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EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRES

Project Outline

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 leaves 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. Forest fires are also considered as a main contributor to the air pollution, due to the fact that during every fire huge number of gases and particle mater are released in the atmosphere. To fight forest fires, different solutions were employed throughout the years. They ware primary aimed at the early detection of the fires. 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.

1.2 Purpose:

The main purpose of the project is to detect the forest fires early. This can be done by using the artificial intelligence technique.

2. LITERATURE SURVEY

2.1 Existing problem:

Frequent fires in the Himalayan region of Uttaranchal in the Indian Himalayas have been blamed for forest deterioration. It is true that frequent fires on large scales cause air pollution, mar quality of stream water, threaten biodiversity and spoil the aesthetics of an area, but fire plays an important role in forest ecosystem dynamics. Moreover, it is not fire, but other anthropogenic activities plus fire that are degrading the forest of the Indian Himalayas. In the present study the role of fire in shaping forest structure and composition is analysed. If fire is managed wisely, it can be used as the cheapest means of forest management. For this purpose, different fire characteristics are assessed together with their interrelationship with forest flora.

2.2 References:

Georgi Hristov et.al. [1] Forest Fires are mainly caused by the actions of humans, but different nature and environmental phenomena, like lightning strikes or spontaneous combustion of dried leaves 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. Forest fires are also considered as a main contributor to the air pollution, due to the fact that during every fire huge number of gases and particle mater are released in the atmosphere. To fight forest fires, different solutions were employed throughout the years. They ware primary aimed at the early detection of the fires. 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. In this paper we will discuss and present two different emerging solutions for early detection of forest fires. The first of these solutions involves the use of unmanned aerial vehicles (UAVs) with specialized cameras. Several different scenarios for the possible use of the drones for forest fire detection will be presented and analysed, including a Date 18 September 2022 Team ID PNT2022TMID06660 Project Name Emerging Methods for Early Detection of Forest Fires Maximum Marks 2 Marks solution with the use of a combination between a fixed-wind and a rotary-wing UAVs. In the next chapter of the paper, we will present and discuss the possibilities for development of systems for early forest fire detection using Lora WAN sensor networks and we will analyse and present some of the hardware and software components for the realisation of such sensor networks.

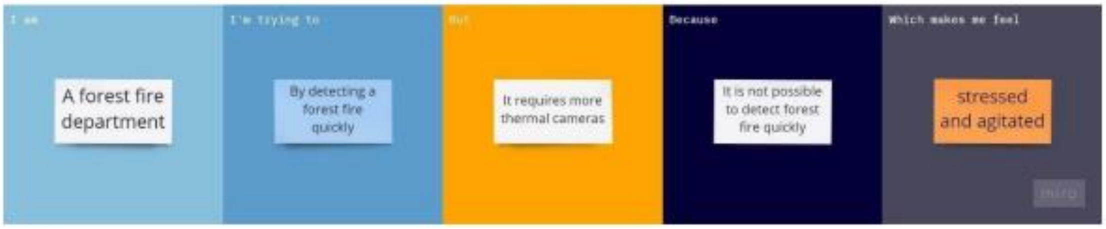
Chi Yuan et.al. [2] Over the last decade, UAV-based forest fire fighting technology has shown increasing promise. This paper presents a systematic overview of current progress in this field. First, a brief review of the development and system architecture of UAV systems for forest fire monitoring, detection, and fighting is provided. Next, technologies related to UAV forest fire monitoring, detection, and fighting are briefly reviewed, including those associated with fire detection, diagnosis, and prognosis, image vibration elimination, and cooperative control of UAVs. The final section outlines existing challenges and potential solutions in the application of UAVs to forest firefighting.

Mohamed Hefeeda et.al. [3] Early detection of forest fires is the primary way of minimizing their damages. We first present the key aspects in modelling forest fires according to the Fire Weather Index (FWI) System which is one of the most comprehensive forest fire danger rating systems in North America. Then, we model the forest fire detection problem as a node kcoverage problem ($k \geq 1$). We propose approximation algorithms for the node k-coverage problem which is shown to be NPhard. We present a constant-factor centralized algorithm, and a fully distributed version which does not require sensors know their locations.

Priyadarshini M Hanamaraddi et.al. [4] Forests can purify water, stabilize soil, cycle nutrients, moderate climate, and store carbon. They can create habitat for wildlife and nurture environments rich in biological diversity. They can also contribute billions of dollars to the country's economic wealth. However, hundreds of millions of hectares of forests are unfortunately devastated by forest fire each year. Forest fire has been constantly threatening to ecological systems, infrastructure, and public safety. In the image processing-based forest fire detection, method adopts rule-based colour model due to its less complexity and effectiveness. The method not only separates fire flame pixels but also separates high temperature fire centre pixels by taking in to account of statistical parameters of fire image like mean and standard deviation. This paper presents a literature study on Image processing for forest fire detection.

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:

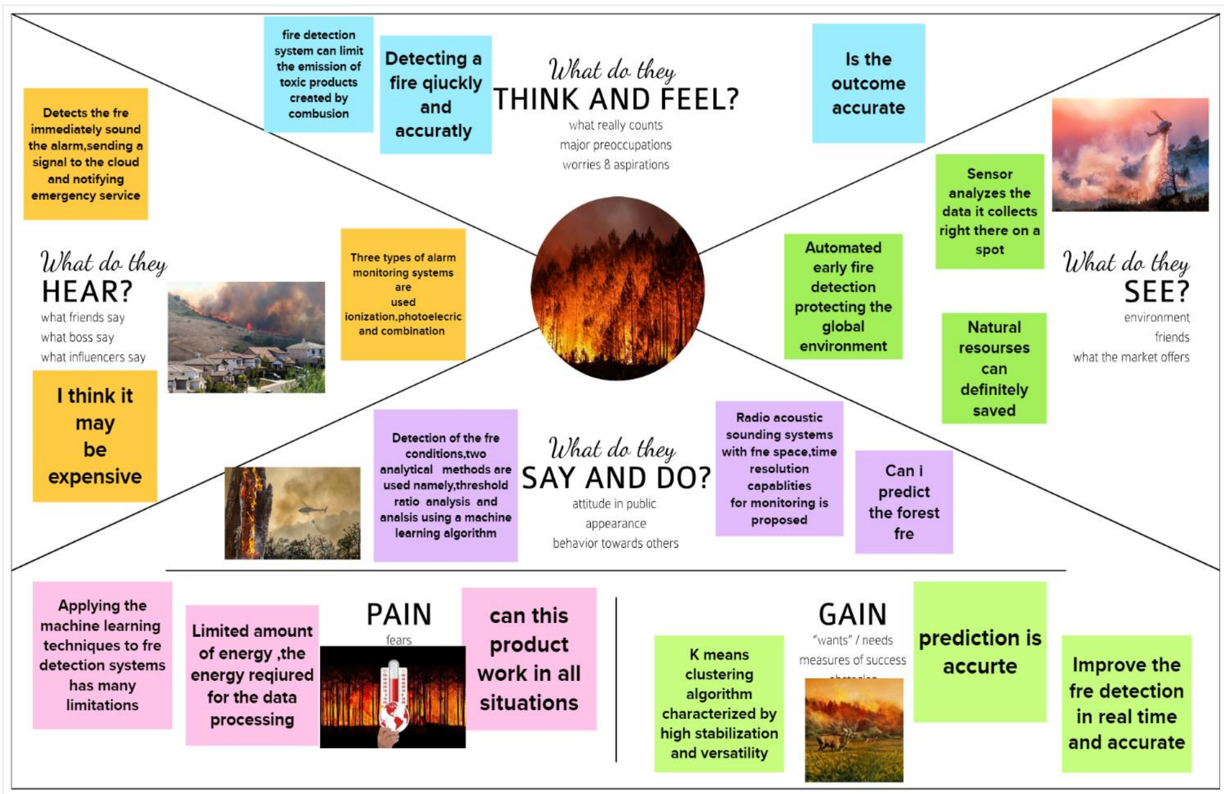


Problem statement(ps):	Forest fires are a major environmental issue, creating economic and ecological damage while endangering human lives. There are typically about 100,000 wildfires in the United States every year. Over 9 million acres of land have been destroyed due to treacherous wildfires. It is 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.
IAM	A Forest fire department
I'm trying to	Frequently monitor fire and make sure to prevent them from getting destroyed. Analyze data from various thermal camera's
But	Requires a lot of thermal cameras for monitoring
Because	It's really hard to cover large boundaries and monitorthem 24 hours a day
Which makes me feel	Stressed and agitated about the forests are burning fast.

3. IDEATION & PROPOSED SOLUTION

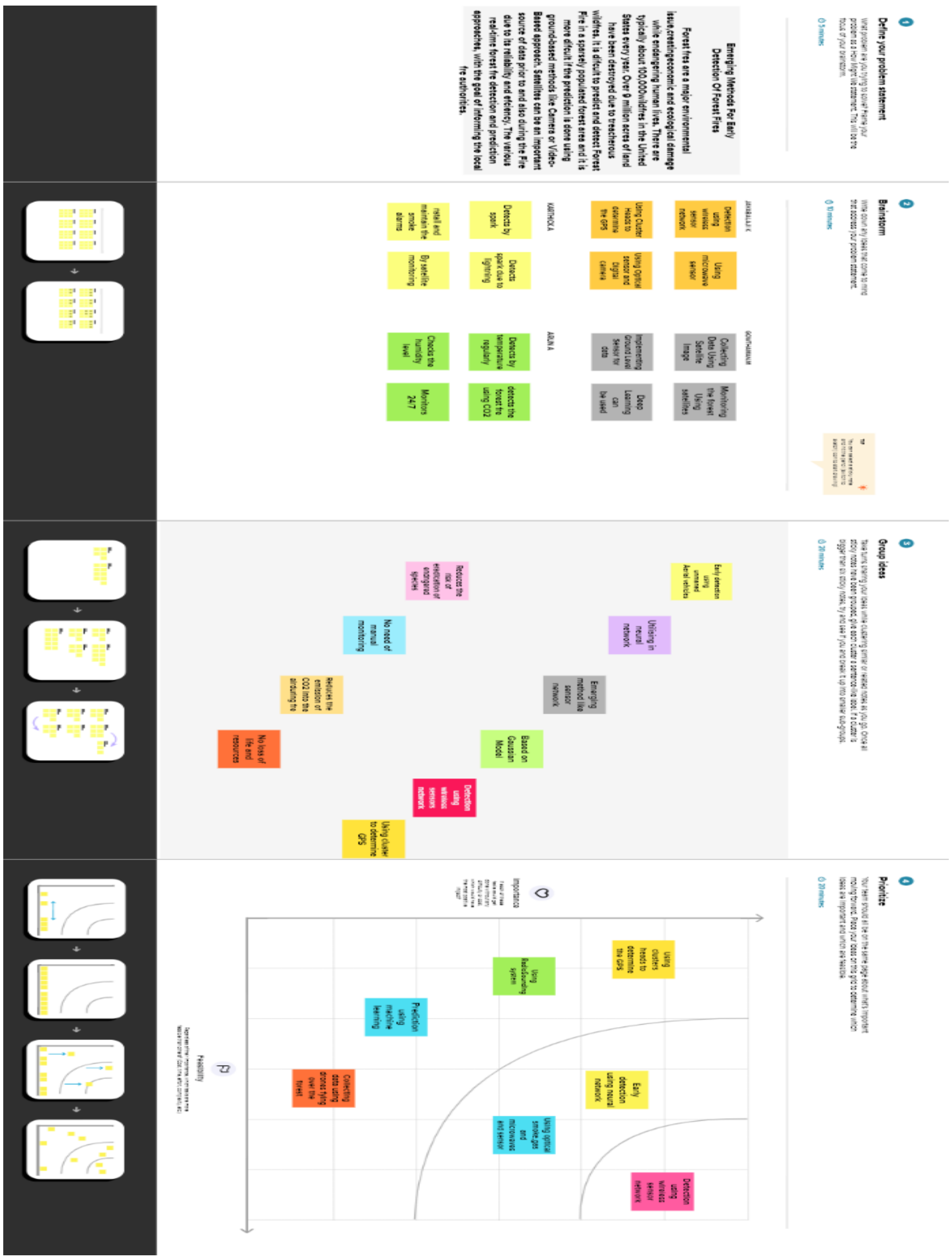
3.1 Empathy Map Canvas:

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user’s behaviours and attitudes. It is a useful tool to helps teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user’s perspective along with his or her goals and challenges.



3.2 Ideation & Brainstorming:

Brainstorming



3.3 Proposed Solution:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Forest Fire Due To Lightning, Human Error, Volcanos, Rising temperatures, a key indicator of climate change, evaporate more moisture from the ground, drying out the soil, and making vegetation more flammable.
2.	Idea / Solution description	Forest Fire can be detected by using convolutional neural networks and artificial intelligence .The main ideation is that it is build by using satellite image preprocessing and video analysis.
3.	Novelty / Uniqueness	The most interesting and unique feature of this system is its capability of ingesting and processing different instrument data, AVHRR and ATSR, into standard fire alerts integrated into an operational environment, benefiting from the synergy of the two instruments.
4.	Social Impact / Customer Satisfaction	By using this system it reduces global warming which causes major climatic changes and prevents wild animals and birds from danger by this method the smoke due to fire is also prevented which causes various effects on Nature.
5.	Business Model (Revenue Model)	This system is used to predict the forest fire at the early stage, prevent the wild lives from fire and prevents global warming. This model is more reliable and can produce accurate detection of forest fire.
6.	Scalability of the Solution	Compared to other methods satellite detection is more efficient and is accurate it can convert large area by using image processing and video analysis by this advantages this method has more benefits.

3.4 Problem Solution fit:

Project Title: EMERGING METHODS FOR EARLY FOREST FIRE DETECTION

Project Design Phase-I - Solution Fit Template

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

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Accurate model	The model gives accurate results for detection of forest fires.
FR-4	Good hardware	To obtain high quality images to perform real time detection
FR-5	Cloud	We need cloud for storage and deploying the application
FR-6	Website	Easy to use and navigate website that send alerts to authorities when forest fire is detected.

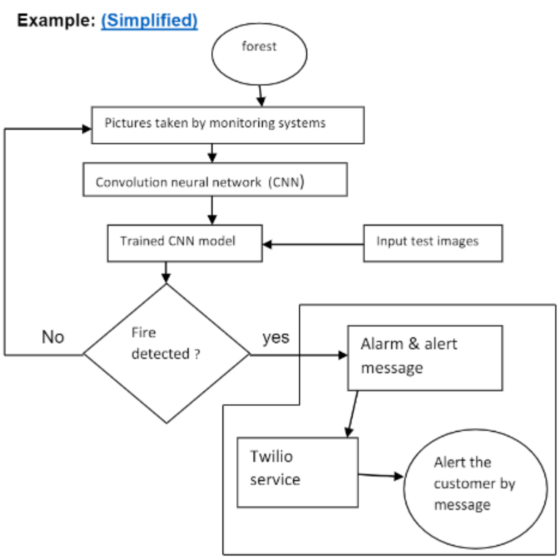
Non-functional Requirements:

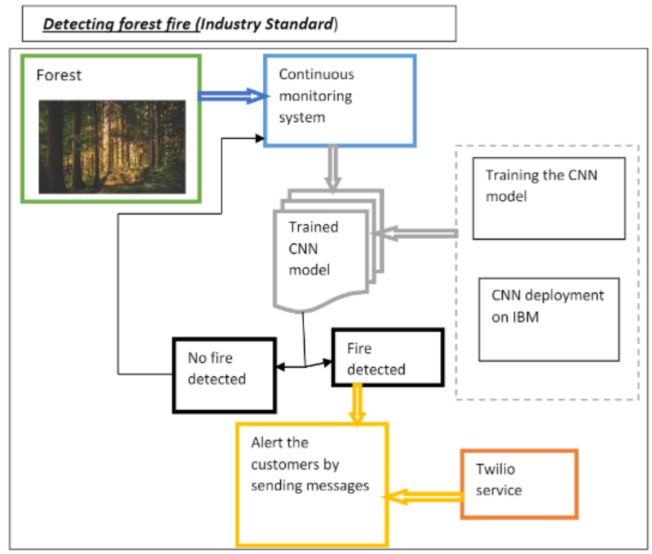
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The interface will be easy to use and very user friendly and can be used by anyone.
NFR-2	**Security**	The application will be secure and safe to use.
NFR-3	**Reliability**	It will be taken care such that the application only produces highly accurate results and will accurately detect forest fires.
NFR-4	**Performance**	The model will perform detection in few seconds.
NFR-5	**Availability**	It will be available 24/7 will minimal downtime to continuously monitor
NFR-6	**Scalability**	The project is highly scalable and can be scaled up to monitor and detect forest fires in large forest or can also be scaled down to monitor and detect forest fires in particular areas alone

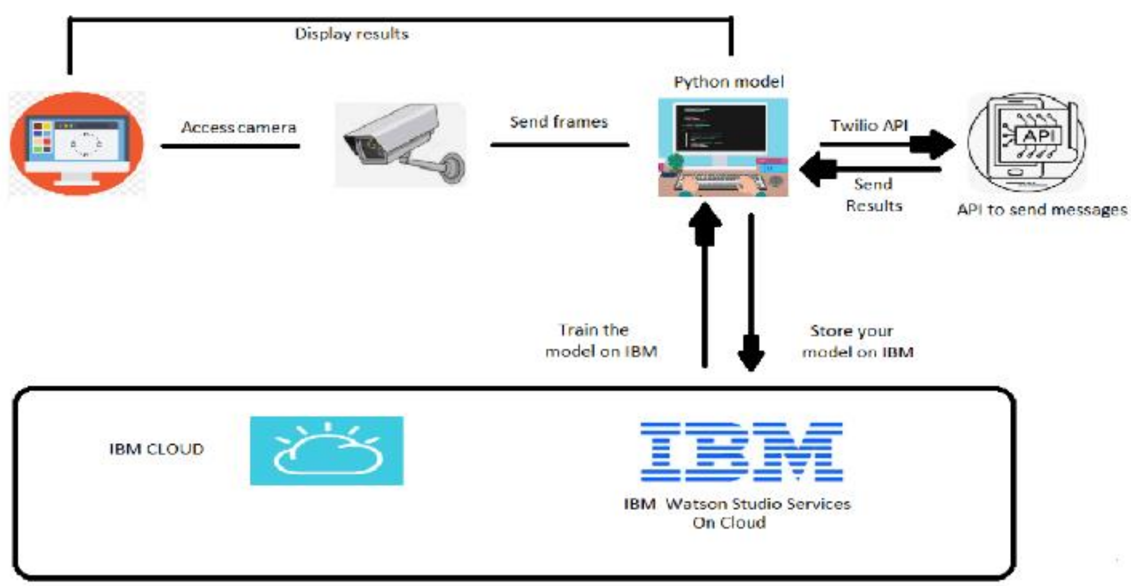
5. PROJECT DESIGN

5.1 Data Flow Diagrams:





5.2 Solution & Technical Architecture:



5.3 User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Developer	Registration	USN-1	As a user, I can sign up and register respective sites to access the required details and data. And import the required libraries for the processes.	I can access the account / dashboard	High	Sprint-1
Assistant developer	Login	USN-2	As a user, I will access the page and test and train the CNN model to predict or detect the forest fire.	I can test and confirm the error free detections	High	Sprint-2
Customer Care Executive	Worker	USN-3	As a customer care executive ,i am available to the customers .so if the customers have any issues or in need of any assistance they will get help and solve them.	I can be in contact with the customers.	medium	Sprint 3
Customer (Web user)	Login	USN-4	As a user , i will have the access to know about the activities in the forest.	I can get messages when there is fire in the forest	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-1	Data Collection	USN-1	Collect Dataset	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K
Sprint-1		USN-2	Image pre processing	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K
Sprint-2	Model Building	USN-3	Import the required libraries, add the necessary layers and compile the mode	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K
Sprint-2		USN-4	Training the image classification model using CNN	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K
Sprint-3	Training and Testing	USN-5	Training the model and testing the model's performance	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K
Sprint-4	Implementation of The application	USN-6	When it is the wildfire then the alarming system is activated. And the alarm will be sent to the corresponding department and required action will be taken soon to control the fire.	20	High	Arun Vignesh S Diwakar N R Gracy S Hari Naath K

6.2 Sprint Delivery Schedule:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I will be provided with pre-determined user ID and password for that particular forest camp	10	High	ARUN VIGNESH
Sprint-1		USN-2	As a user, I will be provided access to the alert information system	10	medium	
Sprint-2		USN-3	The input video will be converted into frames and image preprocessing will be done	20	Low	GRACY S
Sprint-3	Monitoring	USN-4	Constant monitoring will be enabled for the detection of forest fire	20	Medium	HARINAATH K
Sprint-4	Alert System	USN-5	Once the pattern of fire is detected an alert signal will be enabled and notification will be intimated	20	High	DIWAKAR N R

7. DING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1:

We uploaded the dataset that is given and have divided the classes into train set and data set and preprocessed the image.The output is shown here.

```
In [3]:  #Applying ImageDataGenerator functionality to trainset
         x_train=train_datagen.flow_from_directory('/content/drive/MyDrive/Dataset/train_set',target_size=(128,128),batch_size=32,class_mode='binary')

         Found 439 images belonging to 2 classes.

In [4]:  #Applying ImageDataGenerator functionality to testset
         x_test=test_datagen.flow_from_directory('/content/drive/MyDrive/Dataset/test_set',target_size=(128,128),batch_size=32,class_mode='binary')

         Found 121 images belonging to 2 classes.
```

7.2 Feature 2:

After the image preprocessing we have done the model building.The model building output is shown here.

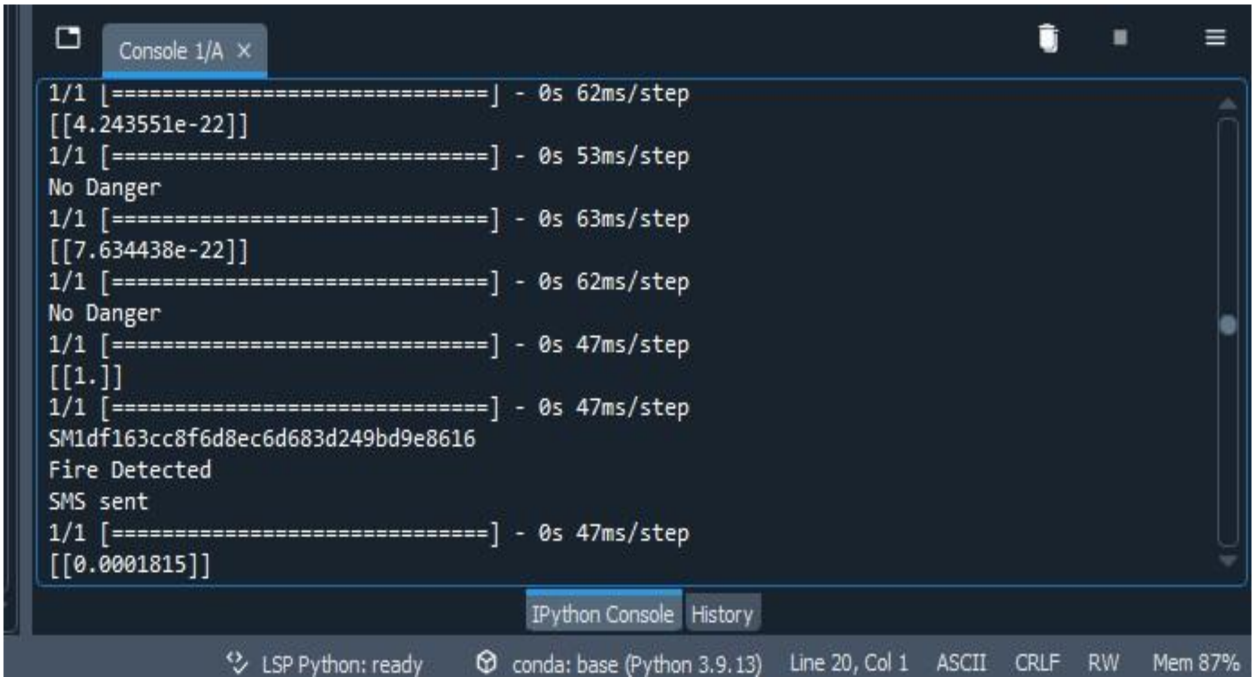
```
In [27]:  #Load the saved model
          model = load_model("forest1.h5")

In [29]:  img=image.load_img('/content/drive/MyDrive/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)

In [31]:  pred=model.predict(x)

          1/1 [==============================] - 0s 31ms/step

In [32]:  pred

Out[32]:  array([[1.]], dtype=float32)

In [ ]:
```

By using the above forest1.h5 model we can take our desired output according to the input.

8. TESTING

8.1 Test Cases:

By the showing image of forest fire the desired output of "Forest fire is detected,stay alert" is sent via SMS form twilio service.By showing the image of forest the desired output is no danger.



8.2 User Acceptance Testing:

We have tested our project by showing the image of forest with fire and forest without fire.The output is shown above.

9. RESULTS

9.1 Performance Metrics:

Model evaluation

```
In [27]: #load the saved model
         model = load_model("forest1.h5")

In [29]: img=image.load_img('/content/drive/MyDrive/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)

In [31]: pred=model.predict(x)

1/1 [==============================] - 0s 31ms/step

In [32]: pred

Out[32]: array([[1.]], dtype=float32)

In [ ]:
```

10. ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- Avoid Smoke Inhalation. The most important reason is perhaps the only one you really need.
- Early Detection. The earlier a fire is detected, the faster it will be that firefighters will respond.
- Insurance Discounts.
- 24/7 Monitoring.
- Easy & Affordable.

DISADVANTAGES:

- The system is essentially useless if the batteries aren't charged, since it won't work properly.
- There is a bit of a burden to business owners to always remember to keep the batteries fresh so the system operates properly when you need it most.

11. CONCLUSION

Early fire detection is best achieved by the installation and maintenance of fire detection equipment in all areas of the forest.

12. FUTURE SCOPE

The future will be with multicriteria detection in which the detector will be more of a sensor, with the detection more for the products of combustion, such as carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen oxides in addition to heat and particulate matter.

13. APPENDIX

Source Code: Python code

```
pwd
!pip install keras
!pip install tensorflow
!pip install opencv-python
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
from tensorflow.keras.preprocessing.image import ImageDataGenerator
train = ImageDataGenerator(rescale=1/255)
test = ImageDataGenerator(rescale=1/255)

import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='4IWkR1z91BsZbSDXFDHyL0yQUyA4gPq20ZVg20gk8Xw6',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')
```

```
bucket = 'sampleproject-donotdelete-pr-bcmldja8taur32'
object_key = 'Dataset.zip'

streaming_body_2 = cos_client.get_object(Bucket=bucket, Key=object_key)['Body']

# Your data file was loaded into a botocore.response.StreamingBody object.
# Please read the documentation of ibm_boto3 and pandas to learn more about the possibilities to load the data.
# ibm_boto3 documentation: https://ibm.github.io/ibm-cos-sdk-python/
# pandas documentation: http://pandas.pydata.org/

from io import BytesIO
import zipfile
unzip = zipfile.ZipFile(BytesIO(streaming_body_2.read()),'r')
file_paths = unzip.namelist()
for path in file_paths:
   unzip.extract(path)
pwd
import os
filenames = os.listdir('/home/wsuser/work/Dataset/ibm/fire/dataset/train_set')
x_train = train_dataset = train.flow_from_directory("/home/wsuser/work/Dataset/ibm/fire/dataset/train_set",target_size = (64,64),batch_size = 32,class_mode = 'binary')
x_test = test_dataset = test.flow_from_directory("/home/wsuser/work/Dataset/ibm/fire/dataset/test_set",target_size= (64,64),batch_size = 32,class_mode = 'binary')
x_test.class_indices
model = Sequential()
model.add(Convolution2D(32,(3,3),activation='relu',input_shape=(64,64,3)))
model.add(MaxPooling2D(2,2))
model.add(Flatten())
model.add(Dense(512,activation='relu'))
```

```
model.add(Dense(1,activation='sigmoid'))
model.compile(optimizer="adam",loss="binary_crossentropy",metrics=["accuracy"])
model.fit(x_train,steps_per_epoch=4 ,epochs=10,validation_data=x_test,validation_steps=4)
model.save("forest1.h5")
!tar -zcvf image-classification-model_new.tgz forest1.h5
ls -1
!pip install watson-machine-learning-client --upgrade
from ibm_watson_machine_learning import APIClient
wml_credentials = {
                "url": "https://us-south.ml.cloud.ibm.com",
                "apikey": "IEMEk7Pn1RJ8Cvhg7oONtaEKuarJVkkFZgO--3Oye9AL"
               }
client = APIClient(wml_credentials)
client = APIClient(wml_credentials)
def guid_from_space_name(client, space_name):
   space = client.spaces.get_details()
   #print(space)
   return(next(item for item in space['resources']if item['entity']["name"] ==
space_name)['metadata']['id'])
space_uid = guid_from_space_name(client, 'training')
print("Space UID = " + space_uid)
client.set.default_space(space_uid)
client.software_specifications.list()
software_spec_uid = client.software_specifications.get_uid_by_name("tensorflow_rt22.1-py3.9")
software_spec_uid
 model_details = client.repository.store_model(model= "image-classification-
model_new.tgz",meta_props={
 client.repository.ModelMetaNames.NAME:"CNN",
 client.repository.ModelMetaNames.TYPE:"tensorflow_2.7",
 client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_spec_uid}
                                       )
model_id = client.repository.get_model_id(model_details)
```

```
model_id
client.repository.download(model_id, 'my_model.tar.gz')
```