ability to spread quickly and wipe out critical habitats. Wildfires can burn through a forest at a speed of 10 kilometers (6 miles) an hour.

The forest cover is also necessary for the environment as it is a source of food and other materials and also to keep the green cover of the planet alive and the environment clean.

Reduce the emission of harmful greenhouse gasses like carbon dioxide, carbon monoxide, methane, etc. during these forest fires.

Smoke from forest fires rises into the atmosphere, causing a set of chemical reactions leading to the loss of the ozone layer, which shields the Earth from harmful UV rays.

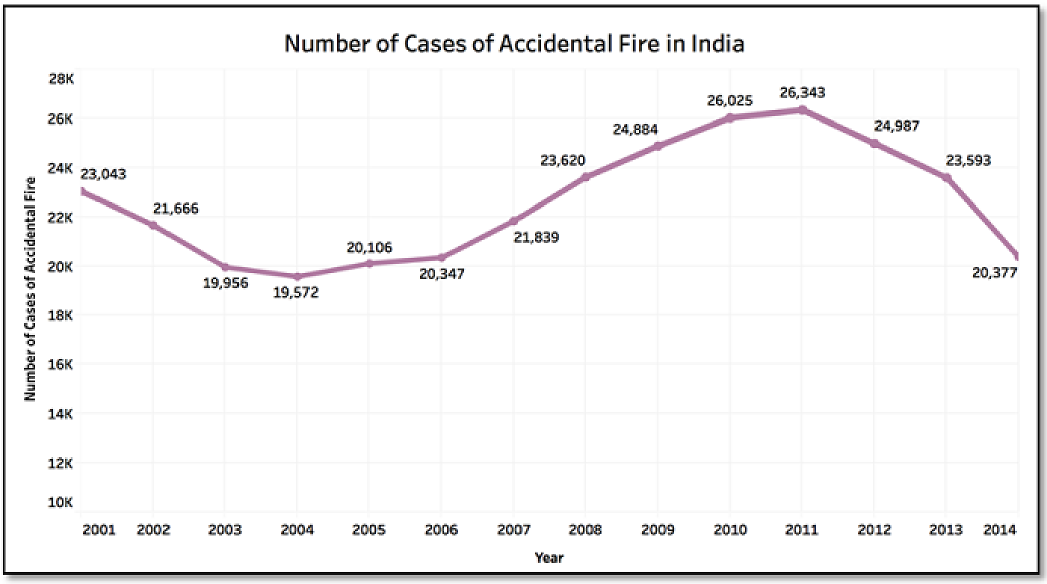


Fig. 4.1: Forest Fire Cases in India

Chapter 2

Literature Survey

Numerous solutions have been proposed and implemented for this problem. The most common systems used in field work are video surveillance systems. Video cameras are sensitive to smoke only in the daytime. Fire sensitive cameras at night, using IR thermal imaging cameras for heat flux detecting and using backscattering of laser light, detect the smoke particles. This fire alert system has a few limitations because of environmental conditions like dust particles, mist, shadows, and so on. Another method is an automated picture capturing of fires in the forest.

The base station collects the information sent by satellite and runs an algorithm to recognize the facts (Basu et al., 2018). The raw data of satellites are processed and then the Advanced Very High-Resolution Radiometer instrument is utilized to recognize hotspots. In South Korea, a forest fire surveillance system was proposed by using wireless sensor networks. Wireless sensor networks detect humidity and application analyses the collected information (Hariyanwal et al., 2013; Kumar et al., 2017).

In this methodology, there is some loss of information during communication. By using a temperature sensor and GPS modem, forest fire detection can be possible (Basu et al., 2018). Here, temperature sensors collected data were sent to the base station by both primary and main antennas (Alahi et al., 2017). The continuous power supply was difficult for too many antennas and sensors. In addition to the above limitations, climatic changes may affect the system. In research done by Zhang et al. (2009), Pirbhulal et al. (2017), and Alahi et al. (2017) an ad hoc network using cluster topology for forest fire forecasting model was used to predict fire-prone areas.

It was concluded that WSNs have greater advantages. In another research done by Demin et al. (2014), sensors were deployed and the weather data were collected. This data was used to calculate and prevent forest fires. In these researches, there was no real-time forest fire monitoring, only the data were collected and fire-prone areas were predicted. Libelium (Solobera, 2010) developed a wasp mote that has four sensors for measuring gases, temperature, and humidity. It gives early warnings and consumes very less energy.

Shunyang X. Du, J. Yongping and W. Riming, Realization of Home Remote Control Network Based on Zigbee (2007),et al. deals with the design of remote monitoring and control systems. The system consists of a real-time home monitoring subsystem and a light control sub-system. A home server with a home camera caters to home status through video to the client.

- Surapong Surit, Watchara Chatwiriya proposed a method to detect fire by smoke detection in video. This approach is based on digital image processing approach with static and dynamic characteristic analysis.

- Akshata & Bhosale proposed another method where Local Binary Pattern acts as a base for fire detection and Wavelet Decomposition is used to detect fire. Pixel level analysis is required in this method.

- Libelium (Solobera, 2010) developed a wasp mote which has four sensors for measuring gases temperature and humidity.

- Terradas, J. and PiÃ±ol et al. (2009)[2] has conferred this system because the wireless web based system has numerous applications in real time system. A program that analyses satellite data in near real time and converts information into instant messages and email alerts to track forest fires.

Chapter 3

Requirements

3.1 Software Requirements

- Arduino IDE (1.8.13)
- ThingSpeak Account (Cloud)
- Software Serial

3.2 Hardware Requirements

- Arduino UNO <<amazon links>>
- SIM808 GPS/GPRS/GSM Module
- Sensors-
  - Flame
  - DHT
  - CO2 MQ135
- Buzzer, LEDs
- 9V- 1A Battery
- Breadboard
- 5 V DC power supply
- Jumper wires and cables.

Chapter 4

System Analysis

4.1 Existing System

There are various existing technologies to detect forest fires in their early stages. A few of them are mentioned below.

- **Satellite-Based Systems**

  Earth-orbiting satellites and even air-floating devices have been employed for the observation and detection of forest fires. Satellite images gathered by two main satellites launched for forest fire detection purposes, the advanced very high-resolution radiometer (AVHRR), launched in 1998, and the moderate resolution imaging spectroradiometer (MODIS), launched in 1999, have been used. Unfortunately, these satellites can provide images of the regions of the earth every two days and that is a long time for fire scanning; besides the quality of satellite images can be affected by weather conditions.

- **Optical Sensor and Digital Camera**

  Nowadays, two different types of sensor networks are available for fire detection, camera surveillance and wireless sensor network. The development of sensors, digital cameras, image processing, and industrial computers resulted in the development of a system for optical, automated early recognition and warning of forest fires.

- **Wireless Sensor Networks**

  The line of sight and the early stage of the fire process problem could be solved with the second type of sensor. A new technology called wireless sensor network (WSN) is nowadays receiving more attention and has started to be applied in forest fire detection. The wireless nodes integrate on the same printed circuit board, the sensors, the data processing, and the wireless transceiver and they all consume power from the same source batteries. Unlike cell phones, WSN does not have the capability of periodic recharging.

- **Authorities Fire Suppression and Detection Techniques**

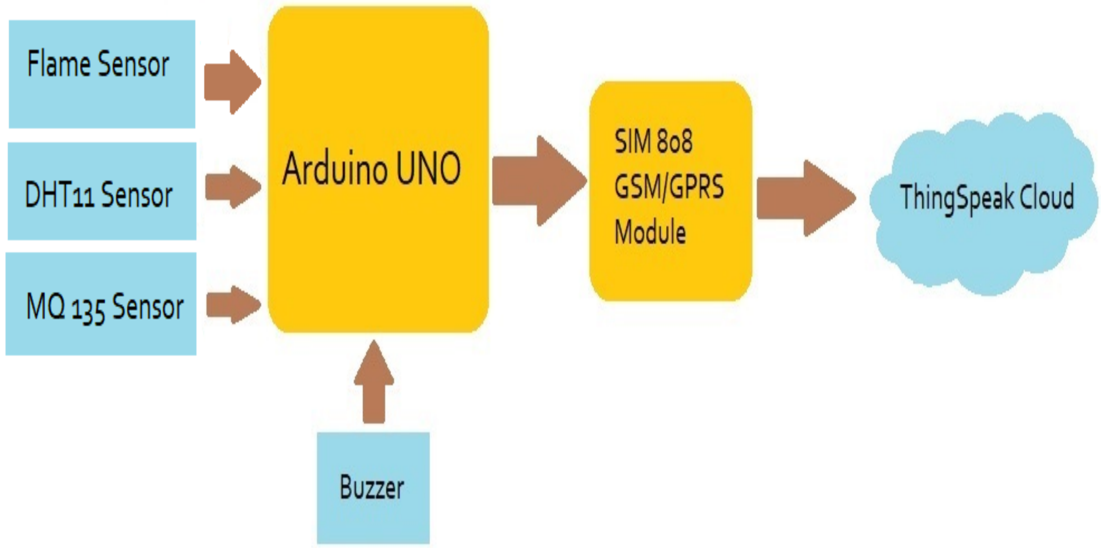
  Some of the techniques used in fire suppression include burning dry areas under the management of firefighters rather than having a crisis later or using flying water tankers like in Canada. Interestingly, others sweep away everything within a planned wide line to surround the fire with a dead-end of unfilled areas like in the Middle East. In some parts of Australia, providing the fire does not harm any humans or properties, it is left to burn until it dies alone.

4.2 Proposed System

This section of the report will include the proposed work as to how the project has been carried out showing the Hardware used, Software utilized, Algorithms used with respect to the deep learning part of the project, and working on the project.

As shown in the schematic block diagram below, the project consists of Arduino UNO, SIM808 GSM/GPRS module, and sensors like flame sensor, DHT11 (Temperature and Humidity) sensor, and MQ135 (CO_2 sensor) as its primary components. The fire can be detected by the sensors which give a digital output that corresponds to the Fire status and is received by the Arduino UNO.

Arduino compares the signal and triggers the SIM808 in case of fire incidents. Through AT commands, SIM808 communicates with the thingspeak server.



A fire alert system comprises three important stages: sensing, routing, and communication. For sensing the physical change in the environment, a couple of sensors are used, namely smoke and fire sensors.

The following steps are followed:

- Connect the Flame sensor, DHT sensor, and the CO2 sensor to the microcontroller (Arduino UNO) using Jumper wires and a breadboard.
- Also connect SIM808 module via Logic shifting resistors.
- Connect the buzzer and LEDs for the alarming system.
- Supply DC current (9V-1A) to the SIM808 module to power it on.
- 5V DC external supply is given to Arduino UNO for the working of UNO and the sensors.
- After the successful integration of hardware, Arduino IDE is used to code those components. and get the required readings.
- Cloud platform needs to be set up, where the real-time data will be received.
- Once all the data is received, the intensity of the fire will be estimated and the level of the wildfire will be determined.

Chapter 5

System Design

5.1 Introduction

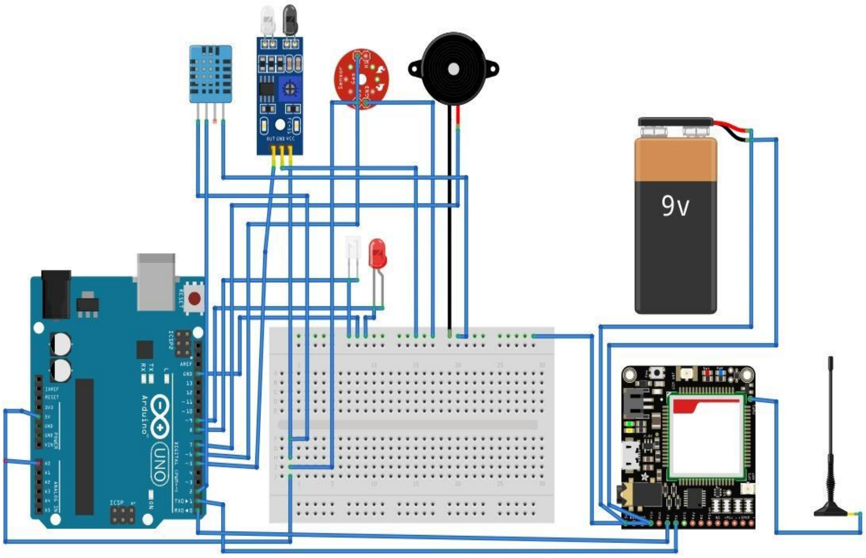
An ioT-based smart approach to detect the forest fire in its initial stages and intimate the respective authorities. The proposed model is designed using the E-Byram's (extended) formula to compute the fire intensity and classifies it into three different stages.

Alerts the surrounding ecosystem with a loud buzzing noise. Also analyses the changes in the measurable analogy of physical quantities to further understand the severity of the calamity

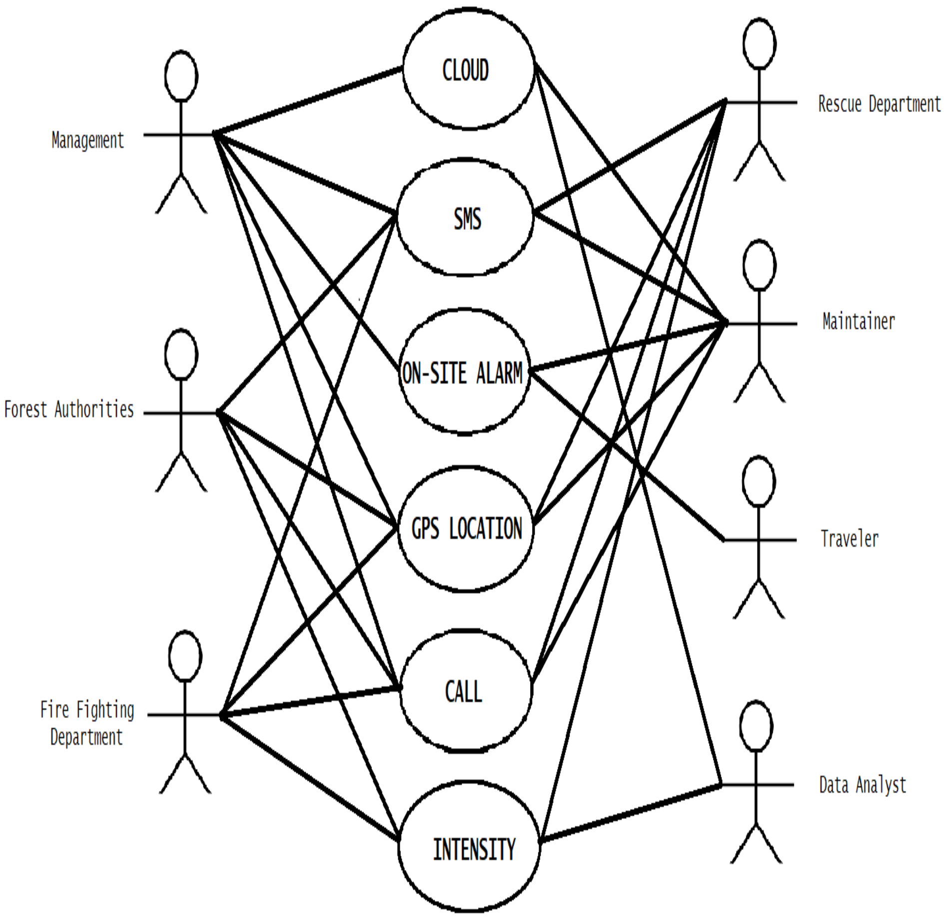
A fire alert system comprises three important stages: sensing, routing, and communication. For sensing the physical change in the environment, a couple of sensors are used, namely smoke and fire sensors.

The fire and smoke sensors detect the respective elements and this initializes an alert and activates the system. This, in turn, sends the location, which is detected by the GPS module, with an alert message via SMS to the user with the help of the GSM module that has been incorporated into the system. Once the user receives the alert message, the required action can be taken to control and cease the fire.

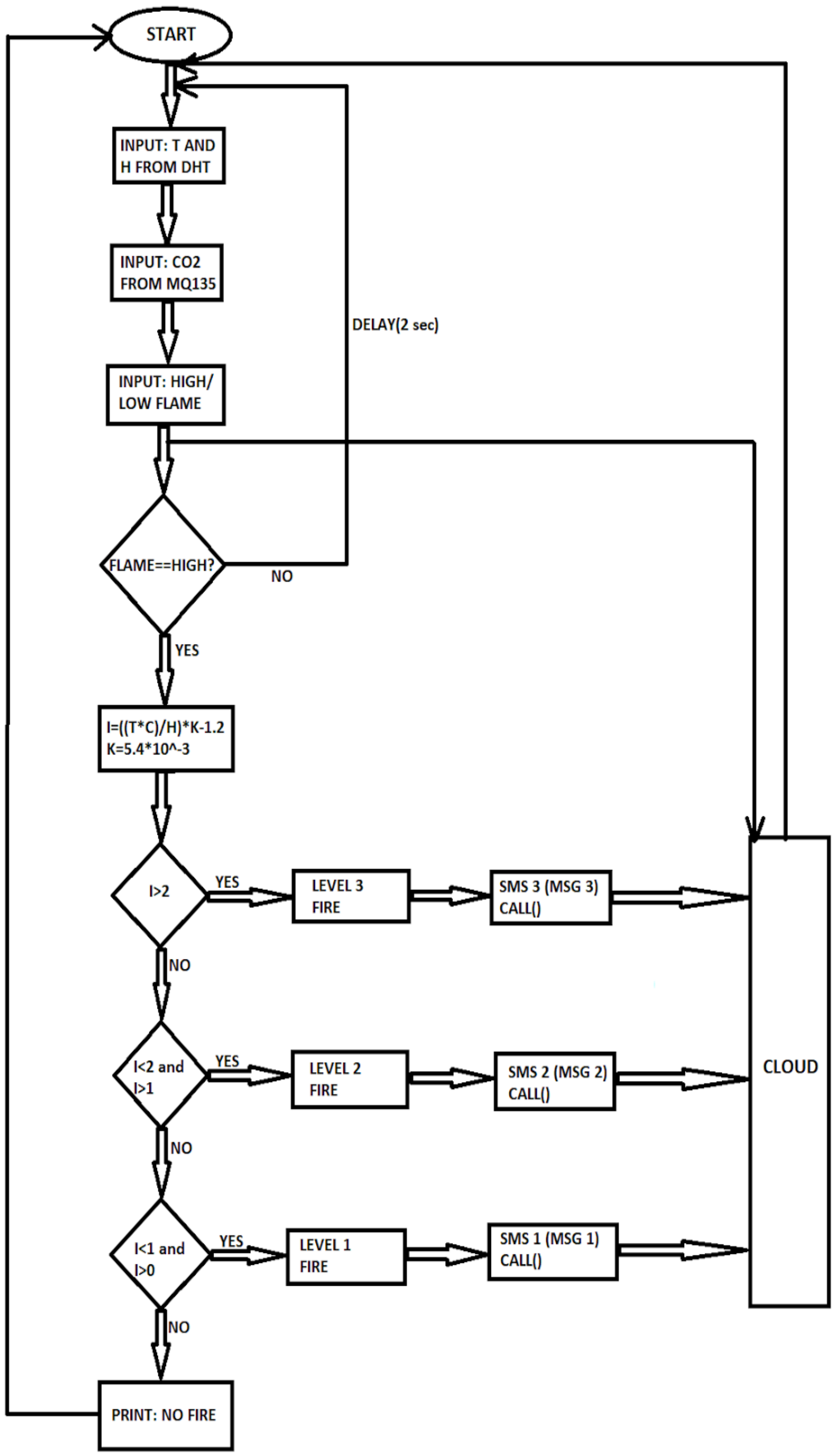
5.2 Architecture Diagram



5.3 Use-case Diagram



5.4 Flow chart Diagram



Chapter 6

Modules

6.1 Modules

1. Determining the Fire Intensity
2. Integration of Cloud
3. Clips of the current state
4. Intimating the Authorities
5. Buzzing Alarm at the site

6.2 Modules Description

1. Determining the Fire Intensity:

The extent of a forest fire is classified into 3 stages:

1. Ignition (Low)
2. Growth (Medium)
3. Fully Developed (High)

Byram's formula:

$I = H w R$ ***Equation 1***

where:

I = fireline intensity (kW m^{-1})

H = heat yield of the fuel consumed (kJ kg^{-1})

w = amount of fuel consumed (kg m^{-2})

R = forward rate of spread of the fire (m s^{-1})

Proposed Formula:

I = [(T * C * k) / H] - 1.2

where,

T= Temperature (in degrees Celsius)

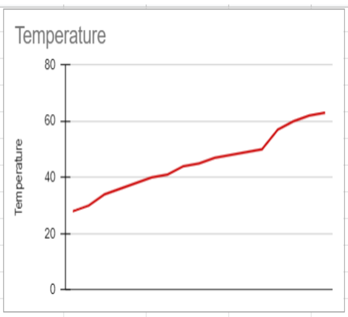
C= Concentration of CO2 present in the air (in ppm)

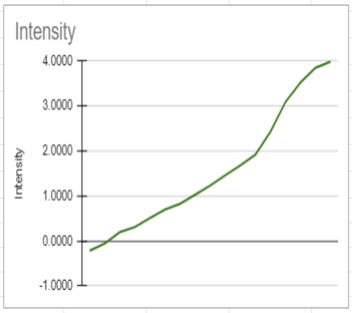
H= Relative humidity of the atmosphere (in RH)

k= proportionality constant

$= 5.397 \times 10^{-3}$ (RH per ppm per degree Celsius)

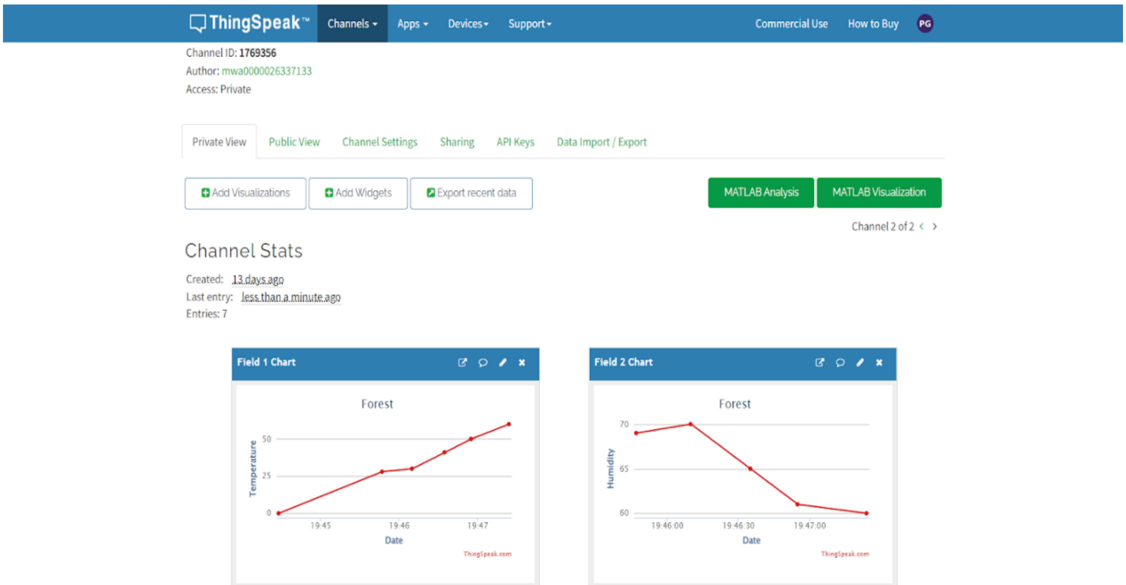
Data sheet for the Intensity of Forest Fire						
S.No	Humidity	Temperature	CO2 concentration	Intensity	Stage of forest fire	Level
1	69	28	450	-0.2145	0	No Fire
2	68	30	480	-0.0571	0	No Fire
3	67	34	510	0.1968	1	Ignition
4	67	36	520	0.3079	1	Ignition
5	66	38	550	0.5091	1	Ignition
6	66	40	580	0.6971	1	Ignition
7	65	41	595	0.8255	1	Ignition
8	64	44	600	1.0263	2	Growth
9	64	45	640	1.2287	2	Growth
10	63	47	660	1.4574	2	Growth
11	63	48	700	1.6784	2	Growth
12	62	49	730	1.9137	2	Growth
13	61	50	820	2.4275	3	Fully Developed
14	61	57	850	3.0866	3	Fully Developed
15	60	60	875	3.5224	3	Fully Developed
16	59	62	890	3.8476	3	Fully Developed
17	59	63	900	3.9866	3	Fully Developed





2. <u>Integration of Cloud:</u>

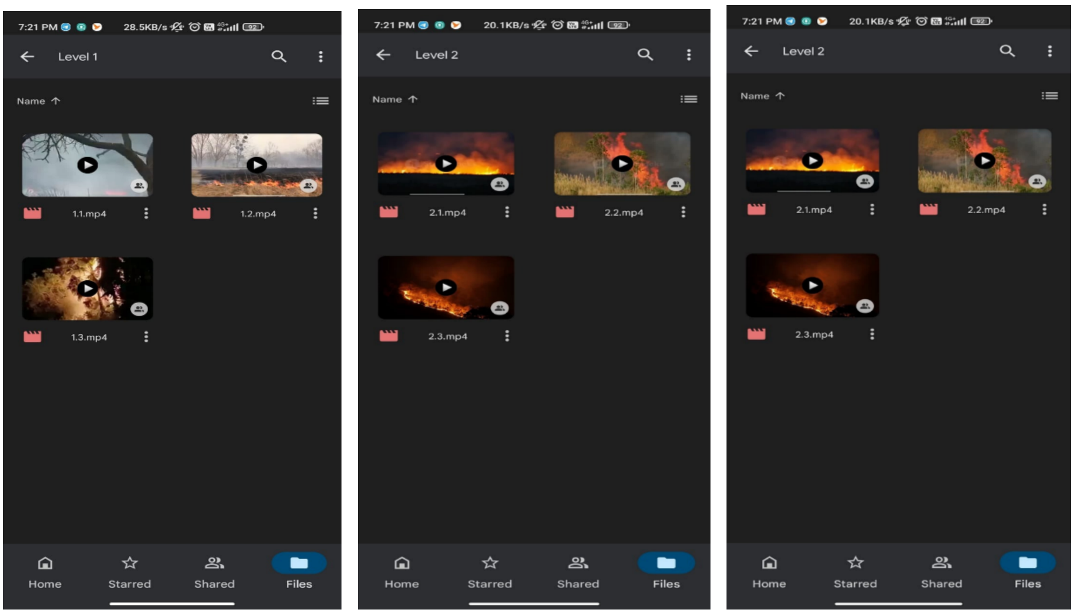
   ThingSpeak, an open-source cloud is integrated with the device with the help of an API to visualize the data in a graphical format (line graph) and to understand the changes in the physical parameters during the incident.



3. Clips of the current state:

The authorities are informed about the current scenario at the site of the incident by an SMS containing a google drive link that has a few video clips.

- Currently, we have uploaded pre-recorded videos in the drive.
- As a future scope, clips of 10 sec each showing the status of the scenario will be posted in the drive at regular intervals of time.

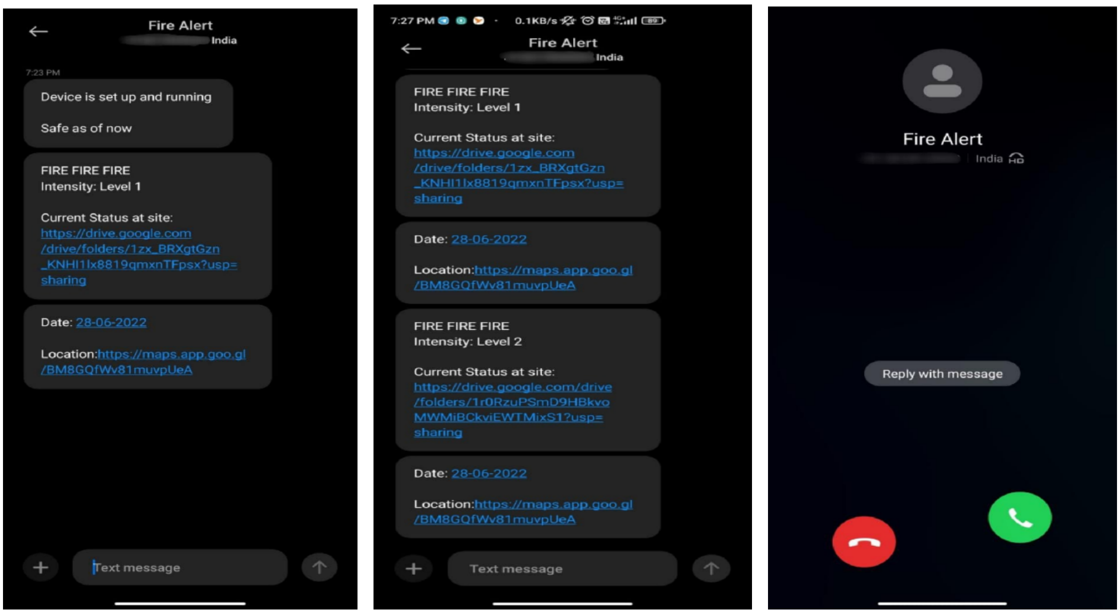


4. Intimating the Authorities:

Authorities are informed about the forest fire at the earliest.

It is done in 2 ways:

- **SMS**: A customized SMS is sent to the authority based on the intensity of the fire along with the date and location to ensure that appropriate measures will be taken.
- **Call**: As a precautionary measure in case there is a delay in sending or receiving the SMS, a call is given.



5. <u>Buzzing the Alarm at the site</u>:

As a matter of fact, all the animals (domestic or wild) and humans are hardwired by evolution to find loud noises frightening. Hence a high-frequency buzzing sound is generated when the fire breaks out which helps in creating a sense of alarm within them and evacuating the hotspots thus, saving many lives.

- For now, the buzzer is audible up to a range of 4 m.
- A future scope implementation would be to create an alarm with a range of about 4-6 km.

Chapter 7

Pseudocode

```
SoftwareSerial mySerial(PIN_TX,PIN_RX);
DFRobot_SIM808 sim808(&mySerial);

void setup()
{
  mySerial.begin(9600);
  Serial.begin(9600);
  digitalWrite(GREEN, HIGH);
  digitalWrite(RED, LOW);
  Serial.print("\n--------------------------------------\n");
  Serial.print("          Physical Parameters         ");
  Serial.print("\n--------------------------------------\n");

  pinMode(MQ, INPUT);
  pinMode(FLAME,INPUT);
  pinMode(DHT,INPUT);
  pinMode(ALARM, OUTPUT);
  pinMode(GREEN,OUTPUT);
  pinMode(RED,OUTPUT);

  if (fire==HIGH)
  {
    Serial.print("\n--------------------------------------\n");
    Serial.print("\tFIRE FIRE FIRE\n");
    Serial.print("--------------------------------------\n");
    digitalWrite(RED, HIGH);
    digitalWrite(GREEN, LOW);
    digitalWrite(ALARM,HIGH);
```

```
if( co2>850)
{
  Serial.print("Fire Intensity = Level 3\n");
  delay(1000);
  Serial.print("Sending the message to the authority\n");
  sim808.sendSMS(PHONE_NUMBER,message3);
  sim808.sendSMS(PHONE_NUMBER,mess);
}

if( co2>700)
{
  Serial.print("Fire Intensity = Level 2\n");
  delay(1000);
   sim808.sendSMS(PHONE_NUMBER,message2);
   sim808.sendSMS(PHONE_NUMBER,mess);
   Serial.print("Message Sent\n");
   Serial.print("\nCalling up...\n");
   sim808.callUp(PHONE_NUMBER);
    return;
}

{
  Serial.print("Fire Intensity = Level 1\n");
  sim808.sendSMS(PHONE_NUMBER,message1);
  sim808.sendSMS(PHONE_NUMBER,mess);
  Serial.print("Message Sent\n");
  Serial.print("\nCalling up...\n");
  sim808.callUp(PHONE_NUMBER);
  return;
}
```

Chapter 8

Testing

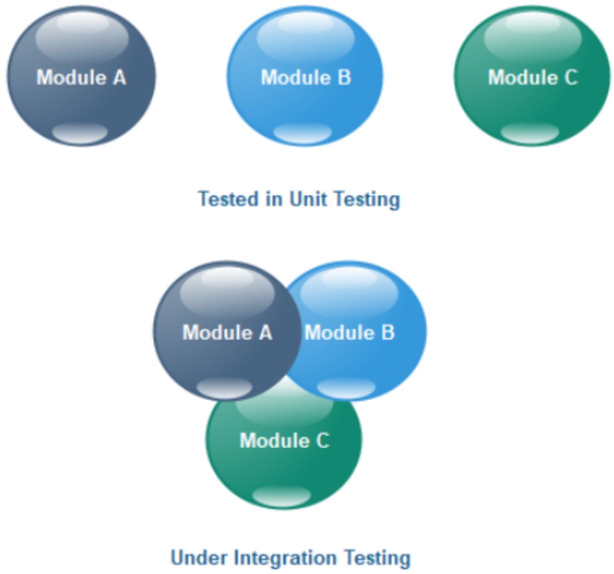
8.1 Basics of software testing

- **Smoke Testing** - smoke tests verify if the most important functionality is working. Detecting fire and determining the intensity was rigorously tested. Smoke Testing is a software testing process that determines whether the deployed software build is stable or not. Smoke testing is a confirmation for QA team to proceed with further software testing. It consists of a minimal set of tests run on each build to test software functionalities. Smoke testing is also known as “Build Verification Testing” or “Confidence Testing.”

- **Black box Testing -** Black box testing assesses a system solely from the outside, without the operator or tester knowing what is happening within the system to generate responses to test actions. Black Box Testing is a software testing method in which the functionalities of software applications are tested without having knowledge of internal code structure, implementation details and internal paths. Black Box Testing mainly focuses on input and output of software applications and it is entirely based on software requirements and specifications. It is also known as Behavioral Testing.

- **White box Testing -** White box testing is an approach that allows testers to inspect and verify the inner workings of a software system. Various paths, statements, conditions, and loops were closely examined. White box testing techniques analyse the internal structures, the used data structures, internal design, code structure and the working of the software rather than just the functionality as in black box testing. It is also called glass box testing or clear box testing or structural testing.

- **Integration testing (Bottom-up) -** A type of software testing in which the different units, modules, or components of a software application are tested as a combined entity. Integration testing is the second level of the software testing process comes after unit testing. In this testing, units or individual components of the software are tested in a group. The focus of the integration testing level is to expose defects at the time of interaction between integrated components or units.



8.2 Test cases

Data sheet for the Intensity of Forest Fire						
S.No	Humidity	Temperature	CO2 concentration	Intensity	Stage of forest fir	Level
1	69	28	450	-0.2145	0	No Fire
2	68	30	480	-0.0571	0	No Fire
3	67	34	510	0.1968	1	Ignition
4	67	36	520	0.3079	1	Ignition
5	66	38	550	0.5091	1	Ignition
6	66	40	580	0.6971	1	Ignition
7	65	41	595	0.8255	1	Ignition
8	64	44	600	1.0263	2	Growth
9	64	45	640	1.2287	2	Growth
10	63	47	660	1.4574	2	Growth
11	63	48	700	1.6784	2	Growth
12	62	49	730	1.9137	2	Growth
13	61	50	820	2.4275	3	Fully Developed
14	61	57	850	3.0866	3	Fully Developed
15	60	60	875	3.5224	3	Fully Developed
16	59	62	890	3.8476	3	Fully Developed
17	59	63	900	3.9866	3	Fully Developed

Chapter 9

Results

The output of the proposed system is as follows:

The fire and smoke sensors detect the respective elements and this initializes an alert and activates the system. This, in turn, sends the location, which is detected by the GPS module, with an alert message via SMS to the user with the help of the GSM module that has been incorporated into the system. Once the user receives the alert message, the required action can be taken to control and cease the fire.

The wireless transmission using RF, from one node to another node was experimented up to 1m. As there would not be any obstructions in the forest, the RF modules can work up to one meter efficiently. For GSM module to work properly, there should be a minimum network coverage to send an SMS with location.

The nodes can be placed 1m away from each other, for maximum coverage of the forest area with minimum number of nodes and to perform with good efficiency. The fire and smoke sensors were tested up to 1m.

Chapter 10

Conclusion and Future Scope

Conclusion:

Early cautioning and quick reaction to a fire breakout are the main approaches to dodge incredible misfortunes and natural and social legacy harms. Hence, the most critical objectives in flame observation are fast and solid identification and restriction of the fire. It is substantially less demanding to stifle a fire when the beginning area is known, and keeping in mind that it is in its beginning periods. Data about the advance of flame is likewise profoundly profitable for dealing with the fire amid every one of its stages. In light of this data, the fire battling staff can be guided on focus to hinder the fire before it achieves social legacy destinations and to smother it rapidly by using the required putting out fires' hardware and vehicles.

The improved system can be deployed for tenement appliances and in industries also. However, the system above is meant for sincere opinion news only. As a result of tomorrow's aggravation, several-decision companies through the IoT landing are studying an object and the exploration is being done to effectuate this enormous toil.

Future Scope:

In the future, we can develop this model to minimize the energy consumption of all sensors. Also, industrial sensors can be used for better range and accuracy. We can also install a wind sensor in the system which helps to determine the direction of the fire and the rate at which it will spread. Along with this, we can implement an automatic fire extinguisher system. As soon as a sensor detects a fire, the extinguisher gets activated.

Wireless Sensors will be used to communicate directly with the motherboard so that each unit can be placed all over the forest for more accuracy and have only one single processing unit in the control room.

Image processing and machine learning can be used to train the device in a better way to predict and accurately measure the intensity of the fire.

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