# EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRES

**A PROJECT REPORT**

***Submitted by***

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**ENGINEERING**

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# 1.INTRODUCTION

## 1.1 Project Overview

Forest fires are occurring throughout the year with an increasing intensity in the summer and autumn periods. These events are mainly caused by the actions of humans, but different nature and environmental phenomena, like lightning strikes or spontaneous combustion of dried leafs or sawdust, can also be credited for their occurrence. Regardless of the reasons for the ignition of the forest fires, they usually cause devastating damage to both nature and humans.

## 1.2 Purpose

While a wildfire refers to an unintentional, uncontrolled fire, the term “wildland fire” is broader and includes fires purposefully set as part of prescribed burns. While all fires have the potential to become dangerous to property and life, prescribed, or controlled, burns are planned extensively and performed with tight safety parameters.

# 2.LITERATURE SURVEY

## 2.1 Existing Problem

Wildfires are becoming more common and increasingly devastating due to several factors, including a longer average season, hotter weather that increases susceptibility, earlier melting of winter snowpacks, and changing meteorological patterns due to climate change.

As wildfires become a more significant risk around the world, it's important to consider the ways that fires and fire season affect the economy. An economic study has estimated that each additional day

of smoke exposure from a wildfire reduces earnings in a community by about 0.04% over two years.

Property loss and damage is one of the primary effects of wildfires. A fire occurs in a structure every 64 seconds across the U.S., although outdoor fires remain more common. In total, fires in the U.S. in 2020 caused $21.9 billion in property damage.

## 2.2 References

Foltz, R.B.; Robichaud, P.R.; Rhee, H. 2008. A synthesis of postfire road treatments for BAER teams: methods, treatment effectiveness, and decision making tools for rehabilitation. Gen. Tech. Rep.

RMRS-GTR-228 Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 152 p.

Napper, C. 2006. Burned Area Emergency Response Treatments Catalog. Technical Report. 0625 1801-SDTDC, Washington, D.C.: U.S. Department of Agriculture, Forest Service, National Technology & Development Program, Watershed, Soil, Air Management. 266 p.[Online].

available: http://www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/06251801L.

Peppin, D.L.; Fule, P.Z.; Sieg, C.H.; Beyers, J.L.; Hunter, M.E.; Robichaud, P.R. 2011. Recent trends in post-wildfire seeding in western US forests: costs and seed mixes. International Journal of Wildland Fire 20(5): 702-708.

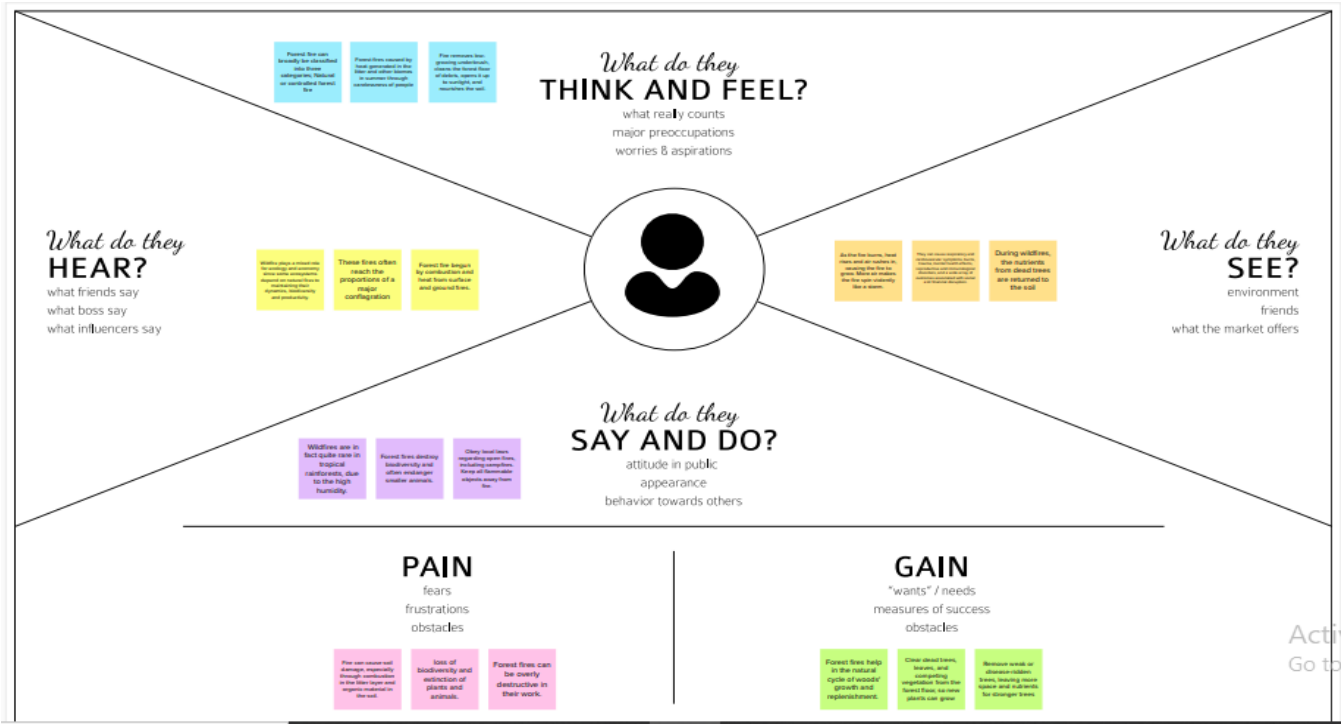
## 2.3 Problem Statement Definition

Forest fires is a wide spread and critical factor  in the earth's ecosystem. The most effective and vital solution is early detection

fires to preserve natural resources and to protect living creatures

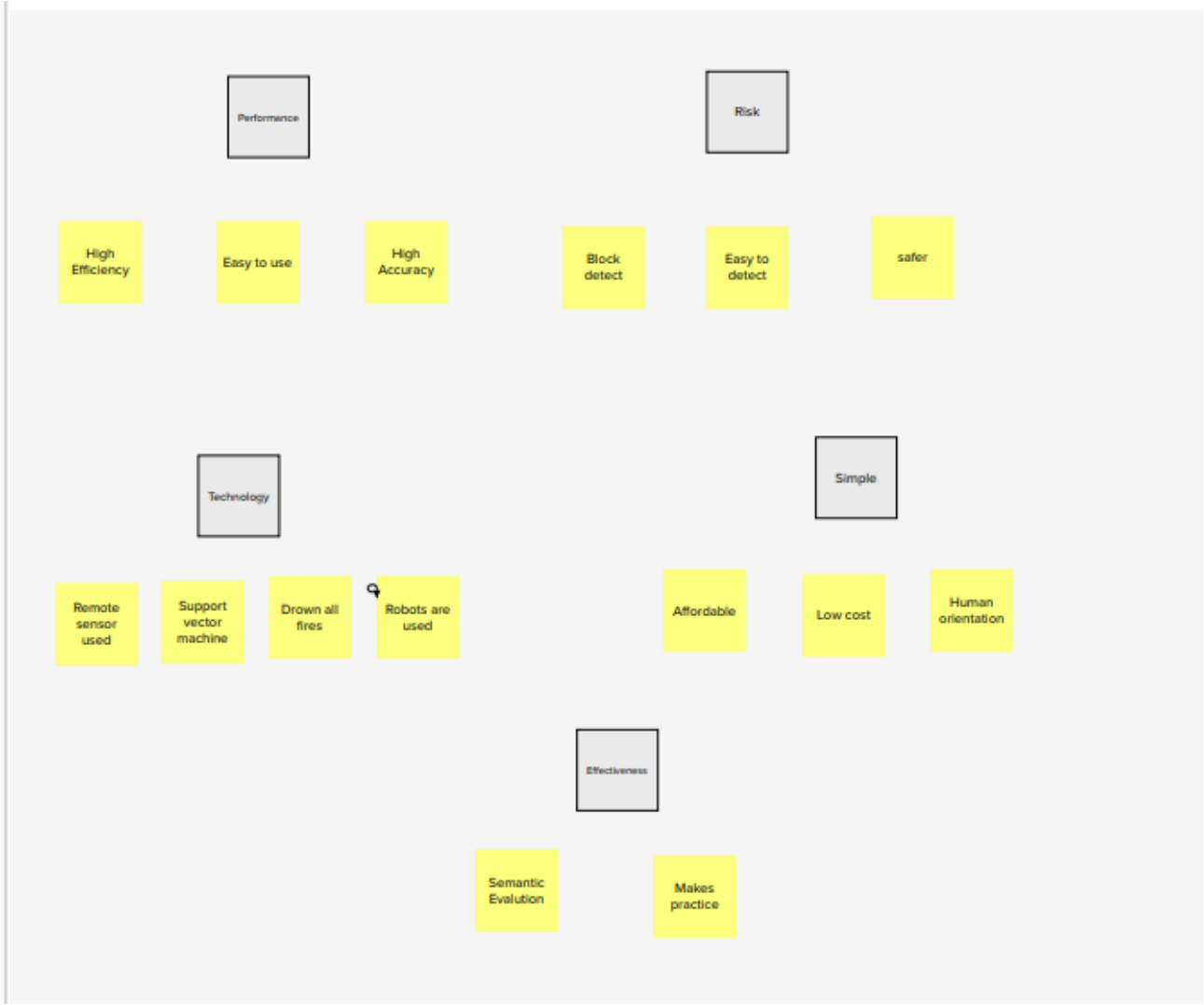

# 3.IDEATION AND PROPOSED SOLUTION

## 3.1 Empathy Map Canvas

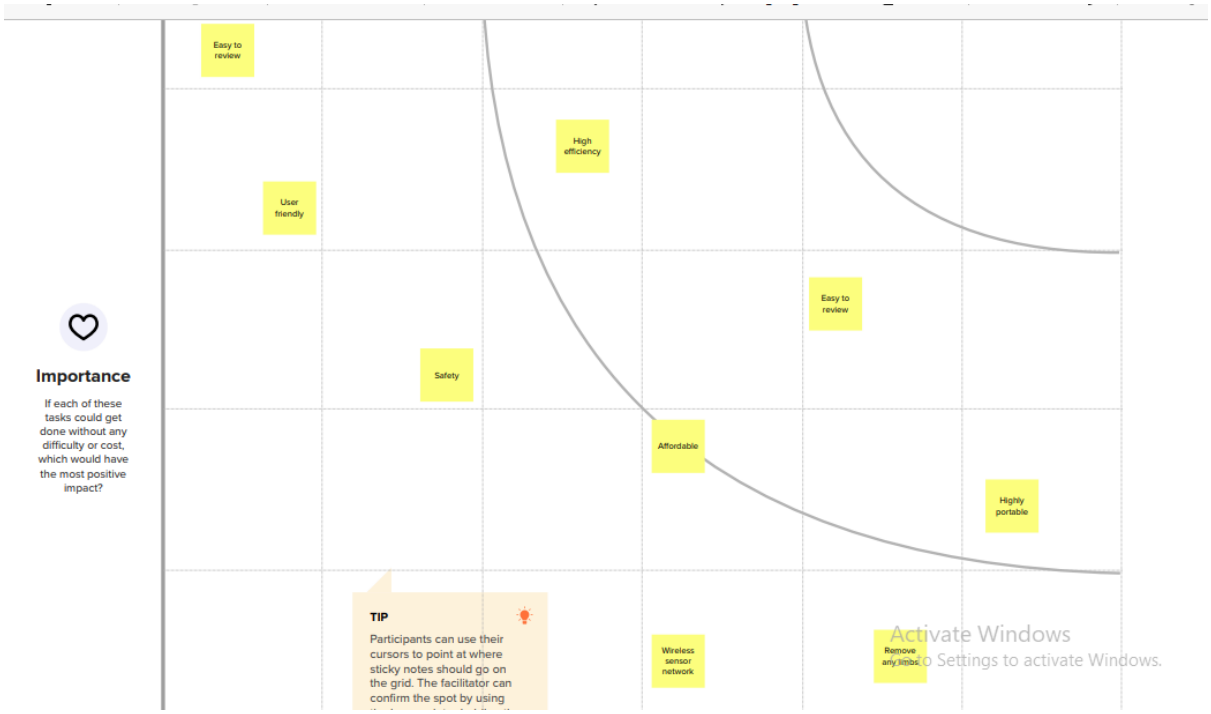


# 3.2 Ideation And Brainstorming

## Group ideas:


Performance
Risk
High Efficiency
Easy to use
High Accuracy
Block detect
Easy to detect
safer
Technology
Simple
Remote sensor used
Support vector machine
Drown all fires
Robots are used
Affordable
Low cost
Human orientation
Effectiveness
Semantic Evalution
Makes practice

# Priortize:

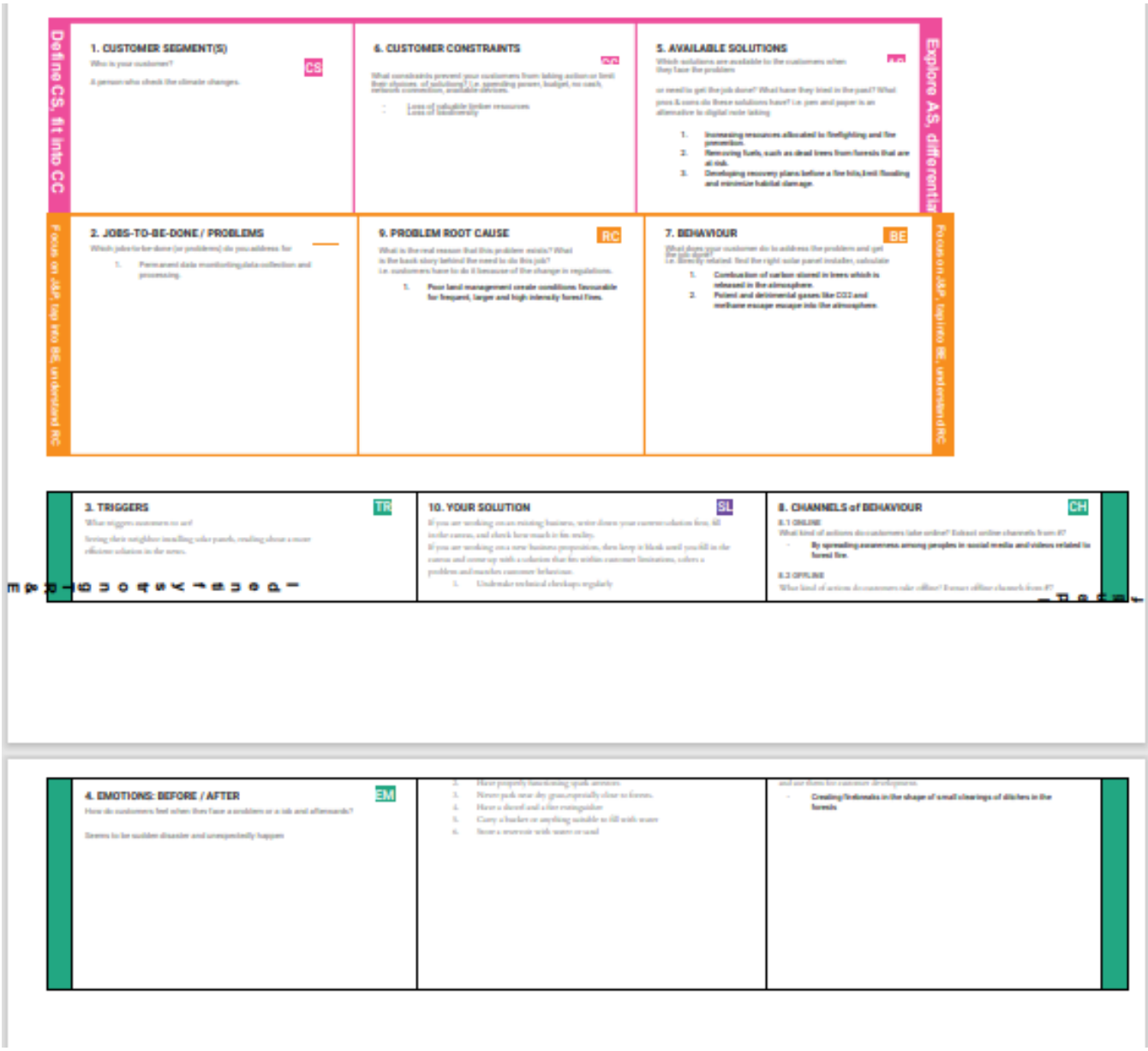

Easy to review
High efficiency
User friendly
Easy to review
Safety
Affordable
Highly portable
Importance
If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?
TIP
Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using
Wireless sensor network
Remove any limbs
Activate Windows
Go to Settings to activate Windows.

## 3.3 Proposed Solution

| S.No. | Parameter | Description |
|---|---|---|
| 1. | Problem Statement (Problem to be solved) | It is difficult to predict and detect Forest Fire in a sparsely populated forest area and it is more difficult if the prediction is done using ground-based methods like Camera or Video-Based approach. Satellites can be an important source of data prior to and also during the Fire due to its reliability and efficiency. |
| 2. | Idea / Solution description | The simplest of these solutions is the establishment of a network of observation posts - both cheap and easy to accomplish, but also time-consuming for the involved people. The constant evolution of the information and communication technologies has led to the introduction of a new generation of solutions for early detection and even prevention of forest fires. ICT-based networks of cameras and sensors and even satellite-based solutions were developed and used in the last decades. These solutions have greatly decreased the direct involvement of humans in the forest fire detection process, but have also proven to be expensive and hard to maintain. |
| 3. | Novelty / Uniqueness | Optical/thermal cameras deployed on the observation towers together with the other sensors such as smoke, temperature, and humidity sensors might detect the hazards in the closed environment rather than in the open environment as these sensors need vicinity to the fire or smoke. The information obtained through these sensors is not appropriate. Distance covered by these methods could be limited, and to cover a large area, more sensors have to be deployed that might incur expenses. Through the deployment of UAV, large areas could be covered, and the images with high spatial and temporal resolutions could be captured properly. The operational cost is very low when compared with the other methods. |

| | | |
|---|---|---|
| 4. | Social Impact / Customer Satisfaction | Some of these events include heat waves, droughts, dust storms, floods, hurricanes, and wildfires. Wildfires have extreme consequences on local and global ecosystems and cause serious damages to infrastructure, injuries, and losses in human lives; therefore, fire detection and the accurate monitoring of the disturbance type, size, and impact over large areas is becoming increasingly important. To this end, strong efforts have been made to avoid or mitigate such consequences by early fire detection or fire risk mapping. Traditionally, forest fires were mainly detected by human observation from fire lookout towers and involved only primitive tools, such as the Osborne fire Finder; however, this approach is inefficient, as it is prone to human error and fatigue. On the other hand, conventional sensors for the detection of heat, smoke, flame, and gas typically take time for the particles to reach the point of sensors and activate them. In addition, the range of such sensors is relatively small, hence, a large number of sensors need to be installed to cover large areas |
| 5. | Business Model (Revenue Model) | This strives many researchers to pay attention in many domains where they work in the processing of surveillance video streams so that abnormal or unusual actions could be detected. The usage of UAVs is recommended in the detection of forest fire due to the high mobility and ensures the coverage areas at various altitudes and locations at a low cost. |

# 3.4 Problem Solution Fit



# 4.REQUIREMENT ANALYSIS

## 4.1 Functional Requirement

**Functional Requirements:**

Following are the functional requirements of the proposed solution.

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story / Sub-Task) |
|---|---|---|
| FR-1 | MODIS | It helps scientists determine the amount of water vapor in a column of the atmosphere and the vertical distribution |
| FR-2 | GSAT-31 | It is used for VSAT networks, television uplinks, digital signage new gathering, DTH services and other communication systems. |
| FR-3 | Telstar 1 | It was the first technology to support transatlantic television transmissions. |
| FR-4 | ASTER | It provide high-resolution images |

## 4.2 Non-Functional Requirements

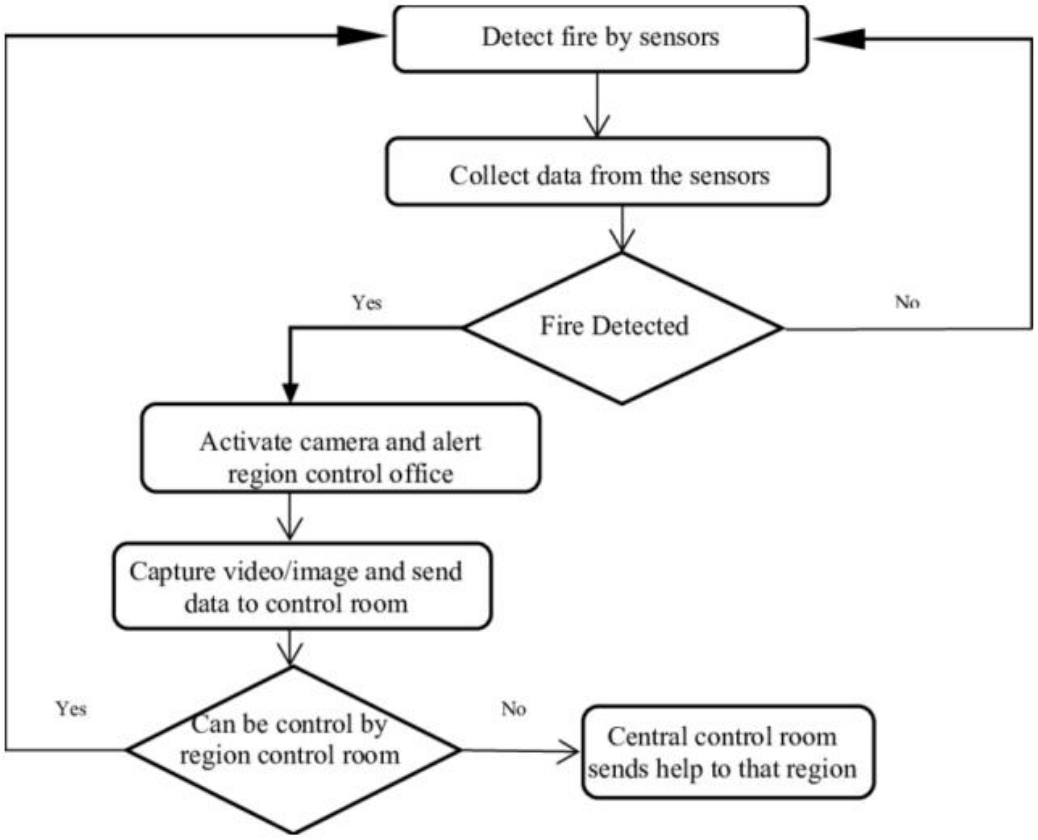
**Non-functional Requirements:**

Following are the non-functional requirements of the proposed solution.

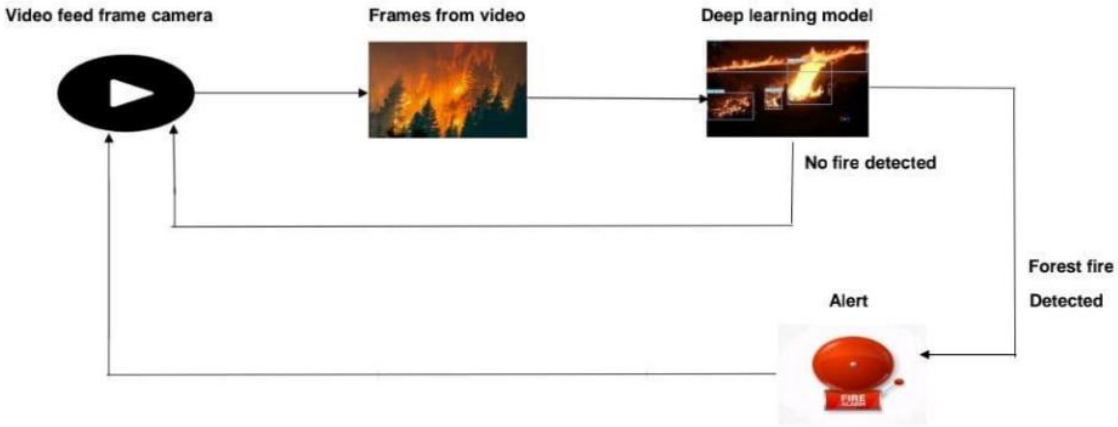
| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | They provide information and services to support global communications, the economy, security and defence, safety and emergency management, the environment **and health.** |
| NFR-2 | **Security** | This allows a ground station to track a satellite's position and control the satellite's propulsion, thermal, and other systems. |
| NFR-3 | **Reliability** | The proposed method has high operating efficiency. |
| NFR-4 | **Performance** | The performance of the system is better |
| NFR-5 | **Availability** | It is fastly growing and it will continue to expand in the future |
| NFR-6 | **Scalability** | It is highly dynamic system |

# 5.PROJECT DESIGN

## 5.1 Data Flow Diagrams



## 5.2 Solution & Technical Architecture



## 5.3 User Stories

**User Stories**

| User Type | Functional Requirement (Epic) | User Story Number | User Story / Task | Acceptance criteria | Priority | Release |
|---|---|---|---|---|---|---|
| Customer (Mobile user,Web user) | RF receivers | USN-1 | As a user, I can receives the serial data | It receives serial data and transmits it wirelessly through through its RF antenna. | High | Sprint-1 |
| | Radar | USN-2 | As a user, I can translate the information | It accept weak target signals, amplify them to a usable level. | Medium | Sprint-2 |
| | splitters | USN-3 | As a user, I can Split the signal | It is a device used to split a cable signal between two or more devices. | Medium | Sprint-3 |
| | satellite modems | USN-4 | As a user, I can transfer the data | A satellite modem or satmodem is a modem used to establish data transfers using a communications satellite as a relay. | Low | Sprint-4 |

# 6.PROJECT PLANNING & SCHEDEULING

## 6.1 Sprint Planning &Estimation

| Sprint | Functional Requirement (Epic) | User Story Number | User Story / Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|
| Sprint-1 | Registration | USN-1 | As a user, I can register for the application by entering my email, password, and confirming my password. | 2 | High | Sahaya Ragavi R Ancy N |
| Sprint-1 | | USN-2 | As a user, I can register for the application through gamil | 1 | High | Asika K S Jeni J |
| Sprint-2 | Login | USN-3 | As a user, I can enter a specific page, website or application, which trespassers cannot see. | 2 | High | Abarna R Sahaya Ragavi R |
| Sprint-3 | Dashboard | USN-4 | As a user, I can view the garbage storage level | 2 | Medium | Abarna R Ancy N Asika K S Jeni J |
| Sprint-4 | Blynk App | USN-5 | As a user, I can allow you to create amazing interfaces for your projects using various widgets which are provided | 2 | High | Sahaya Ragavi R Ancy N Asika K S |

## 6.2 Sprint Delivery Schedule

| Sprint | Total Story Points | Duration | Sprint Start Date | Sprint End Date (Planned) | Story Points Completed (as on Planned End Date) | Sprint Release Date (Actual) |
|---|---|---|---|---|---|---|
| Sprint-1 | 20 | 6 Days | 24 Oct 2022 | 29 Oct 2022 | 20 | 29 Oct 2022 |
| Sprint-2 | 20 | 6 Days | 31 Oct 2022 | 05 Nov 2022 | 20 | 05-Nov 2022 |
| Sprint-3 | 20 | 6 Days | 07 Nov 2022 | 12 Nov 2022 | 20 | 12 Nov 2022 |
| Sprint-4 | 20 | 6 Days | 14 Nov 2022 | 19 Nov 2022 | 20 | 19 Nov 2022 |

# 7.CODING & SOLUTIONING

## 7.1 Feature 1

### 1.IMAGE DATA GENERATOR

Keras ImageDataGenerator is used for getting the input of the original data and further, it makes the transformation of this data on a random basis and gives the output resultant containing only the data that is newly transformed. It does not add the data.

### 2.PARAMETRES

#### 2.1.Rescale:

Rescale is a technology company that builds cloud software and services that enable organizations of every size to deliver engineering and scientific breakthroughs that enrich humanity.

#### 2.2.Rotation range:

ImageDataGenerator class allows you to randomly rotate images through any degree between 0 and 360 by providing an integer value in th n_range argument. When the image is rotated, some e rotatio pixels will move outside the image and leave an empty area that needs to be filled in.

#### 2.3.Horizontal Flip:

To horizontally flip an image (flip the image about its vertical axis), we use the flip() function. The flip() function takes in 2 parameters. The first parameter is the image you want to flip. The second parameter is 1 (for horizontal flipping).

## 3.CONVOLUTION NEURAL NETWORK

A convolutional neural network (CNN or ConvNet), is a network architecture for deep learning which learns directly from data, eliminating the need for manual feature extraction. CNNs are particularly useful for finding patterns in images to recognize objects, faces, and scenes.

### 3.1.Convolutional Layer:

A convolutional layer is the main building block of a CNN. It contains a set of filters (or kernels), parameters of which are to be learned throughout the training. The size of the filters is usually smaller than the actual image.

### 3.2.Flatten Layer:

Rectangular or cubic shapes can't be direct inputs. And this is why we need flattening and fully-connected layers. Flattening is converting the data into a 1-dimensional array for inputting it to the

next layer. We flatten the output of the convolutional layers to create a single long feature vector.

**4. DENSE LAYER**

Dense Layer is simple layer of neurons in which each neuron receives input from all the neurons of previous layer, thus called as dense. Dense Layer is used to classify image based on output from convolutional layers. Working of single neuron. A layer contains multiple number of such neurons.

7.2 Feature 2

**Importing Keras libraries**

```
import keras
```

**Importing ImageDataGenerator from Keras**

```
import keras
from keras.preprocessing.image import ImageDataGenerator
```

**Defining the Parameters**

```
train_datagen=ImageDataGenerator(rescale=1./255,shear_range=0.2
,rotation_range=180,zoom_range=0.2,horizontal_flip=True)

test_datagen=ImageDataGenerator(rescale=1./255)
```

**Applying ImageDataGenerator functionality to train dataset**

```
from google.colab import drive

drive.mount('/content/drive')
```

```
x_train=train_datagen.flow_from_directory('/content/drive/MyDriv
e/IBM PROJECT/dataset/DATA

SET/archive/Dataset/Dataset/train_set',target_size=(64,64),batch_size
=32,class_mode=binary
```

**Applying Image  DataGenerator functionality to test dataset**

```
x_test=test_datagen.flow_from_directory('/content/drive/MyDrive/
IBM PROJECT/dataset/DATA
SET/archive/Dataset/Dataset/test_set',target_size=(64,64),batch_size=
32,class_mode=binary)
```

**Importing Model Building Libraries**

```
import keras
```

```
from keras.preprocessing.image import ImageDataGenerator


train_datagen=ImageDataGenerator(rescale=1./255,shear_range=0.2,r
otation_range=180,zoom_range=0.2,horizontal_flip=True)

test_datagen=ImageDataGenerator(rescale=1./255)

x_train=train_datagen.flow_from_directory('/content/drive/MyDrive/
Dataset/Dataset/Dataset/train_set',target_size=(128,128),batch_size=3
2,class_mode='binary')

from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Convolution2D
from keras.layers import MaxPooling2D
from keras.layers import Flatten
import  warnings
warnings.filterwarnings('ignore')
```

**Initializing the model**

```
model = Sequential()
```

**Adding CNN Layers**

```
from keras.layers import Dense
from keras.layers import Convolution2D
from keras.layers import MaxPooling2D
from keras.layers import Flatten
import warnings
warnings.filterwarnings('ignore')
model=Sequential()
```

```
model.add(Convolution2D(32,(3,3),input_shape=(128,128,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Flatten())
```

**Add Dense layers**

```
model.add(Flatten())
model.add(Dense(150,activation='relu'))
model.add(Dense(1,activation='sigmoid'))
```

**configuring the learning process**

```
model.compile(loss='binary_crossentropy',optimizer="adam",metrics=["accuracy"])
```

**Training the model**

```
model.fit_generator(x_train,steps_per_epoch=14,epochs=10,validation_data=x_test,validation_steps=4)
```

**Save the model**

```
model.save("forest.h5")
```

**Predictions**

```
#import load model from keras.model

from keras.models import load_model

#import image from keras
```

```
from tensorflow.keras.preprocessing import image

import numpy as np

#import cv2

import cv2

#load the saved model

model=load_model("/content/drive/MyDrive/IBM PROJECT/dataset/forest.h5")

img=image.load_img('/content/drive/MyDrive/IBM PROJECT/dataset/DATA SET/archive/Dataset/Dataset/test_set/with fire/FORESTFIRE (1).jpg')

x=image.img_to_array(img)

res=cv2.resize(x,dsize=(64,64),interpolation=cv2.INTER_CUBIC)

#expand the image shape

x=np.expand_dims(res,axis=0)


pred=model.predict(x)

pred = int(pred[0][0])

pred
```

**Open cv for video processing**

```
pip install twilio
```

```
from logging import WARNING
#import opencv library

import cv2

#import numpy

import numpy as np

#import image function from keras

from keras.preprocessing import image

#import load_model from keras

from keras.models import load_model

#import client from twilio API

from twilio.rest import Client

#import playsound package
```

**Creating An Account in Twilio Service**

**Sending Alert Message**

```
import cv2

import numpy as np

from google.colab.patches import cv2_imshow
```

```
from matplotlib import pyplot as plt
import librosa
from tensorflow.keras.preprocessing import image
from keras.models import load_model
# Create a VideoCapture object and read from input file
# If the input is the camera, pass 0 instead of the video file name
cap = cv2.VideoCapture('/content/drive/MyDrive/IBM PROJECT/dataset/datasetvideo.mp4')

# Check if camera opened successfully
if (cap.isOpened()== False):
  print("Error opening video stream or file")

# Read until video is completed
while(cap.isOpened()):
  # Capture frame-by-frame
  ret, frame = cap.read()
  if ret == True:
```

```
        cv2_imshow(frame)
        x=image.img_to_array(frame)

res=cv2.resize(x,dsize=(64,64),interpolation=cv2.INTER_CUBIC)
        #expand the image shape
        x=np.expand_dims(res,axis=0)
        model=load_model("/content/drive/MyDrive/IBM PROJECT/dataset/forest.h5")
        pred=model.predict(x)
        pred = int(pred[0][0])
        pred
        int(pred)
        if pred==0:
          print('Forest fire')
          break
        else:
          print("no danger")
          break
```

```
# When everything done, release the video capture object
cap.release()

# Closes all the frames
cv2.destroyAllWindows()



from twilio.rest import Client
if pred==0:
  print('Forest fire')
  from twilio.rest import Client
account_sid='  AC9261eb711254ff2902708b5f2e9107da’

auth_token='6484cc70c8880fcc0k'

  client=Client(account_sid,auth_token)
  message=client.messages \
  .create(
     body='forest fire is detected,stay alert',
```

```
    #use twilio free number
from_=' +1607535689’

#to number
    to='+917397109866')
print(message.sid)
print("Fire detected")
print("SMS Sent!")
```

# 8.TESTING

## 8.1 Test Cases

**Purpose of Document:**

The purpose of this document is to briefly explain the test coverage and open issues of the [Early detection of forest fire using Deep Learning] project at the time of the release to User Acceptance Testing (UAT).

## 8.2 User Acceptance Testing

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

| Test Frame | Expected Output | Actual Output | Accuracy | Result |
|---|---|---|---|---|
|  | Fire | Fire | 62% | Pass |
|  | No Fire | No Fire | 100% | Pass |
|  | No Fire | No Fire | 95% | Pass |
|  | Fire | Fire | 100% | Pass |
|  | No Fire | No Fire | 65% | Pass |

# 9.RESULTS

## 9.1 Performance Metrics

Forest fires are very intense deadly destroying the homes, wildlife, timber also polluting the atmosphere with hazardous compounds of pollutants. Forest fire produces various ill effects and increases the global temperature; it has a prolonged impact on landscapes and deduces the production of oxygen as it destroys past spreading. As wildfire is a part of nature its intensity cannot be handled after crossing a threshold level. The proposed system detects the forest fire at minimal stage with assistance of cameras fixed at the towers.

# 10.ADVANTAGES & DISADVANTAGES

**ADVANTAGES**

1. The smoke detector system will be connected to a loud alarm system that will be set off when a fire has been detected.

2. There are some instances that some buildings require access control systems. This advanced fire detection system is beneficial when these systems are interconnected

3. One of the benefits is that no human intervention is needed and this is because the fire detection system uses sensors to detect smoke.

**DISADVANTAGES:**

1.Individual learner is responsible for learning global information to avoid false positives.

2.The limited learning and perception ability of individual learners is not sufficient to make them perform well in complex tasks.

3.Proper connectivity and maintenance will be a complex task.

# 11.CONCLUSION

To limit the damage caused by forest fires and to control the start of fires and its spread, we have presented in this study a method of early detection of forest fires. This method is based on three steps: Estimate the general risk level of the forest, assess and predict in several places the existence or not of fires, and alert the necessary first responders to quell the spread of the fires. The originality of this work lies in the use of a wireless sensor and RF network distributed over the entire forest area and the deep learning methods to predict in real-time a possible origination and predicted path of the forest fire

# 12.FUTURE SCOPE

1. Fire detection in forest could also be possible if we used temperature sensors and humidity sensors along with the device which can also avoid wastage of valuable trees. Forest not only provides home to the large variety of flora and fauna, the animals but also the major producer of oxygen to the ecosystem.

2. The sub server unit can be used between the transmitter unit and the main receiver unit which makes the whole procedure evenly proportional and take preventive measures to alert the forest officer. The system can be reformed with lower capacity components and higher versions of ZigBee, making the system more efficient.

## 13.APPENDIX

### SOURCE CODE:

Our project source code link:

https://colab.research.google.com/drive/11IWkiKhaZgp5I-fA5nNznlz3YVCgpy8V?ts=6375b5af

Our Github link: https://github.com/IBM-EPBL/IBM-Project-40603-1660631837

### DEMO VIDEO:

Demo video link: https://youtu.be/EnT6LLlC8ZI