EMERGING METHODS FOR EARLY DETECTION OF FORESTFIRES

A PROJECT REPORT

Submitted by

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1.INTRODUCTION

1.1.PROJECT OVERVIEW

It is difficult to predict and detect forest fires in sparsely populated forest areas and it is more difficult when the prediction is done using ground-based models like cameras. Satellites can be an important source of data prior to and also during the fire due to their reliability and efficiency.The various real time forest fire detection and prediction approaches, results in the goal of informing the local fire authorities.

1.2.PURPOSE:

To detect the forest fire in the early stage.For the early detection of forest fire, the proposed model has an image recognition system method based on Deep learning model.

2.LITERATURE SURVEY

2.1.EXISTING METHOD:

Paper 1:

Title : Emerging methods for early detection of forest fires using unmanned aerial vehicles and lorawan sensor networks.

Author : Hristov, Georgi and Raychev, Jordan and Kinaneva, Diyana and Zahariev, Plamen

Journal : EAEEIE Annual Conference

Year : September 2018

Methodology : LoRaWAN, sensor network

Scope : In this paper they have briefly presented two new methods for early forest fire detection, including part of their characteristics and main components. They have also analysed some of the benefits, which these methods can provide to the involved Bachelor, Master and PhD students. Both solutions are still under development, but they show great potential and work on their development and improvement will continue in the following years.

Paper 2:

Title : Early Forest Fire Detection Using Drones and Artificial Intelligence

Author : Diyana kinaneva, Georgi Hristov, Jordan Raychev and Plamen Zahariev

Journal : Computer intel Neurosci

Year : 2019

Methodology: UAVs, Artificial intelligence

Scope : The system for early forest fire detection is still in its development stage. They thought that the system could enhance the available platforms for fire detection and they hope that such improvement could significantly reduce the damages caused by untimely or late fire detection.

Paper 3:

Title : A Review on Early Forest Fire Detection Systems Using Optical Remote Sensing

Author : Panagiotis Barmpoutis, Periklis Papaioannou, Kosmas Dimitropoulos and Nikos Grammalidis .

Journal : MDPI

Year : November 2020

Methodology : Multispectral imaging systems, terrestrial, aerial, artificial intelligence.

Scope : In this paper presents an overview of the optical remote sensing technologies used in early fire warning systems and provides an extensive survey on both flame and smoke detection algorithms employed by each technology. Three types of systems are identified, namely terrestrial, airborne, and spaceborne-based systems, while various models aiming to detect fire occurrences with high accuracy in challenging environments are studied.

Paper 4:

Title : Early Detection of Forest Fire Using Mixed Learning Techniques and UAV

Author : Varanasi L VSKB Kasyap, D. Sumathi, kumaraju Alluri, Pradeep Reddy CH, Navod Thilakarathne, and R. Mahammad Shafi

Journal : Computational Intelligence and Neuroscience

Year : 2022

Methodology : Autonomous Drone Routing , Fire Detection and Fire Region Prediction, 3D Modeling of Forest Fire.

Scope : The author aims in developing the 3D model for the captured scene. YOLOv4 tiny network is deployed to detect the fire. The accuracy of the detection rate achieved through this model is 91%. The proposed model outperforms the other existing techniques in terms of detecting in the early stage.The 3D modeling techniques presented in this paper can also be extended to various natural disaster prediction models.

Paper 5:

Title : Forest Fire Modeling and Early Detection using Wireless Sensor Networks

Author : Mohamed Hefeeda and Majid Bagher

Journal : Exeley

Year : 2020

Methodology : Wireless Sensor Networks, Forest Fire Modeling, Forest Fire Detection Systems, Coverage Protocols, k-Coverage Protocols, Fire Weather Index

Scope : The proposed fire alert system overcomes the need of a human intervention to continuously monitor the forest area. Monitoring and detecting is done by the sensors installed and message alerts are used to alert the required authorities. GPS module can be added to the nodes to get the exact location of fire or smoke

Paper 6:

Title : Multi-hazard disaster studies:Monitoring,detection,recovery,and management based on emerging technologies and optimal techniques

Author : Amina Khan, Sumeet Gupta, Sachin Kumar Gupta.

Journal : Elsevier

Methodology : satellite remote sensing, WSN, Mobile Ad hoc Network (MANET), IoT, Artificial Intelligence (AI), Fuzzy Logic, Unmanned Aerial Vehicle (UAV), Big Data Analytics (BDA)

Scope : This paper give a systematic approach to various technologies for disaster monitoring , detection, prediction, and management. Identification and critical review of the recent techniques and technologies like WSN, IoT, NN, AI, UAV, RS, satellite imagery, etc. that are involved in providing a better solution for disaster monitoring, detection, and management have been made. The paper also describes the importance of various networks in monitoring disasters, specially landslide, forest.

Paper 7:

Title : Early Forest Fire Detection System using Wireless Sensor Network and Deep Learning.

Author : Wiame Benzekri1, Ali El Moussati, Omar Moussaoui. Mohammed Berrajaa4 LANOL

Year : 2020

Journal : International Journal of Advanced Computer Science and Applications.

Methodology : Deep learning, RNN.

Scope : 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 possibly surveyed the place declared to be burning with

the help of a UAV. The originality of this work lies in the use of a wireless sensor network distributed over the entire forest and the deep learning methods to predict in real time a possible start of the fire.

2.2.REFERENCES:

1.Early detection of forest fire - https://ieeexplore.ieee.org/document/9293722
using deep learning.

2.Deep Learning Applied -https://ieeexplore.ieee.org/document/9408859
Forest fire Detection.

3.A Real-time Forest Fire Smoke detection - https://ijnaa.semnan.ac.ir/article_5899.html
System Using Deep Learning.

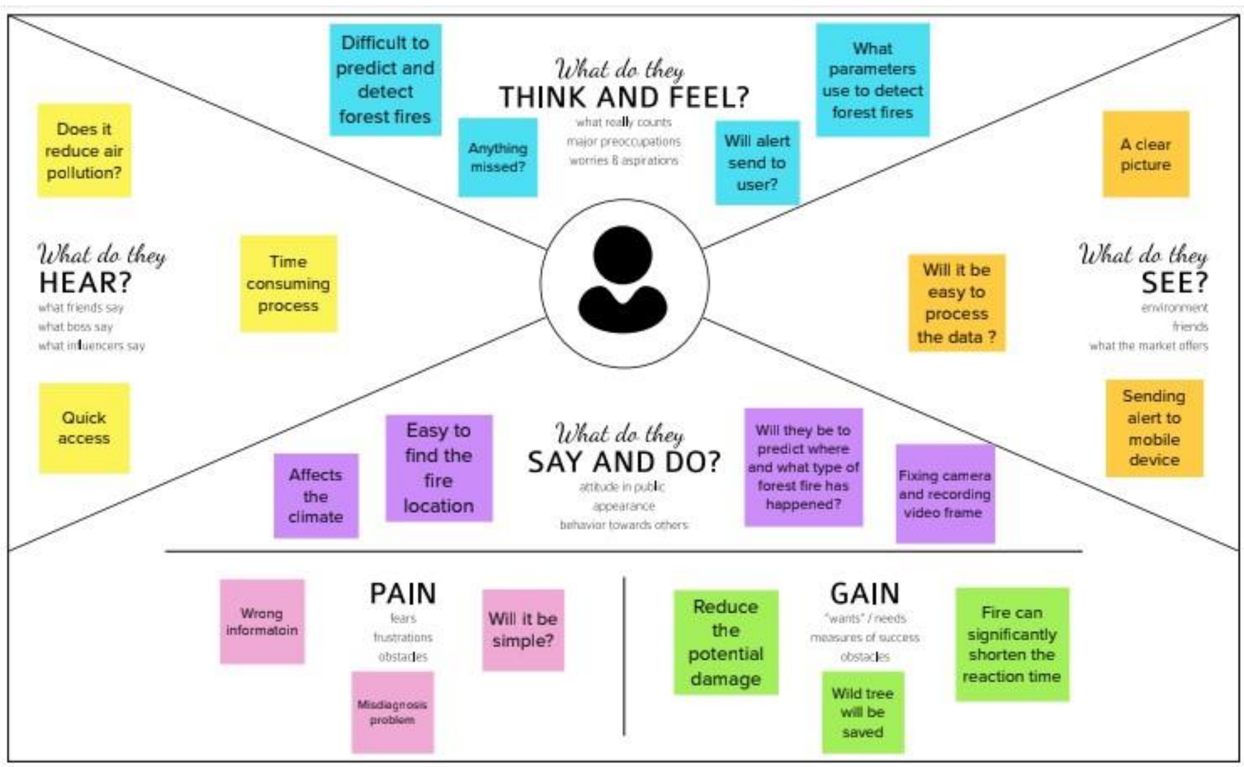
4.Fire Detection Using - https://journals.grdpublications.com/index.php/ijprse/article/view/141
Deep Learning

2.3.PROBLEM STATEMENT DEFINITION

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Forest Officer	Detecting a forest Fires	It is takes a long time to send an alert	The fire detection process takes some time	Frustrated

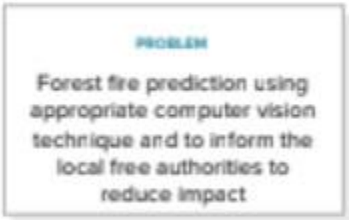
3.IDEATION & PROPOSED SOLUTION

3.1.EMPATHY MAP CANVAS

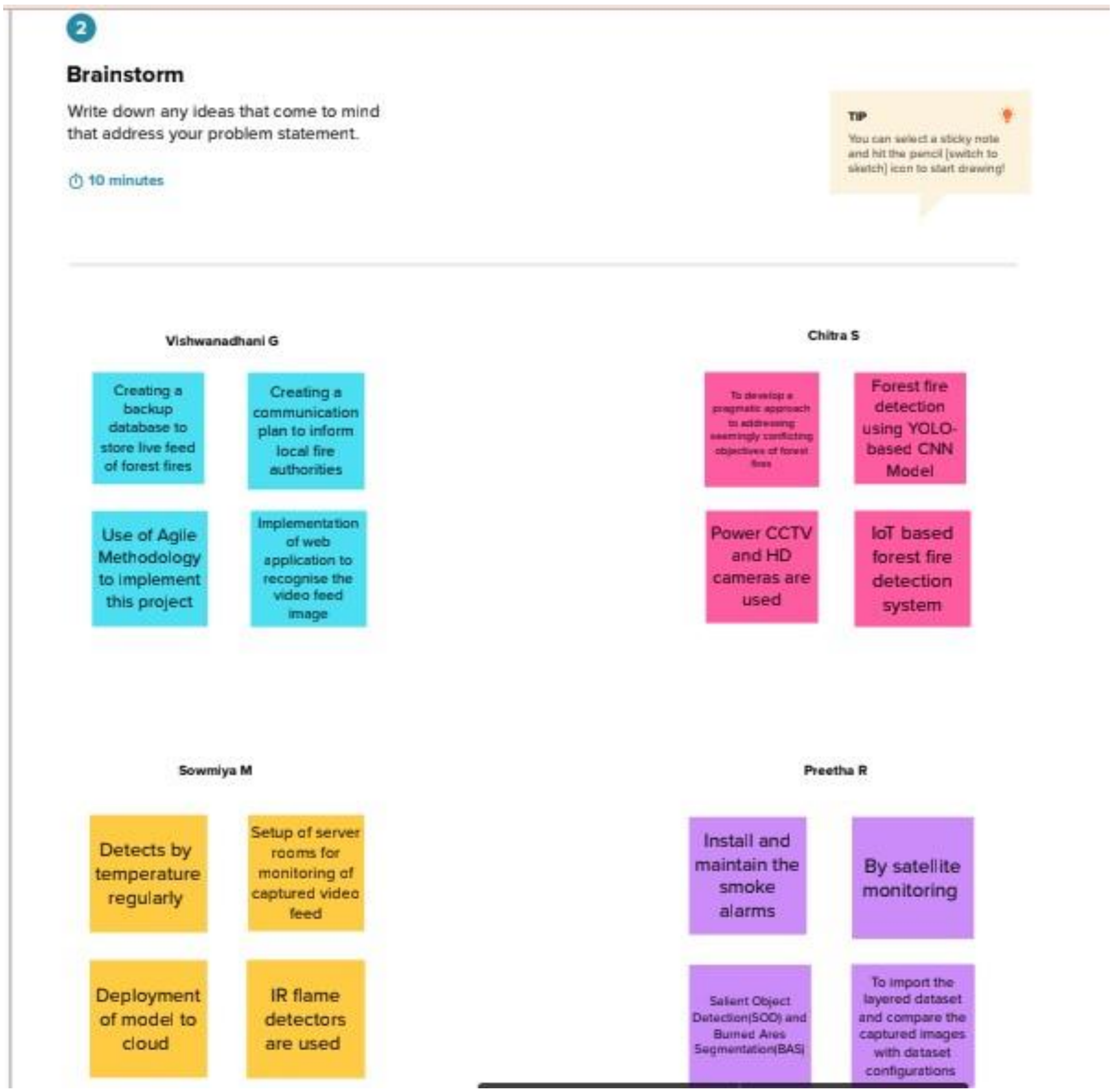


3.2.BRAINSTORMING :

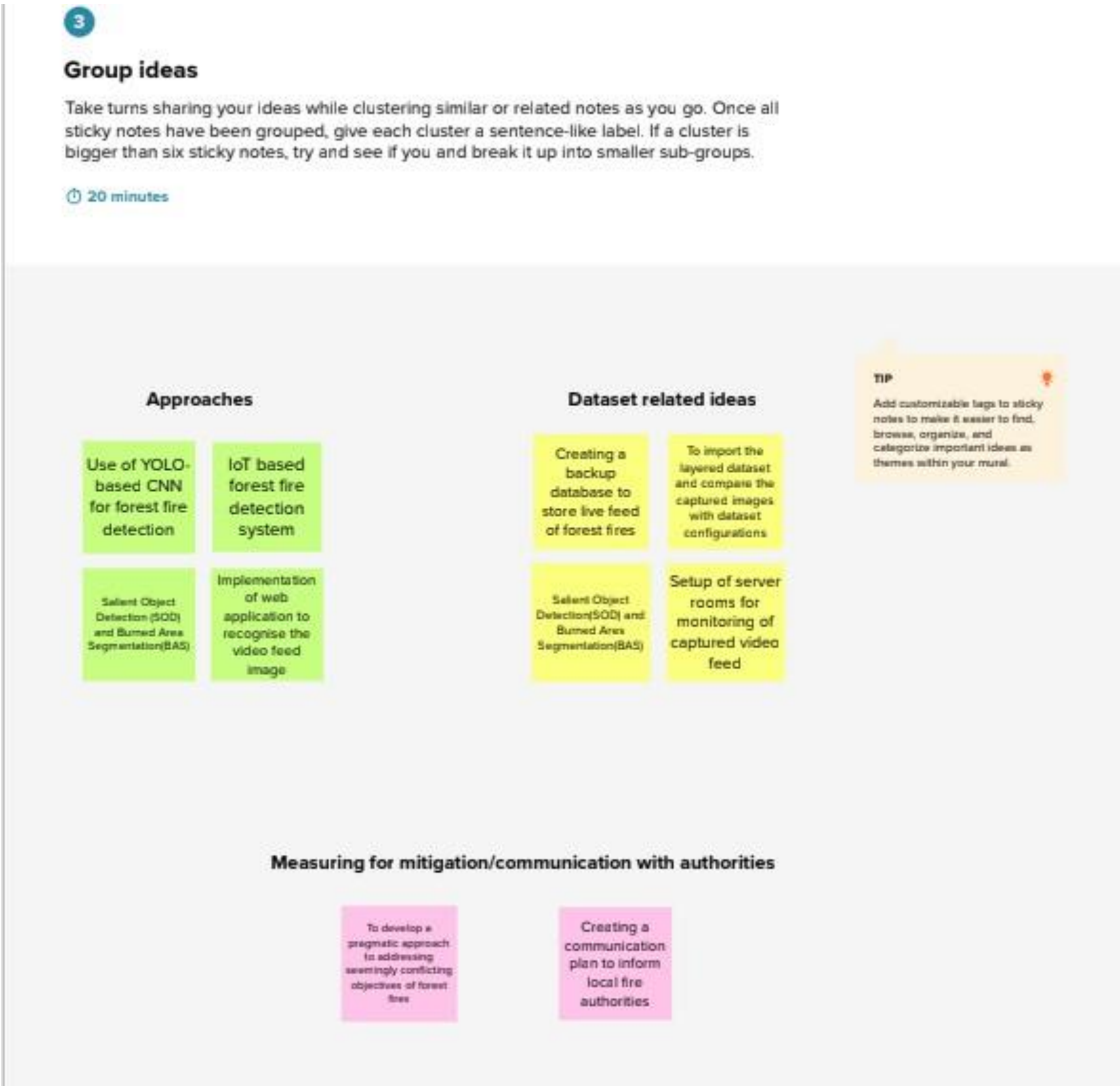
Problem Statements:



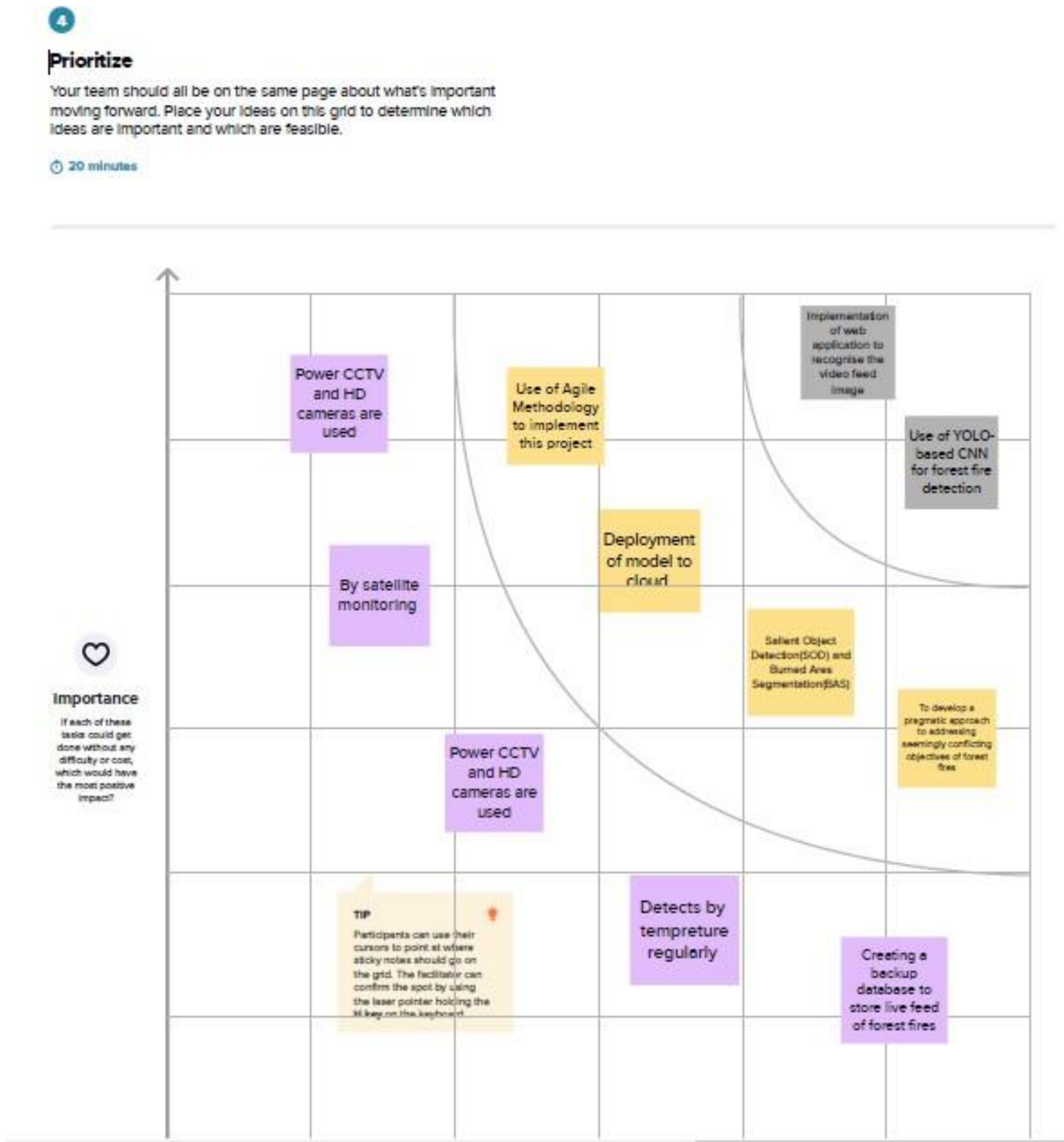
Brainstorm:



Group ideas:



Priortize:



3.3.PROPOSED SOLUTION:

S/no	Parameter	Description
1.	Problem Statement (Problem to be solved)	A forest fire risk prediction algorithm, based on support vector machines, is presented. The algorithm depends on previous weather conditions in order to predict the fire hazard level of a day.
2.	Idea / Solution description	Use computer vision methods for recognition and detection of smoke or fire, based on the still images or the video input from the drone cameras.
3.	Novelty / Uniqueness	Real time computer program detects forest fire in earliest before it spread to larger area.
4.	Impact on society	Blocked roads and railway lines, electricity, mobile and land telephone lines cut, destruction of homes and industries.
5.	Business Model (Revenue Model)	The proposed method was implemented using the Python programming language on a Core i3 or greater (CPU and 4GB RAM.)
6.	Scalability of the Solution	Computer vision models enable land cover classification and smoke detection from satellite and ground cameras

3.4.PROPOSED SOLUTION FIT:

Project Title: Emerging Methods for Detection of Forest Fires

Project Design Phase-I - Solution Fit Template

Team ID: PNT2022TMID38776

Define CS, fit into CC

1. CUSTOMER SEGMENT(S) CS

Forest officer
Common people

6. CUSTOMER CONSTRAINTS CC

Satellites allow for detecting and monitoring a range of fires, providing information about the location, duration, size, temperature, and power output of those fires that would otherwise be unavailable. Satellite data is also critical for observing and monitoring smoke from the fires.

5. AVAILABLE SOLUTIONS AS

Avoid burning wastes around dry grass.
Obey local laws regarding open fires, including campfires
Have firefighting tools nearby and handy.
Use fire resistant roofing materials.
undertake technical checkups regularly.
Monitoring weather analytics,
monitoring thermal anomalies,
monitoring water stress and temperature rises.

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

2. JOBS-TO-BE-DONE / PROBLEMS J&P

Satellite remote sensing offers a useful tool for forestfire detection, monitoring, management and damage assessment. During a fire event, active fires can be detected bydetecting the heat, light and smoke plumes emitted from the fires. This applicationuses real-time satellite data to detect and monitor forest fires (sending alerts to mobile devices), and understand fire patterns.

9. PROBLEM ROOT CAUSE RC

Forest fires cause lots of damage, some of them are – loss of wildlife habitat, extinction of plants and animals, destroys the nutrient rich top soil, reduction in forest cover, loss of valuable timber resources, ozone layer depletion, loss of livelihood for tribal people and poor people, increase in global warming.

7. BEHAVIOUR BE

When the people don't have knowledge about forest fire

Focus on J&P, tap into BE, understand RC

Identify strong TR & EM

3. TRIGGERS TR

Human-caused fires result from campfires left unattended, the burning of debris, equipment use and malfunctions, negligently discarded cigarettes, and intentional acts of arson.

4. EMOTIONS: BEFORE / AFTER EM

Before : unsafe and worries about lives and belongings

After : safety and relief

10. YOUR SOLUTION SL

For this problem we use image processing and video analysis so by using satellite image processing we can able to find the fire at the early stage and stop spreading fire in the forest . This model is mainly build by using CNN and machine learningand deep learning

8. CHANNELS of BEHAVIOUR CH

ONLINE: fire alert sensor

OFFLINE: Fire awareness program

Identify strong TR & EM

4.REQUIREMENT ANALYSIS

4.1.FUNCTIONAL REQUIREMENTS:

Functional Requirements:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User system	• The system shall take training sets of fire images and recognize whether there is a fire or the beginning of a fire or if there is no fire • The system shall send a notification to the admin when it recognizes a fire in the image given • The system shall take real inputs of satellite images and determine whether the image contains a fire or not
FR-2	User system identification	• The system shall be able to take images with a variety of sizes and convert it to one fixed image to be used throughout the application • The system shall run as a service on either a Windows or Linux operating system. • In the event that the computer on which the system is running shuts down, the system service should start automatically when the computer restarts
FR-3	System performance	• The system shall be able to analyze the image given has a fire or not in less than five minutes • The system shall have an accuracy rate of at least 90% when attempting to detect if a given image has a fire or not

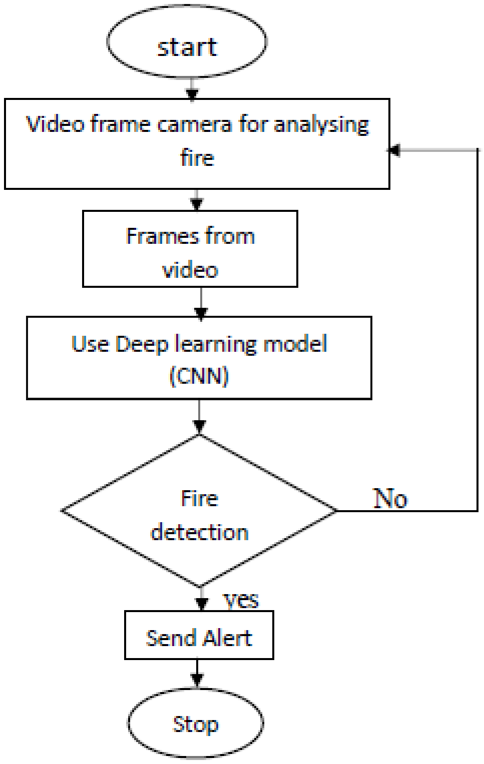
4.2.NON-FUNCTIONAL REQUIREMENTS

Non-functional Requirements:

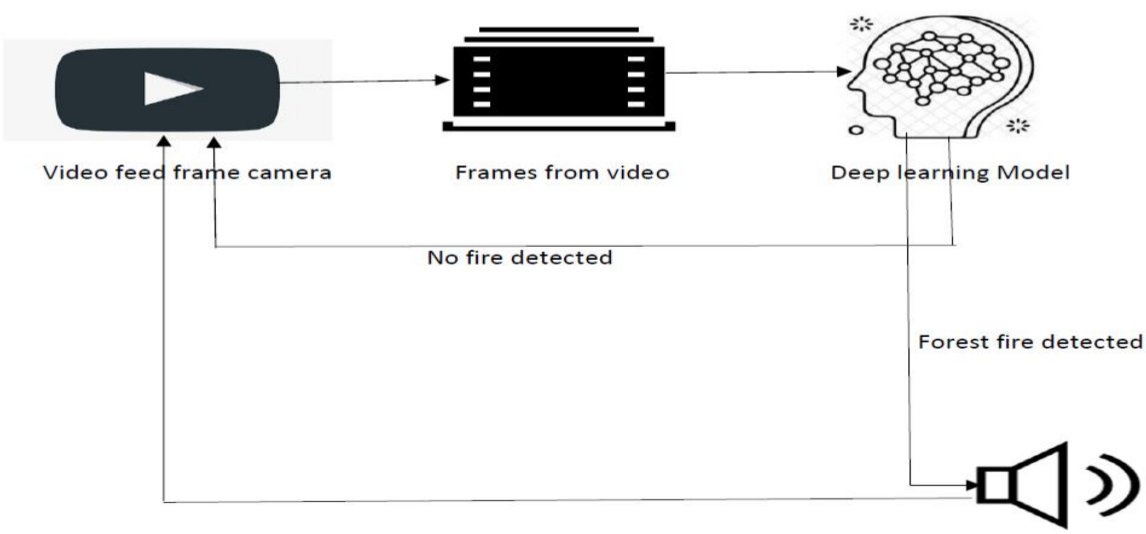
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	Timely information about the appearance of fire reduce the number of areas affected by this fire and thereby minimizes the costs of fire extinguishing and the damage caused in the woods
NFR-2	Security	Blocked roads and railway lines, electricity, mobile and land telephone lines cut, destruction of homes and industries.
NFR-3	Reliability	Stay with outside fires until they are completely safe and dead out. Dispose of wood ashes in a metal bucket, soaking them with water before dumping them.
NFR-4	Performance	Use computer vision methods for recognition and detection of smoke or fire, based on the still images or the video input from the drone cameras.
NFR-5	Availability	Real time computer program detects forest fire in earliest before it spread to larger area.
NFR-6	Scalability	Computer vision models enable land cover classification and smoke detection from satellite and ground cameras

5.PROJECT DESIGN

5.1.DATA FLOW DIAGRAMS:



5.2.SOLUTION AND TECHNICAL ARCHIETECTURE:



5.3.USER STORIES:

User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Forest Officer)	Monitor, Camera	USN-1	As a user, interacts with a web camera to read the video.	I can access through web camera	High	Sprint-1
		USN-2	once the input image from the video frame is sent to the model.	I can analysis Video frame	High	Sprint-1
		USN-3	if the fire is detected it is showcased on the console, and alerting sound will be generated and an alert message will be sent to the Authorities.	I can trace where the fire started.	Low	Sprint-2
	Alaram	USN-4	As a user, I can identify the fire alert.		High	Sprint-1
	Dashboard					
Customer (people)						
Customer Care Executive						
Administrator						

6.PROJECT PLANNING & SCHEDULING:

6.1.SPRINT PLANNING & ESTIMATION:

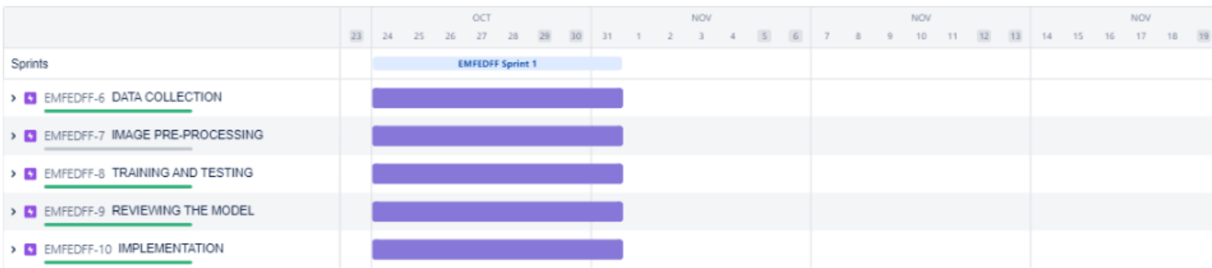
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	DATA COLLECTION	USN-1	Data collected by sensors aboard orbiting satellites, carried aboard aircraft, or installed on the ground provide a wealth of data that can be used to assess conditions before a burn and track the movement of a wildfire in near real-time.	1	High	Vishwanadhani G Chitra S Preetha R Sowmiya M
Sprint-1	IMAGE PREPROCESSING	USN-2	Image processing-Image processing technique automatically detect forest fires around the world by using infrared(IR) images sourced from satellites and CNN used for image recognition and tasks that involve the processing of pixel data.	2	Medium	Vishwanadhani G Chitra S Preetha R Sowmiya M
Sprint-2	TRAINING AND TESTING	USN-3	The model is trained for detecting the fire by training with real time work and the testing is done according the accuracy of the model	2	High	Vishwanadhani G Chitra S Preetha R Sowmiya M

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	REVIEWING THE MODEL	USN-4	The main task is to check that the model is efficient to work in real time to ensure there is no error in the model	3	Medium	Vishwanadhani G Chitra S Preetha R Sowmiya M
Sprint-4	IMPLEMENTATION	USN-5	After completing every step the model is implemented on the forest and the quick responses is collected from forest organization	3	High	Vishwanadhani G Chitra S Preetha R Sowmiya M

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

6.3.REPORTS FROM JIRA:



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.

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

2.PARAMETERS

2.1.Rescale:

The ImageDataGenerator class can be used to rescale pixel values from the range of 0-255 to the range 0-1 preferred for neural network models. Scaling data to the range of 0-1 is traditionally referred to as normalization.

2.2.Shear Range:

Shear range means that the image will be distorted along an axis, mostly to create or rectify the perception angles. It's usually used to augment images so that computers can see how humans see things from different angles.

2.3.Rotation range:

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

2.4.Zoom Range:

The zoom augmentation method is used to zooming the image. This method randomly zooms the image either by zooming in or it adds some pixels aroundthe image to enlarge the image. This method uses the zoom_range argument of the ImageDataGenerator class. It can specify the percentage value of the zooms either in a float**,** range in the form of an array.

2.5.Horizontal Flip:

Horizontal flip basically flips both rows and columns horizontally. So for this, It have to pass the horizontal_flip=True argument in the ImageDataGenerator constructor.

3.CONVOLUTION NEURAL NETWORK:

A CNN is a kind of network architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. There are other types of neural networks in deep learning, but for identifying and recognizing objects, CNNs are the network architecture of choice. The layers used in the CNN is Convolutional ,maxpooling, and flatten layer.

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. Each filter convolves with the image

Convolution layer is used for a image processing to blur and sharpen images, but also to perform other operations.

from keras.layers import Convolution2D

3.2.Maxpooling Layer:

Max pooling is a pooling operation that selects the maximum element from the region of the feature map covered by the filter.

```
from keras.layers import MaxPooling2D
```

3.3.Flatten Layer:

Flattening is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector. The flattened matrix is fed as input to the fully connected layer to classify the image.

```
from keras.layers import Flatten
```

4.DENSE LAYER:

Dense Layer is used to classify image based on output from convolutional layers.

7.2.FEATURE 2(CODE):

Importing Keras libraries

```
import keras
```

Importing ImageDataGenerator from Keras

```
from matplotlib import pyplot  as plt
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,shear_range=0.2,rotation_range=180,zoom_range=0.2,horizontal_flip=True)
```

Applying ImageDataGenerator functionality to train dataset

```
x_train=train_datagen.flow_from_directory('/content/drive/MyDrive/Dataset/Dataset/train_set',
target_size=(128,128),batch_size=32,class_mode='binary')
```

Applying ImageDataGenerator functionality to test dataset

```
x_test=test_datagen.flow_from_directory('/content/drive/MyDrive/Dataset/Dataset/test_set',
target_size=(128,128),batch_size=32,class_mode='binary')
```

Importing Model Building Libraries

```
#To define linear intialisation import Sequential
from keras.models import Sequential
#To add layers import Dense
from keras.layers import Dense
#To creat Convolution kernal import Convolution2D
from keras.layers import Convolution2D
#import Maxpooling layer
from keras.layers import MaxPooling2D
#import Flatten layer
from keras.layers import Flatten
import warnings
warnings.filterwarnings('ignore')
```

Initializing the model

```
model=Sequential()
```

Adding CNN Layers

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

Add Dense layers

```
#add hidden layer
model.add(Dense(150,activation='relu'))
#add output Layer
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("forest1.h5")
```

Predictions

```
#import load_model from keras.model
from keras.models import load_model
#import image class from keras
from tensorflow.keras.preprocessing import image
#import numpy
import numpy as np
#import cv2
import cv2
#load the saved model
model = load_model("forest1.h5")

img=image.load_img('/content/drive/MyDrive/Dataset/Dataset/test_set/with fire/180802_CarrFire_010_large_700x467.jpg')
x=image.img_to_array(img)
res = cv2.resize(x, dsize=(128, 128), interpolation=cv2.INTER_CUBIC)
#expand the image shape
x=np.expand_dims(res,axis=0)

pred=model.predict(x)
pred
```

Open cv for video processing

```
pip install twilio
pip install playsound
pip install pygobject
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
from playsound import playsound
```

Creating An Account in Twilio Service

Sending Alert Message

```
account_sid='ACff2114503c83032fe8cb614ba790fa6f'
auth_token='ae033e259f08d7b1f5b64d38f3e4def7'
client=Client(account_sid,auth_token)
message=client.messages \
.create(
   body='forest fire is detected,stay alert',
#use twilio free number
   from_='+19789449117',
#to number
   to='+916380582296')
print(message.sid)
```

8.TESTING

8.1.Test Cases:

8.2.User Acceptance Testing:

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).

Defect Analysis:

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

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	5	1	1	1	8
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	7	2	4	10	23
Not Reproduced	0	0	0	0	0
Skipped	0	0	1	1	2
Won'tFix	0	3	2	1	6
Totals	15	9	11	14	49

Test Case Analysis:

This report shows the number of test cases that have passed, failed, and untested

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	5	0	0	5
Client Application	30	0	0	30
Security	2	0	0	2
Out source Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

9.RESULTS

9.1.PERFORMANCSE METRICS:

S.No.	Parameter	Values
1.	Model Summary	As a threat of forest fire increases due to climate changes, the need for finding a detection system increases .The proposed Deep Learning-based model to predict early detection of forest fire. The Proposed model successfully classifies the images into fire and no fire, and sends an alert messages in case of fire. Thus, the Deep Learning algorithms proved their efficiency in detecting different objects.

2.	Accuracy	Training Accuracy - 98% Validation Accuracy - 95%

10.ADVANTAGES & DISADVANTAGES

ADVANTAGES:
1.Ability to cover areas at different altitudes and locations.
2.The results is quite accurate with the accuracy upto 95% .
3.Reliability - The model is very effective, inexpensive and easy to apply.
4.The model, it shows the 'fire' and 'no fire' images classified with high accuracy.
5.Video analysis of this model leads to low degree of misjudgment of fire detection.

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

As a threat of forest fire increases due to climate changes, the need for finding a detection system increase .The proposed Deep Learning-based model to predict the early detection of forest fire. The Proposed model successfully classifies the images into fire and no fire, and sends an alert messages in case of fire. Thus, the Deep Learning algorithm proved their efficiency in detecting the forest fire.

12.FUTURE SCOPE

- Integrate live satellite data and process real time processing of the fires.
- Enchance the time complexity of the detection of forest fires to improve the speed.
- These accidents can be controlled to a greater extend.
- Forest fire leads to destruction of excess of species, by using this technique it will save the life and environment.

13.APPENDIX

SOURCE CODE:
- Our project source code link: http://localhost:8888/notebooks/Desktop/Train%20image%20classification%20del.ipynb
- Our Github link - **https://github.com/IBM-EPBL/IBM-Project-3782-1658634691**
- Demo link - https://www.youtube.com/embed/tLSVqYB_A