EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRE

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1. INTRODUCTION

Forest fires are a major environmental issue, creating economic and ecological damage while endangering human lives. There are typically about 100,000 wildfires in the United States every year. Over 9 million acres of land have been destroyed due to treacherous wildfires. 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. The various real-time forest fire detection and prediction approaches, with the goal of informing the local fire authorities.

1.1 Project Overview

The idea is to create aand develop a system that can identify the effects of the forest fire and it can analyse the forest fire by advanced AI techniques and CNN Algorithm then the Prediction model is Checked and then the model is connected with Twilio account credentials of the Developer consisting of phone numbers of the persons in the surroundings of the people in the area of easy forest fire zone then an security sound alert system is developed to make a alert sound which is downloaded from internet then the entire model is deployed to the IBM Cloud account that we have created.

1.2 Purpose

The forest fires destroys the wildlife habitat, damages the environment, affects the climate, spoils the biological properties of the soil, etc. So the forest fire detection is a major issue in the present decade. At the same time the forest fire have to be detected as fast as possible.

2. LITERATURE SURVEY

2.1 Existing problem

Forest fires have been and still are serious problem for theEuropean Union and for all other countries in Europe. In the year 2000, the EU has established the European Forest Fire Information system (EFFIS) [1], which will soon become part of the European Emergency

Management Service, maintainedby the Copernicus Earth Observation Programme [2]. This system provides valuable near real-time and also historical data on the forest fires in Europe, the Middle East and North Africa. Currently EFFIS is being used and supported with data by 25 EU member states and by numerous other countries. According to the annual report of EFFIS for 2016 [3], more than 54 000 forest fires have occurred all around Europe and they have led to nearly 376 thousand hectares of burnt areas.If we compare these values to the average values from the EFFIS reports for the period 2006-2015, the number of forest fires have decreased by 13327 or by nearly 20%. This decrease can be explained with the more severe actions and sanctions towards the arsonists and with the introduction of more advanced technical solutions for early detection of the fires. Even though their number is decreasing, the forest fires continue to be extremely devastating events and they have destroyed just 27 thousand hectares (or 6.6 %) less than the average burnt areas for the period 2006-2015, according to [3]. Confirmation for this are the devastating forest fires form 2018, which took place in the Attica region of Greece and led to more than 90 fatalities and to more than 200 injured people,as well as to the destruction to thousands of buildings [4]. Forest Fires can be divided into 4 categories in the forests of Hungary based on tree and other vegetation species: • underground burning, peat fire; • fire in undergrowth or dead fallen leaves; • fire in seedlings and saplings; • fire in trunks and shrouds.[5]

2.2 References

1. Georgi Hristov; Jordan Raychev; Diyana Kinaneva; Plamen Zahariev , Published in: 2018 28th EAEEIE Annual Conference (EAEEIE).
2. Chi Yuan, Youmin Zhang, and Zhixiang Liu , Published in: 2015, Published by NRC Research Press.
3. Mohamed Hefeeda and Majid Bagheri , Published in: June 26, 2008.
4. PRIYADARSHINI M HANAMARADDI , Published in: January 2016.
5. Dr. Panagiotis Barmpoutis, Periklis Papaioannou, Dr. Kosmas Dimitropoulos, Dr. Nikos GRAMMALIDIS , Published in: 11 November 2020.
6. Vinay Chowdary , Mukul Kumar Gupta , Rajesh Singh, Published in:2018
7. Majid Bahrepour, Nirvana Meratnia, Paul Havinga , Published in: January 2008.
8. Dr.L.Latha , Published in: January 2015 9. P. Piccinini, S. Calderara, and R. Cucchiara , Published in: September, 2006.

2.3 Problem Statement Definition

The user interacts with a web camera to read the video.
Once the input image from the video frame is sent to the model, 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.

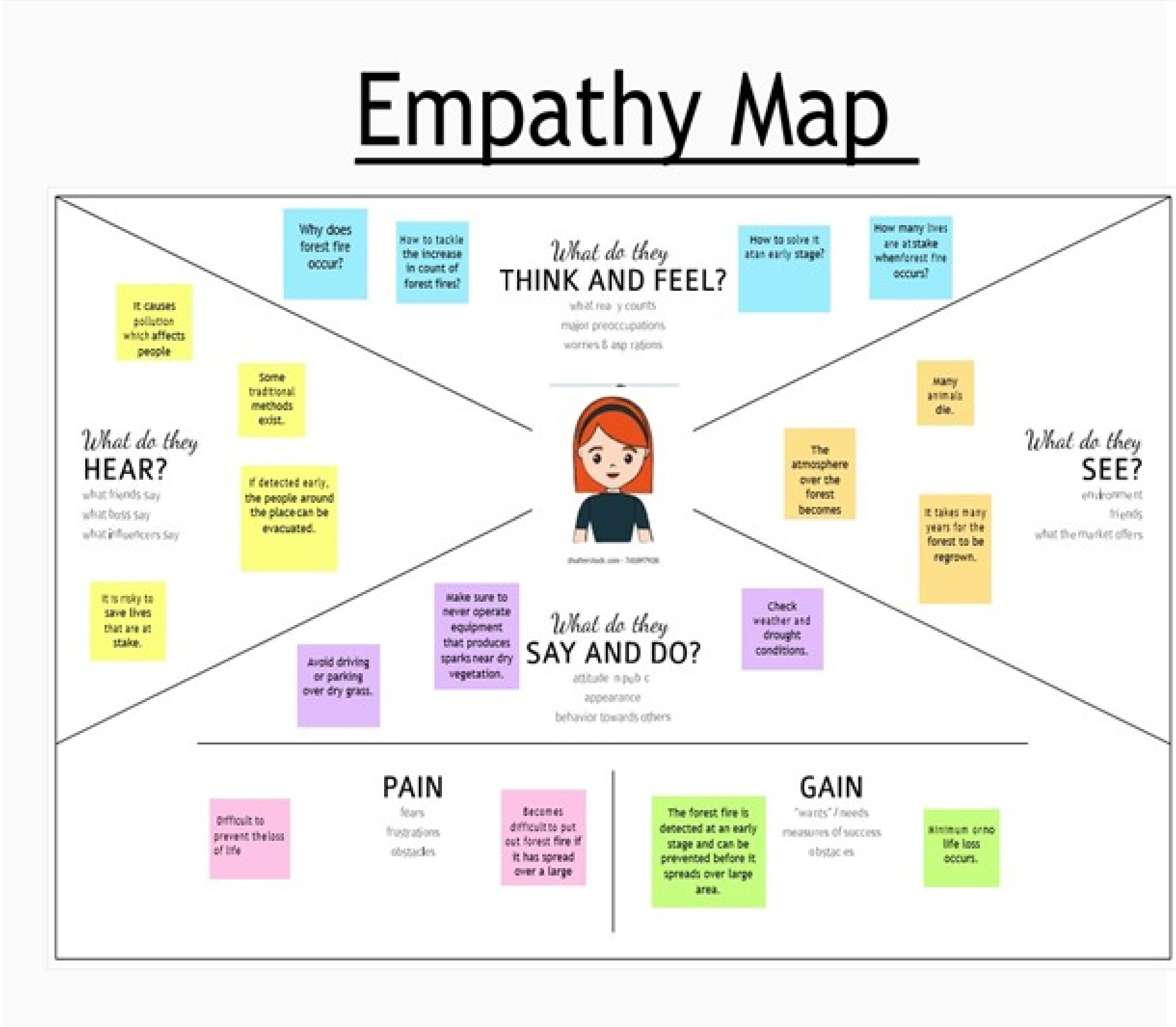
- **Data Collection.**

- Collect the dataset or create the dataset.
- **Image Preprocessing.**
  - Import ImageDataGenerator Library.
  - Define the parameters /arguments for ImageDataGenerator class
  - Applying ImageDataGenerator on trainset and test set.
- **Model Building**
  - Import the model building Libraries
  - Initializing the model
  - Adding CNN Layers
  - Adding Hidden Layer
  - Adding Output Layer
  - Configure the Learning Process
  - Training and testing the model
  - Optimize the Model
  - Save the Model
- **Video Streaming and alerting**
  - OpenCV for video processing
  - Creating an account in Twilio service
  - Use Twilio API to send messages.

3. IDEATION AND PROPOSED SOLUTION

3.1 Empathy Map Canvas

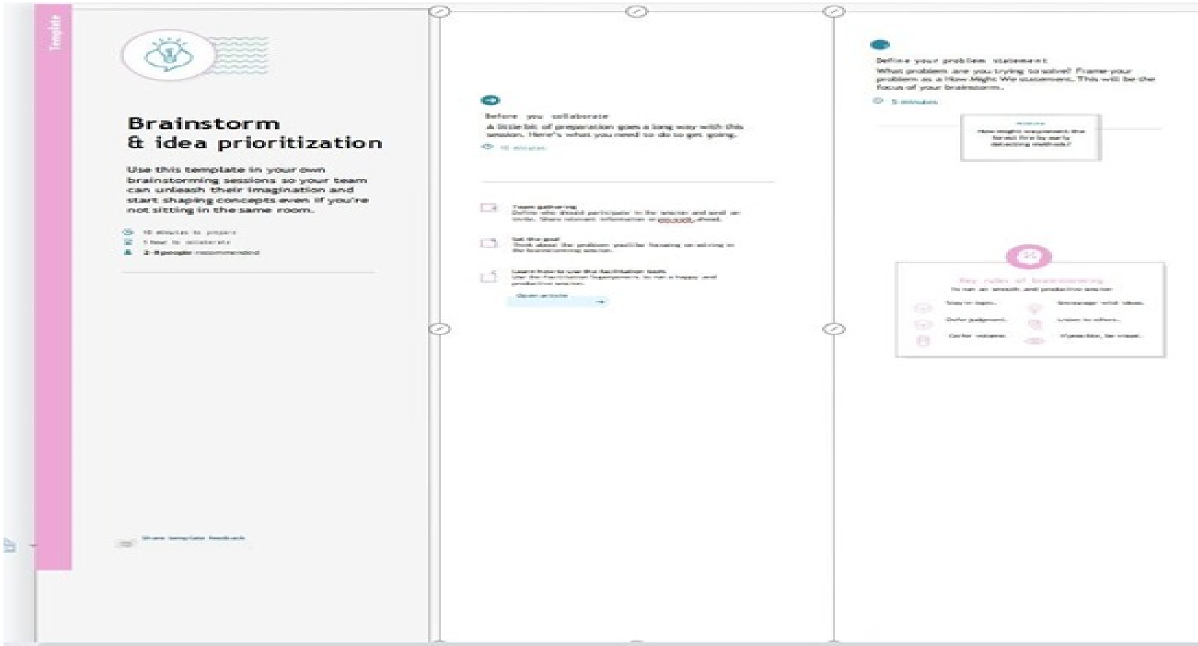
An empathy map canvas is a more in-depth version of the original empathy map, which helps identify and describe the user's needs and pain points.



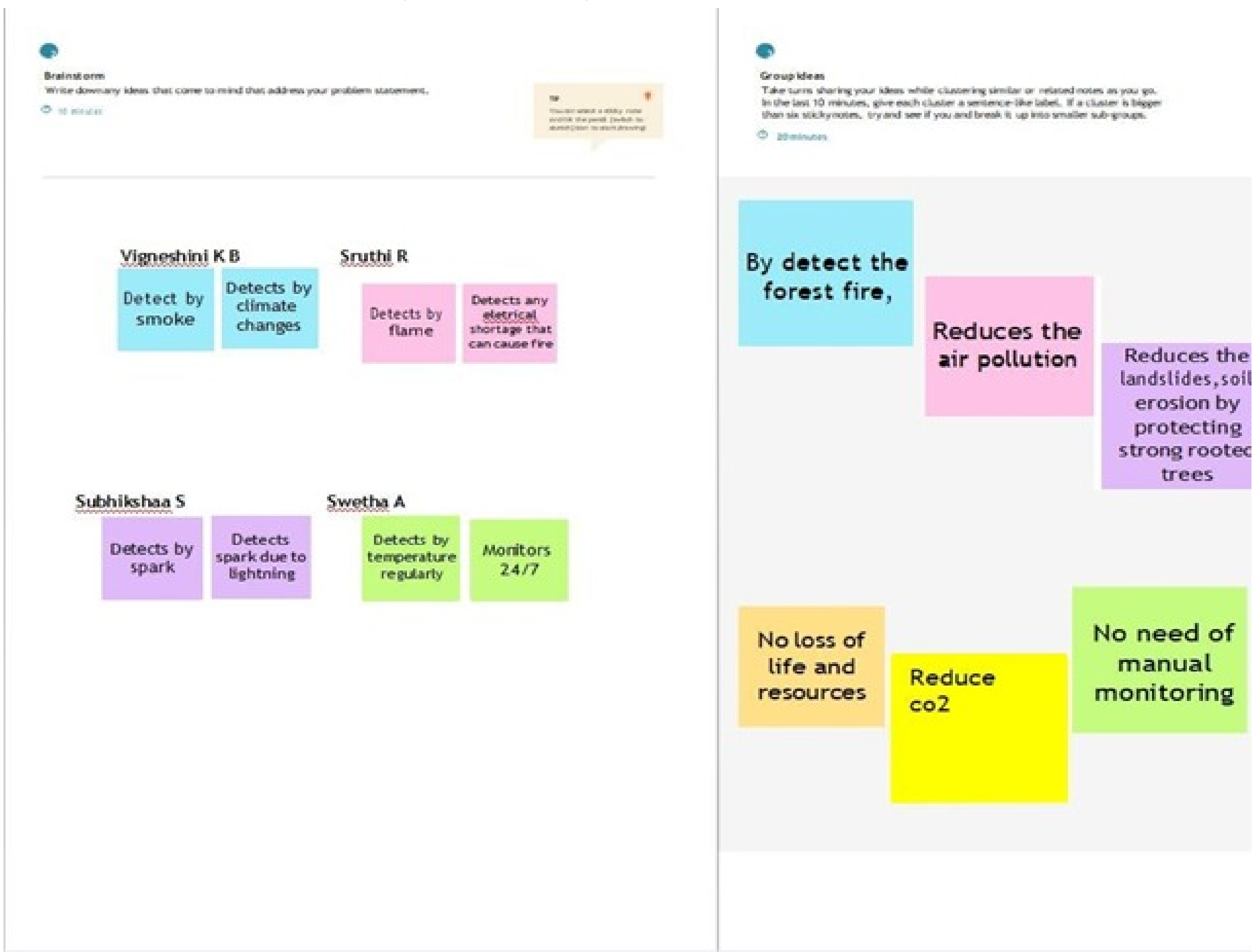
3.2 Ideation & Brainstorming

organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.

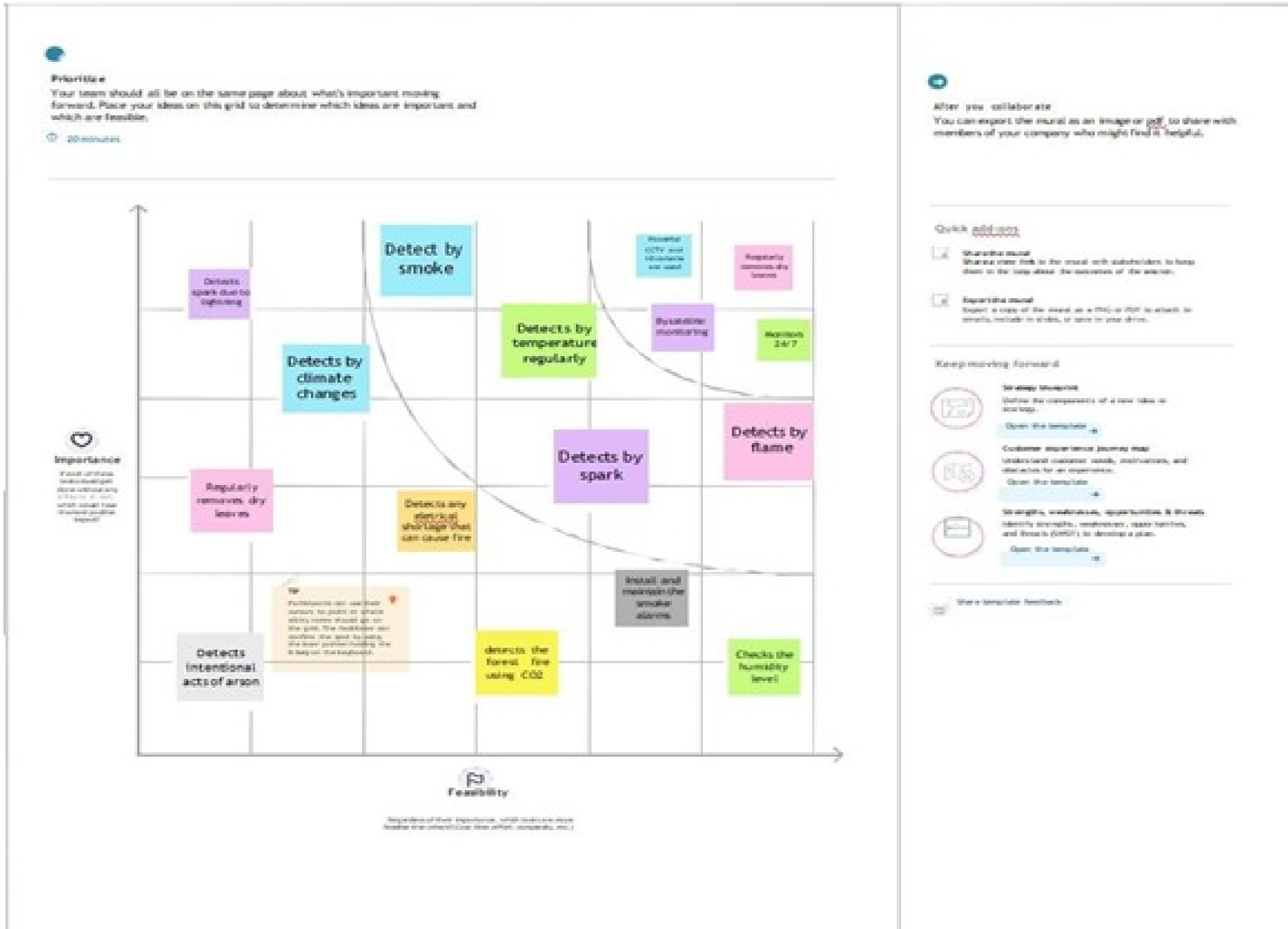
Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping



Step-3: Idea Prioritization



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 recognitionand detection of smoke or fire.
3	Novelty / Uniqueness	Real time computer program detect forest fire in earliest before itspread 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

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

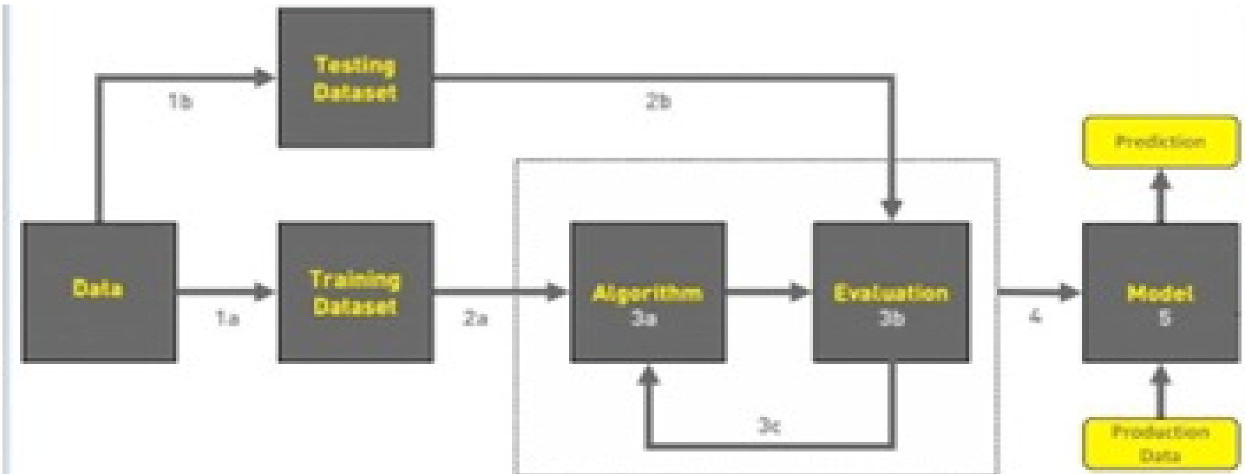
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User Login	Login using credentials
FR-4	User Search	Search for Info on forest fire occurrence
FR-5	User Profile	User shall be given a live feed of the forest
FR-6	User Application	User is alerted if there is a forest fire occurrence intheir surroundings

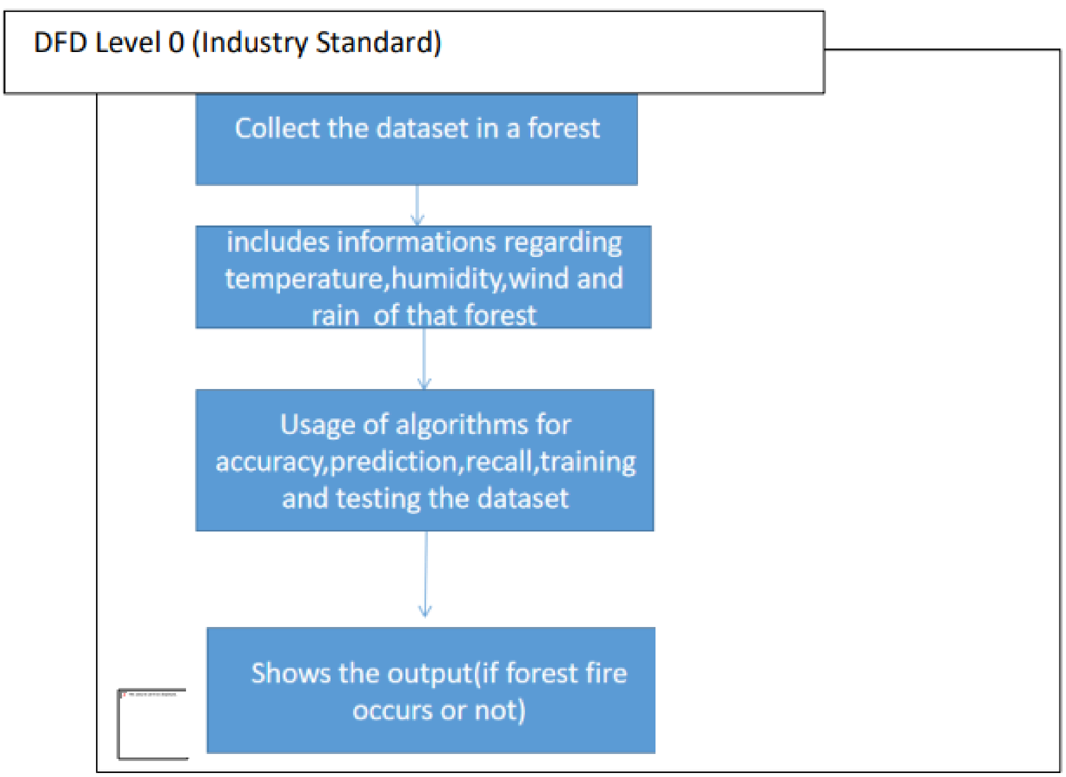
4.2 Non-Functional requirements

FR No	Non-Functional Requirement	Description
NFR-1	Usability	Alerts according to the user location
NFR-2	Security	Instant live feed with alert of the situation
NFR-3	Reliability	The prediction of the forest fire is 87% accurate
NFR-4	Performance	The feed and the alert message an immediate action without a lag
NFR-5	Availability	The application gives alerts and live feeds 24/7
NFR-6		Early detection and alerting users are done efficiently and in a faster means

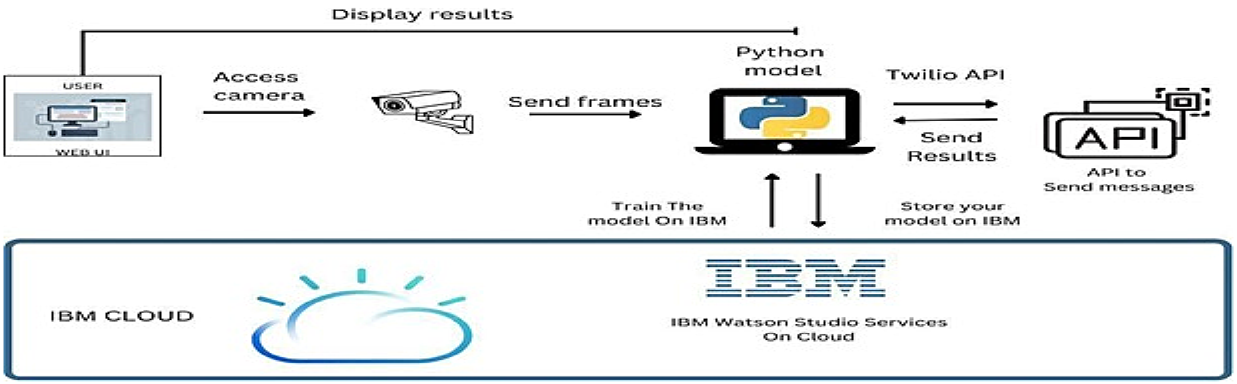
5. PROJECT DESIGN

5.1 Data Flow Diagrams





5.2 Solution & Technical Architecture



S.No	Component	Description	Technology
1	User Interface	The user uses the console to access the interface	Python/HTML ,CSS , Javascript and react.Js
2	Input	Video Feed	Web Camera/Video on a site
3	Conversion	Video inputted is converted into Frames	Frame Converter
4	Feeding the Model	The Frames are sent to the Deep learning model	Our Model
5	Dataset	Using Test set and train set , train the model	Data set from Cloud Storage , Database
6	Cloud Database	The model is trained in the cloud more precise with detections more images can be added later on.	IBM Cloudant ,Python Flask.
7	Infrastructure (Server / Cloud), API	Application Deployment on Local System / Cloud Local ,Cloud Server Configuration , Twilio API to send messages	Java/python ,React.Js ,JavaScript ,HTML ,CSS ,IBM Cloud ,OPEN CV ,Anaconda Navigator ,Local.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1	Open-Source Frameworks	Python Flask framework is used	Technology of Opensource framework
2	Security Implementations	Mandatory Access Control (MAC) and Preventative Security Control is used	e.g. SHA-256, Encryptions, IAM Controls, OWASP etc.
3	Scalable Architecture	High scalability with 3-tier architecture	Web server – HTML ,CSS ,JavaScript Application server – Python , Anaconda Database server –IBM DB2
4	Availability	Use of load balancing to distribute traffic across servers	IBM load balancer
5	Performance	Enhance the performance by using IBM CDN	IBM Content Delivery Network

5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Environmentalist	Collect the data	USN-1	As an Environmentalist,it is necessary to collect the data of the forest which includes temperature,humidity,wind and rain of the forest	It is necessary to collect the right data else the prediction may become wrong	High	Sprint-1

		USN-2	Identify algorithms that can be used for prediction	To collect the algorithm to identify the accuracy level of each algorithms	Medium	Sprint-2
		USN-3	Identify the accuracy of each algorithms	Accuracy of each algorithm-calculated so that it is easy to obtain the most accurate output	High	Sprint-2
		USN-4	Evaluate the Dataset	Data is evaluated before processing	Medium	Sprint-1
		USN-5	Identify accuracy,preci sion,recall of each algorithms	These values are important for obtaining the right output	High	Sprint-3
		USN-6	Outputs from each algorithm are obtained	It is highly used to predict the effect and to take precaution ary measures	High	Sprint-4

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-2	Saving the Model	USN-2	As a developer saving the model developed for estimation of fire	10	high	Vigneshini KB Sruthi R Subhikshaa S Swetha A
Sprint-3	Video Analysis	USN-3		10	Medium	Vigneshini KB Sruthi R Subhikshaa S Swetha A
Sprint-3	Twilio Message Service	USN-3		10	Low	Vigneshini KB Sruthi R Subhikshaa S Swetha A
Sprint-4	Alert Sound and Message	USN-4	Sending Alert text message using registered twilio account and produce output sound alert alarm	10	Low	Vigneshini KB Sruthi R Subhikshaa S Swetha A
Sprint-4	Train Model on cloud	USN-5	Application Deployment on Local System/ Cloud Local Server Congiguration: Cloud Server Configuration:and to train the deep learning model in IBM Cloud	10	Medium	Vigneshini KB Sruthi R Subhikshaa S Swetha A

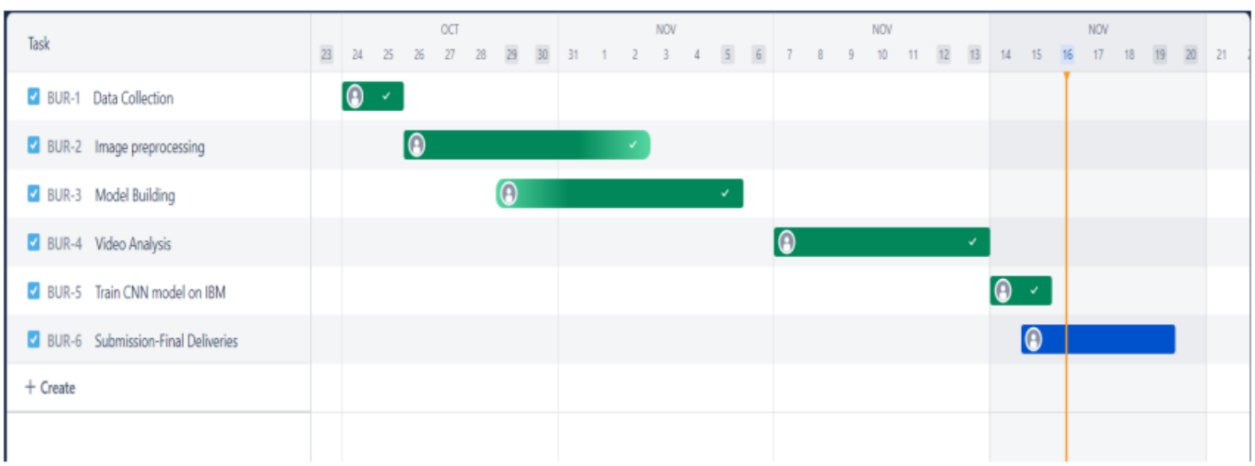
6.2 Sprint Delivery Schedule

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	6days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

The following table shows the sprint works assigned to the members along with the priority and story points assigned with the functional requirements with regards to user story.

6.3 Reports from JIRA

Burndown Chart:



7. CODING & SOLUTION

7.1 Feature 1

In Feature 1 module we have made data collection and Image preprocessing for and Model training.

importing Required Libraries:

import keras from keras.preprocessing.image

import ImageDataGenerator

import matplotlib.pyplot as plt

import numpy as np batch_size = 32

image resizing and preprocessing :

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

train_generator = train_datagen.flow_from_directory('train_set/', target_size=(150, 150), batch_size=batch_size, class_mode='binary')

val_generator = val_datagen.flow_from_directory('test_set/', target_size=(150, 150), batch_size=batch_size, class_mode='binary')

Creating the sequential model:

from keras.models

import Sequential from keras.layers

import Convolution2D from keras.layers

import MaxPooling2D from keras.layers

import Activation from keras.layers

import Dropout from keras.layers

import Flatten from keras.layers

import Dense model=Sequential()

model.add(Convolution2D(32,(3,3),input_shape=(150,150,3))) #Convolutional 2D Layer model.add(Activation('relu'))

model.add(MaxPooling2D(pool_size=(2,2))) # MaxPooling Layer

model.add(Flatten()) #Flatten Layer to make a array

model.add(Dense(150))

model.add(Activation('relu'))

model.add(Dropout(0.5))

model.add(Dense(1))

model.add(Activation('sigmoid'))

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

Model summary:

model.summary()

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 148, 148, 32)      896
_________________________________________________________________
activation (Activation)      (None, 148, 148, 32)      0
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 74, 74, 32)        0
_________________________________________________________________
flatten (Flatten)            (None, 175232)            0
_________________________________________________________________
dense (Dense)                (None, 150)               26284950
_________________________________________________________________
activation_1 (Activation)    (None, 150)               0
_________________________________________________________________
dropout (Dropout)            (None, 150)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 151
_________________________________________________________________
activation_2 (Activation)    (None, 1)                 0
=================================================================
Total params: 26,285,997
Trainable params: 26,285,997
Non-trainable params: 0
```

7.2 Feature 2

```
import cv2 import
numpy as np
from keras.preprocessing import
image from keras.models import
load_model from twilio.rest import
Client from playsound import
playsound
model=load_model('forest1.h5')
video=cv2.VideoCapture(0)
name=['forest','with fire']
while(True):
  ret,frame=video.read()
  cv2.imshow('frame',frame)
  cv2.imwrite('image.jpg',frame)
  img=image.load_img('train_set/forest/NoFire
(1).bmp',target_size=(64,64))
  x=image.img_to_array(img)
  x=np.expand_dims(x,axis=0)
  pred=model.predict(x)
    index=np.argmax(pred)
    if index==0:

account_sid='AC50d663c8a7c2d8b35b1fc09dfda93bda'
        auth_token='86f345babfa094d1015a0e1137dbb679'
        client =Client(account_sid,auth_token)
        message=client.messages \
       .create(body='-------Fire is detected,Stay Alert !!!--------',
                from_='+19457581434',to='+916369 659 356')
        print(message.sid)
        print('Fire detected')
       print("Alert Message sent!")
        playsound('tornado-siren.mp3')

   else:
      print('No Danger')
      cv2.imshow("image.jpg",frame)
      if cv2.waitkey(2)&0xff == ord('q'):
            break
video.release()
cv2.destroyAllWindows()
```

```
SM200b2510df1efe889005ac80731425ff
Fire detected
Alert Message sent!
```

```
In [ ]:
```

8.TESTING

8.1 Test Cases & User Acceptance Testing

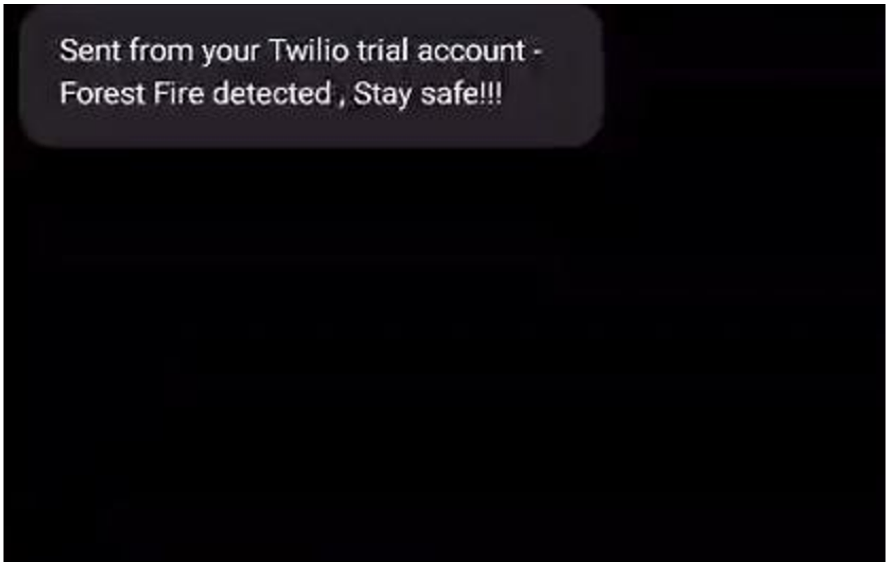
Testing with input video recording from user end:

```
import cv2
import numpy as np
from keras.preprocessing
import image from keras.models
import load_model from twilio.rest
import Client from playsound
import playsound
model=load_model('forest1.h5')
video=cv2.VideoCapture(0)
name=['forest','with fire']
while(True):
   ret,frame=video.read()
   cv2.imshow('frame',frame)
   cv2.imwrite('image.jpg',frame)
   img=image.load_img('train_set/forest/NoFire (1).bmp',target_size=(64,64))
   x=image.img_to_array(img)
   x=np.expand_dims(x,axis=0)
   pred=model.predict(x)
   index=np.argmax(pred)
   if index==0:
      account_sid='AC50d663c8a7c2d8b35b1fc09dfda93bda'
      auth_token='86f345babfa094d1015a0e1137dbb679'
      client =Client(account_sid,auth_token)
      message=client.messages \
      .create(body='-------Fire is detected,Stay Alert !!!--------',
              from_='+19457581434',to='+916369 659 356')
      print(message.sid)
      print('Fire detected')
      print("Alert Message sent!")
      playsound('tornado-siren.mp3')

   else:
      print('No Danger')
      cv2.imshow("image.jpg",frame)
      if cv2.waitkey(2)&0xff == ord('q'):
          break
```

```
video.release()
cv2.destroyAllWindows()
```

OUTPUT:



9.Result

9.1 Performance Metrics

```
loss: 0.3438 - accuracy: 0.8483 - val_loss: 0.2485 - val_accuracy: 0.958

loss: 0.3816 - accuracy: 0.8483 - val_loss: 0.2569 - val_accuracy: 0.958

loss: 0.4068 - accuracy: 0.8391 - val_loss: 0.2547 - val_accuracy: 0.958

loss: 0.3312 - accuracy: 0.8437 - val_loss: 0.2601 - val_accuracy: 0.950

loss: 0.5621 - accuracy: 0.8368 - val_loss: 0.2679 - val_accuracy: 0.958
```

10. ADVANTAGES & DISADVANTAGES

Advantages :

- Easily detect and Estimate the Forest Fire.
- Most Accurate
- Flexible Model which can give maximized outcome
- No Specific Requirements needed to implement the model

Disadvanatges:

- Training model is time consuming process.
- Error in CV can cause damage to camera
- Access of camera are prohibited due to personal issues

11.CONCLUSION :

Thus we have constructed a model that can identify the effects of the forest fire and it can analyse the forest fire by advanced AI techniques and CNN Algorithm then the Prediction model is Checked and then the model is connected with Twilio account credentials of the Developer consisting of phone numbers of the persons in the surroundings of the people in the area of easy forest fire zone then an security sound alert system is developed to make a alert sound which is downloaded from internet then the entire model is deployed to the IBM Cloud account that we have created was made with the studies we have done.

12.FUTURE SCOPES :

1. It can be developed as a Web or Android Application.
2. In future Alternate Advanced technologies can be Implemented.
3. The Identification and tracking system can be implemented if possible.

13.APPENDIX :

Source Code : https://github.com/IBM-EPBL/IBM-Project-31025-1660194638/blob/main/Final%20Deliverables/EntireModel.ipynb

GitHub & Project Demo Link

Github: https://github.com/IBM-EPBL/IBM-Project-31025-1660194638

Demo Link:

https://drive.google.com/file/d/1MmxM2gr7TgNv_0eDZ6fgQSWnhPxCRcqA/view?usp=share_link