

EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRES

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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. Forest fires are also considered as a main contributor to the air pollution, due to the fact that during every fire huge amounts 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 were primarily 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-wing 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 k-coverage 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 Barmoutis, 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.

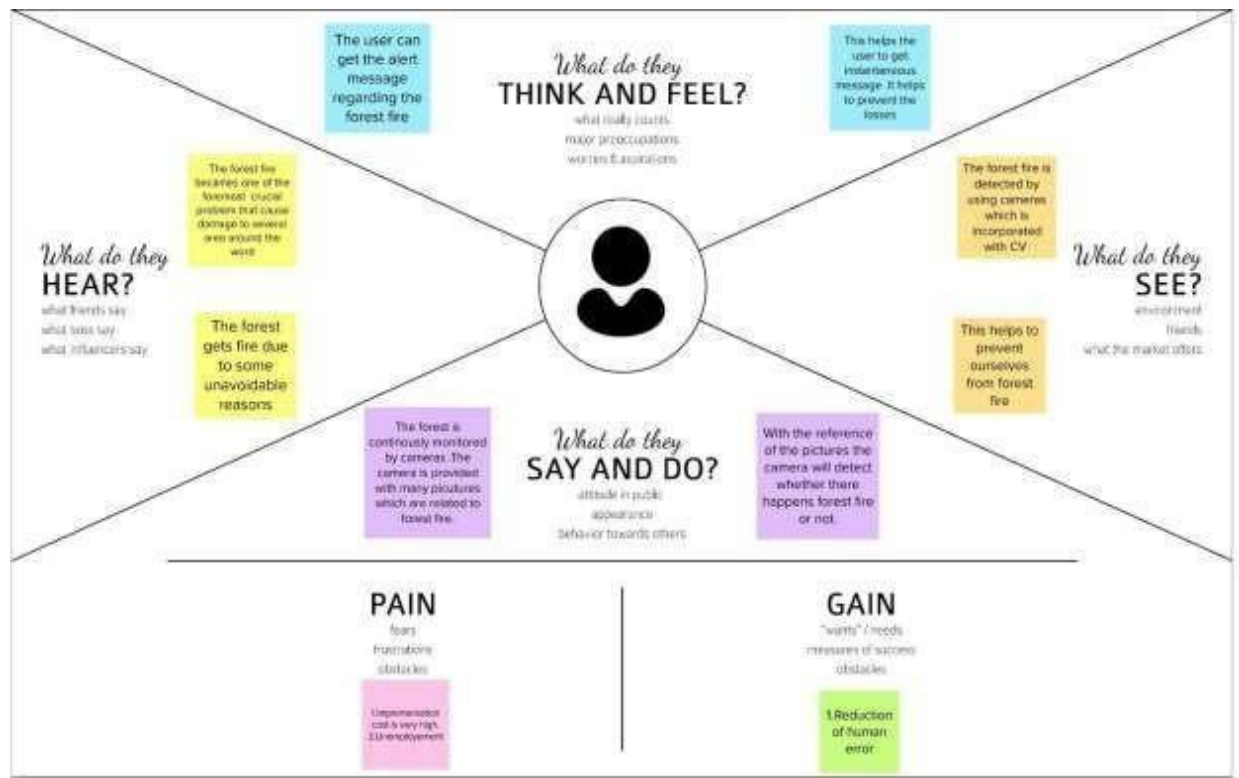
2.3 Problem Statement Definition:

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.

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 help 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:

Ideation

Template



Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

🕒 90 minutes to prepare
👥 1 hour to collaborate
👤 2-6 people recommended

[Share template feedback](#)

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

🕒 10 minutes

A Team gathering
Define who should participate in this session and send an invite. Share relevant information or pre-work ahead.

B Set the goal
Share about the problem you'll be focusing on during this brainstorming session.

C Learn how to use the facilitation tools
Use the Facilitation Superpowers to run a happy and productive session.

[Open article](#)

1 Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

🕒 5 minutes

🎯 **How might we detect the Forest Fire Early to prevent the loss of valuable timber resources?**

Key rules of brainstorming
To run an insightful and productive session:

- 🗣️ Stay on topic
- 💡 Encourage wild ideas
- 👂 Defer judgment
- 👤 Listen to others
- 📝 Get to volume
- 👁️ If possible, be visual

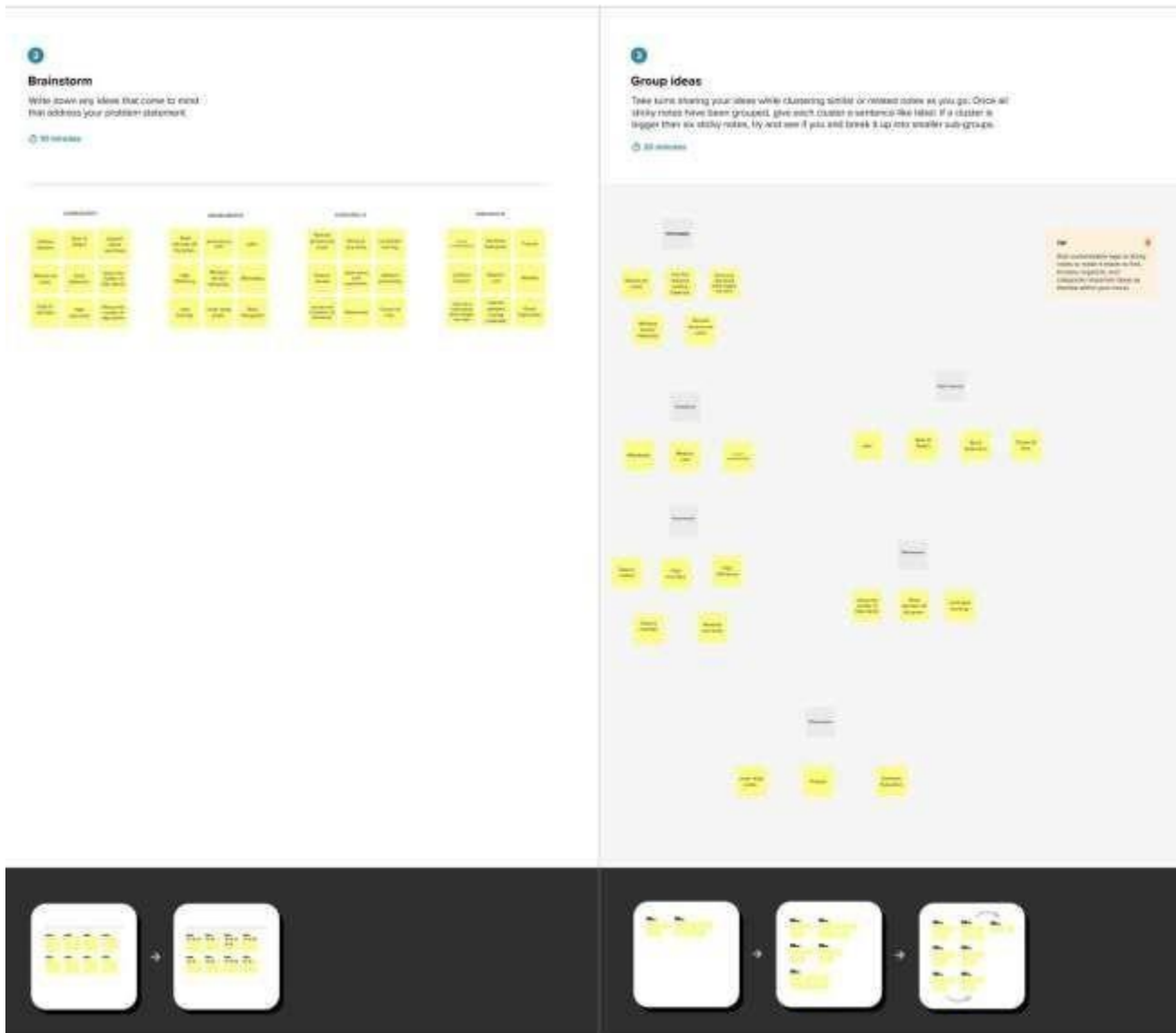


Need some inspiration?
See a limited number of this template in action your own.

[Open examples](#)

Brainstorming

GrouStep-2: Brainstorm, Idea Listing and Grouping



Step-3: Idea Prioritization

Prioritize

⌚ 10 minutes



After you collaborate

Quick action

- Keep moving forward

- **Share company feedback**

S/no	Parameter	Description
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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.
3	Novelty / Uniqueness	Real time computer program detect forestfire in earliest before it spread to larger area.
4	Impact on society	Blocked roads and railway lines, electricity, mobile and land telephone linescut, 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 landcover classification and smoke detection from satellite and ground cameras

3.4 Problem Solution fit:

<p>Define CS, fit into CC</p> <p>1. CUSTOMER SEGMENT(S) Who is your customer? i.e. working parents of 0-5 y.o. kids CS</p> <p>The forest resources which plays a vital role in sustaining lives on the earth, therefore to preserve them from unexpected outbreak of fire and smoke. The forest management team do need this device in fire prone areas.</p>	<p>4. CUSTOMER CONSTRAINTS CC</p> <p>What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.</p> <p>Climatic changes and the greenhouses gases are the reasons behind the destruction. Along with this the human factor to greedily use resources also play a vital reason for the forest fires.</p>	<p>5. AVAILABLE SOLUTIONS AS</p> <p>Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking.</p> <p>Existing systems uses optical sensors for detecting forest fires. As fire is detected the sensors sends signal to the office of forest management. Among with that satellites are used to detect IR rays spotted in forest lands.</p>
<p>Focus on J&P, fit into BE, understand RC</p> <p>2. JOBS-TO-BE-DONE / PROBLEMS J&P</p> <p>Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.</p> <p>The main problem that exists is weather and climate by releasing large number of carbon dioxide, carbon monoxide and fine particulate matter into the atmosphere.</p>	<p>9. PROBLEM ROOT CAUSE RC</p> <p>What is the real reason that this problem exists? What is the back story behind the need to do this job? i.e. customers have to do it because of the change in regulations.</p> <p>The reasons possible are: 1. Due to natural causes- Lightning 2. Man-made causes- Naked flame, cigarette, electric spark</p> <p>Thus, continuous care and monitoring is needed to preserve natural resources to save lives.</p>	<p>7. BEHAVIOUR BE</p> <p>What does your customer do to address the problem and get the job done? i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)</p> <p>When fire is detected the system which is implemented to monitor the forests sets the alarm to ring, that is it gives the signal through which fire management team and the forest committee tries to call off the fire. Thus, the aim is to recognize the fire as early as possible to prevent spread of fire which will cause further damage to control.</p>

<p>Identify strong TR & EM</p> <p>3. TRIGGERS TR</p> <p>What triggers customers to act? i.e. seeing their neighbor installing solar panels, reading about a more efficient solution in the news.</p> <p>The unconscious behavior towards burned cigarette left, chances of leaving the campfire remained burnt and electric supply being disrupted</p> <p>4. EMOTIONS: BEFORE / AFTER EM</p> <p>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure -> confident, in control - use it in your communication strategy & design.</p> <p>Wildfires can cause lot of stress since the factor that influence their direction and intensity are unpredictable and can change at anytime. People who have lived through wildfires can face dramatic mood swings, anxiety and mood-swings.</p>	<p>10. YOUR SOLUTION SL</p> <p>If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behavior.</p> <p>To minimize these losses, we have proposed a solution to detect early detection of forest fires by using CCTV camera surveillance, which can detect fire in indoor and outdoor activities. Thus instant alerts has to be sent to the forest management office so that they can take further actions to disrupt the damage caused by the fire.</p>	<p>8. CHANNELS of BEHAVIOUR CH</p> <p>8.1 ONLINE What kind of actions do customers take online? Extract online channels from #7.</p> <p>8.2 OFFLINE What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.</p> <p>Online Detection: Thus the chatbot or the API can connect through internet to feed you with the current status of the forest.</p> <p>Offline Detection: Thus, the forest management can send notice to the nearby residential areas or the media can bring the awareness through news, radio.</p> <p>Identify strong TR & EM</p>
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4. REQUIREMENT ANALYSIS

4.1 Functional requirement:

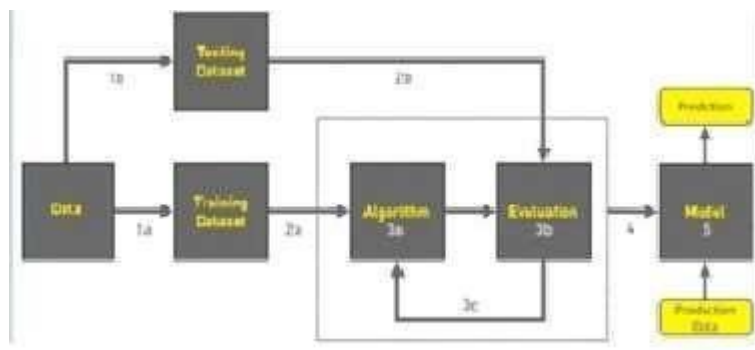
FR No.	Functional Requirement (Epic)	SubRequirement (Story / Sub-Task)
FR-1	User Registration	Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User Login	Login using credentials
FR-4	User Search	Search for Info on forest fire occurrence
FR-5	User Profile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

4.2 Non-Functional requirements:

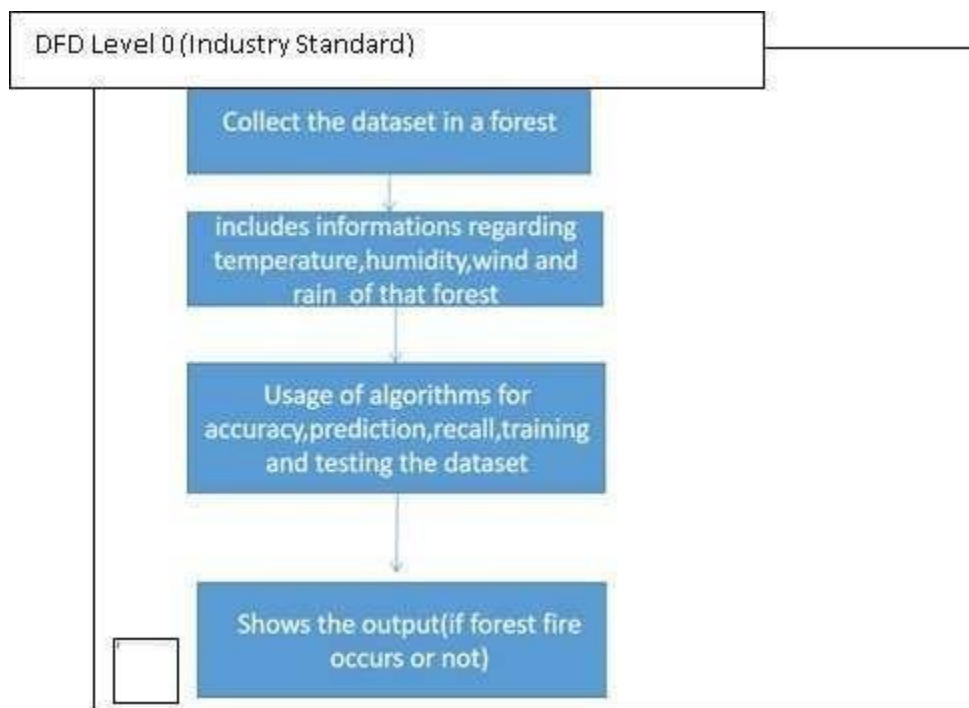
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	Alerts according to the user location
NFR-2	Security	Instant live feed with alert of the situation
NFR-3	Reliability	The prediction of the forest fire is 87% accurate
NFR-4	Performance	The feed and the alert message an immediate action without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

5. PROJECT DESIGN

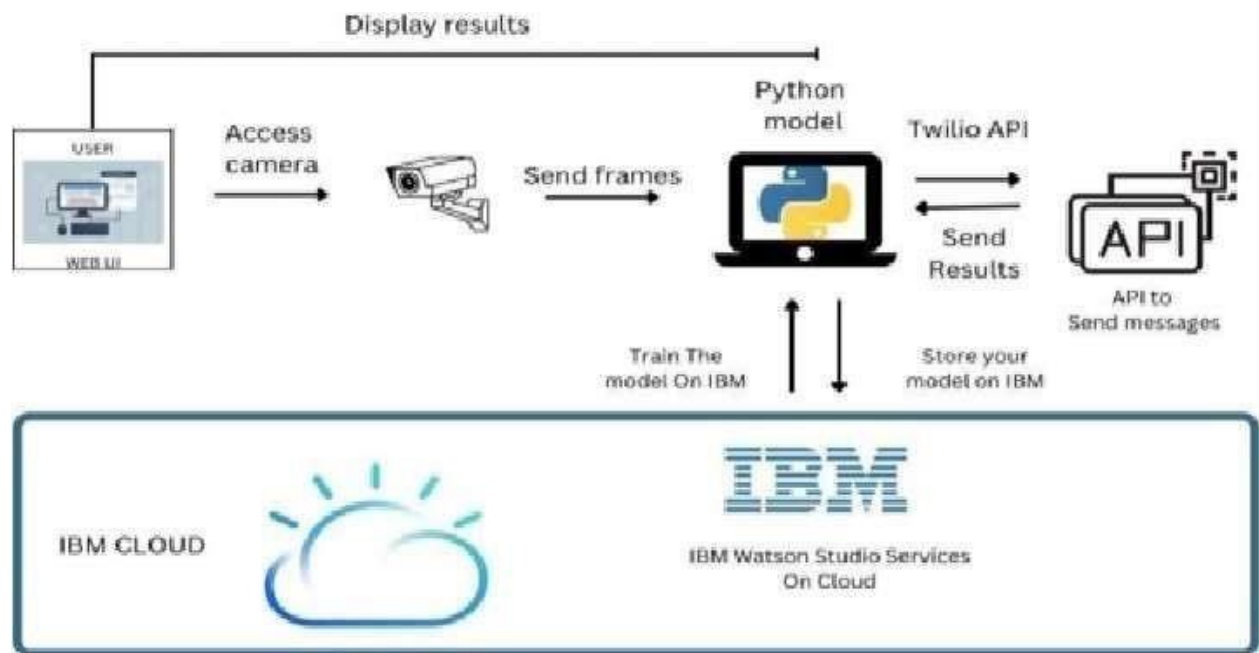
5.1 Data Flow Diagrams:



1. COLLECT DATA
2. EVALUATE DATA SET
3. IMPLEMENT ALGORITHMS
4. EVALUATE THE ACCURACYOF EACH ALGORITHMS
5. DISPLAY RESULTS



5.2 Solution & Technical Architecture:



5.3 User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story/ Task	Acceptance criteria	Priority	Release
Environmentalists	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 be come 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, precision ,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 precautionary 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-1	Data Collection	USN-1	Collect Dataset	20	High	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN
Sprint-1		USN-2	Image preprocessing	20	High	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN
Sprint-2	Model Building	USN-3	Import the required libraries, add the necessary layers and compile the mode	20	High	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN
Sprint-2		USN-4	Training the image classification model using CNN	20	High	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN
Sprint-3	Training and Testing	USN-5	Training the model and testing the model's performance	20	High	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN
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	PIREVEEN KUMAR PRABAKARAN CHANDRU KANNAN

6.2 Sprint Delivery Schedule:

Sprint	Total story points	Duration	Sprint StartDate	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date(Actual)

Sprint-1	20	6 Days	26 Oct 2022	31 Oct 2022	20	31 Oct 2022
Sprint-2	20	6 Days	02 Nov 2022	07 Nov 2022	20	07 Nov 2022
Sprint-3	20	6 Days	09 Nov 2022	14 Nov 2022	20	14 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

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

6.3 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.

```
▶ train_dataset=test.flow_from_directory("/content/drive/MyDrive/Dataset/Train set",  
                                         target_size=(128,128),  
                                         batch_size=32,  
                                         class_mode='binary' )
```

Found 95 images belonging to 2 classes.

```
[ ] test_dataset=test.flow_from_directory("/content/drive/MyDrive/Dataset/Test set",  
                                         target_size=(128,128),  
                                         batch_size=32,  
                                         class_mode='binary' )
```

Found 100 images belonging to 2 classes.

6.4 Feature 2:

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

```
[ ] model = load_model("/content/drive/MyDrive/forest.h5")
```

```
▶ def predictImage(filename):  
    img1 = image.load_img(filename,target_size=(128,128))  
    Y = image.img_to_array(img1)  
    X = np.expand_dims(Y,axis=0)  
    val = model.predict(X)  
    print(val)  
    if val == 1:  
        print(" fire")  
    elif val == 0:  
        print("no fire")
```

```
▶ predictImage("/content/drive/MyDrive/Dataset/Test set/with fire/with fire (1).jpg")
```

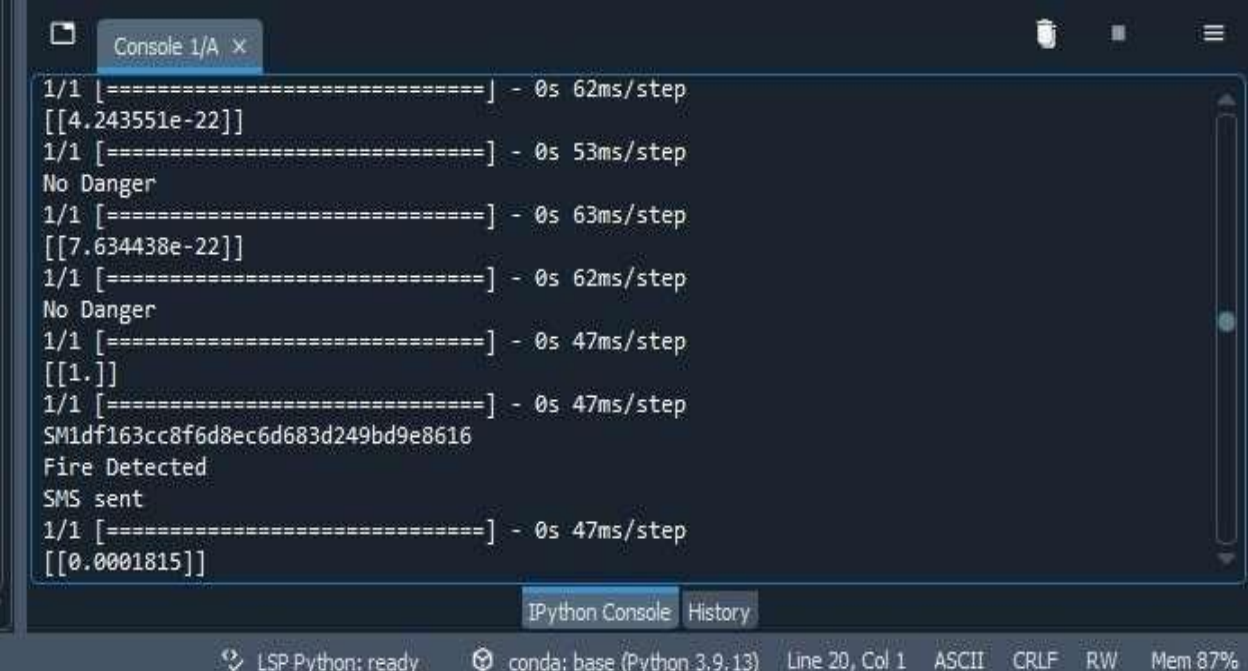
```
1/1 [=====] - 41s 41s/step  
[[1.]]  
fire
```

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

7. TESTING

7.1 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.



```
1/1 [=====] - 0s 62ms/step
[[4.243551e-22]]
1/1 [=====] - 0s 53ms/step
No Danger
1/1 [=====] - 0s 63ms/step
[[7.634438e-22]]
1/1 [=====] - 0s 62ms/step
No Danger
1/1 [=====] - 0s 47ms/step
[[1.]]
1/1 [=====] - 0s 47ms/step
SM1df163cc8f6d8ec6d683d249bd9e8616
Fire Detected
SMS sent
1/1 [=====] - 0s 47ms/step
[[0.0001815]]
```

IPython Console History

LSP Python: ready conda: base (Python 3.9.13) Line 20, Col 1 ASCII CRLF RW Mem 87%

7.2 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.

8. RESULTS

8.1 Performance Metrics:

Model evaluation

```
[ ] model = load_model("/content/drive/MyDrive/forest.h5")
```

```
▶ def predictImage(filename):  
    img1 = image.load_img(filename, target_size=(128,128))  
    Y = image.img_to_array(img1)  
    X = np.expand_dims(Y, axis=0)  
    val = model.predict(X)  
    print(val)  
    if val == 1:  
        print(" fire")  
    elif val == 0:  
        print("no fire")
```

```
▶ predictImage("/content/drive/MyDrive/Dataset/Test set/with fire/with fire (1).jpg")
```

```
1/1 [=====] - 41s 41s/step  
[[1.]]  
fire
```

9. 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.

10. CONCLUSION

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

11. 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.

12. APPENDIX

Source Code: Python code

```
import cv2
from playsound import playsound
from twilio.rest import Client

fire_cascade = cv2.CascadeClassifier('fire_detection.xml')

cap = cv2.VideoCapture(0)

while(True):
    ret, frame = cap.read()
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    fire = fire_cascade.detectMultiScale(frame, 1.2, 5)

    for (x,y,w,h) in fire:
        cv2.rectangle(frame,(x-20,y-20),(x+w+20,y+h+20),(255,0,0),2)
        roi_gray = gray[y:y+h, x:x+w]
        roi_color = frame[y:y+h, x:x+w]
        print("Fire is detected 🚒🚒")
        playsound('audio.mp3')

    account_sid = 'ACf232c8d290c2e56b760b27dcfe4a481e'
    auth_token = '329e940af6e7ee375f8fd4a2a94968bc'
    twilio_number = '+19803757860'
    target_keys = '+919962828967'
    client = Client(account_sid, auth_token)
    message = client.messages.create(
        body="yelaai pathikichuleyyy 🚒",
        from_=twilio_number,
        to=target_keys
    )
    print(message.body)
    exit()
```



```
cv2.imshow('frame', frame)
if cv2.waitKey(1) & 0xFF == ord('q'):
    break
```

GitHub Link:

<https://github.com/IBM-EPBL/IBM-Project-46091-1660737286>