PROJECT REPORT

TEAM ID: PNT2022TMID52907

PROBLEM STATEMENT: Emerging Methods For Early Detection Of Forest Fires

TEAM DETAILS:

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1. INTRODUCTION

1.1 Project Overview

Our project deals with early detection of forest fires. Here the aim is to detect the start of forest fires from videos obtained from drones. On obtaining the video real time detection of fire is enabled and an alert is sent to the forest officials informing them the exact location of the fire. An alarm is also switched ON in case fire is detected to alert people present in and around the forests. The problem statement is a 2 class classification problem and is implemented using Convolutional Neural Networks (CNN). The dataset consists of labeled data (fire and no fire).

1.2 Purpose

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.

2. LITERATURE SURVEY

2.1 Existing problem

There are three methods of fire detection possible: Sensor based Fire Detection, Feature based fire detection and deep CNN based fire detection. [1] Currently, forest fire detection system

is present but early detection has not been facilitated yet. Also in the existing systems, wireless sensor networks or stationary cameras placed at specific spots are used for detecting fire. In [2] CCTV cameras and weather data are used. These methods prove inefficient because sensor performance is affected by climatic conditions, they are also inefficient. Stationary cameras can also be damaged easily. Vision sensor-based fire detection methods can be broadly divided into traditional machine learning (TML)- and deep learning (DL).[3] TML-based fire detection methods focus on the motion, shape, texture, and color features of an input frame for fire detection . These methods are highly dependent on the quality of the handcrafted features. However, in these methods, the process of selecting optimal features is very challenging, i.e. different materials may have different fire colors, the effects of light on the fire vary, and the fire shape is not constant due to the flow of air. Therefore, maintaining a good balance among the accuracy, loss, and false-positive rate metrics is an unresolved challenge for these methods. DL is a well-known data-driven end-to-end learning technique that has been extensively used for fire detection; it provides a better detection accuracy and significantly reduced false alarm rates compared to TML-based methods.

Very recent developments in forest fire detection include the usage of drones and unmanned aerial vehicles (UAV). Also,the onboard CPU is able to make a 3D model of the forest region and transmits the data in real time to the ground station. Fire detection at night is also being enabled because of the usage of IR Cameras. In [4] CNN model is used for real time video fire smoke detection. In [5], a synthetic method to enlarge the imagery dataset is used. And a new framework for automated dead tree detection from aerial images using a re-trained Mask RCNN (Mask Region-based Convolutional Neural Network) approach, with a transfer learning scheme is also used. Drones are also being used to monitor fire in the forest. Such systems provide a broader and more accurate perception of the fire, even in regions that are inaccessible or considered too dangerous for fire-fighting crews. Even though the recent developments are good, there are some disadvantages. There is no practical detection. Necessity of Early Detection is not met. Models are sensitive to the forest with dense fogs and clouds. In the case of UAVs , they are affected by weather conditions and in many conditions their flight time is limited.

2.2 References

[1]J. Zhang, H. Zhu, P. Wang and X. Ling, "ATT Squeeze U-Net: A Lightweight Network for Forest Fire Detection and Recognition," in IEEE Access, vol. 9, pp. 10858-10870, 2021, doi: 10.1109/ACCESS.2021.3050628.

[2]D. Q. Tran, M. Park, Y. Jeon, J. Bak and S. Park, "Forest-Fire Response System Using Deep-Learning-Based Approaches With CCTV Images and Weather Data," in IEEE Access, vol. 10, pp. 66061-66071, 2022, doi: 10.1109/ACCESS.2022.3184707.

[3]H. Yar, T. Hussain, M. Agarwal, Z. A. Khan, S. K. Gupta and S. W. Baik, "Optimized Dual Fire Attention Network and Medium-Scale Fire Classification Benchmark," in IEEE Transactions on Image Processing, vol. 31, pp. 6331-6343, 2022, doi: 10.1109/TIP.2022.3207006.

[4]J. S. Almeida, C. Huang, F. G. Nogueira, S. Bhatia and V. H. C. de Albuquerque, "EdgeFireSmoke: A Novel Lightweight CNN Model for Real-Time Video Fire–Smoke Detection," in IEEE Transactions on Industrial Informatics, vol. 18, no. 11, pp. 7889-7898, Nov. 2022, doi: 10.1109/TII.2021.3138752.

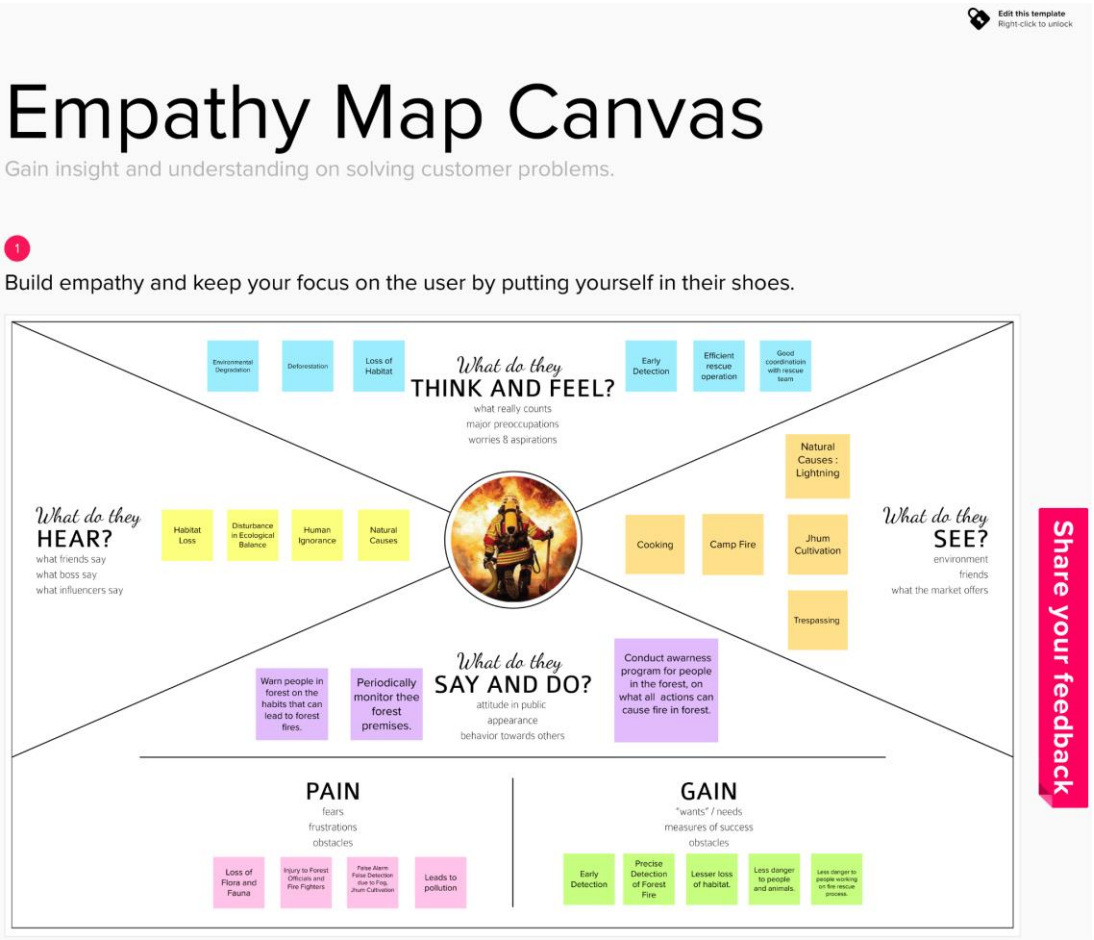
[5]C. -Y. Chiang, C. Barnes, P. Angelov and R. Jiang, "Deep Learning-Based Automated Forest Health Diagnosis From Aerial Images," in IEEE Access, vol. 8, pp. 144064-144076, 2020, doi: 10.1109/ACCESS.2020.3012417.

2.3 Problem Statement Definition

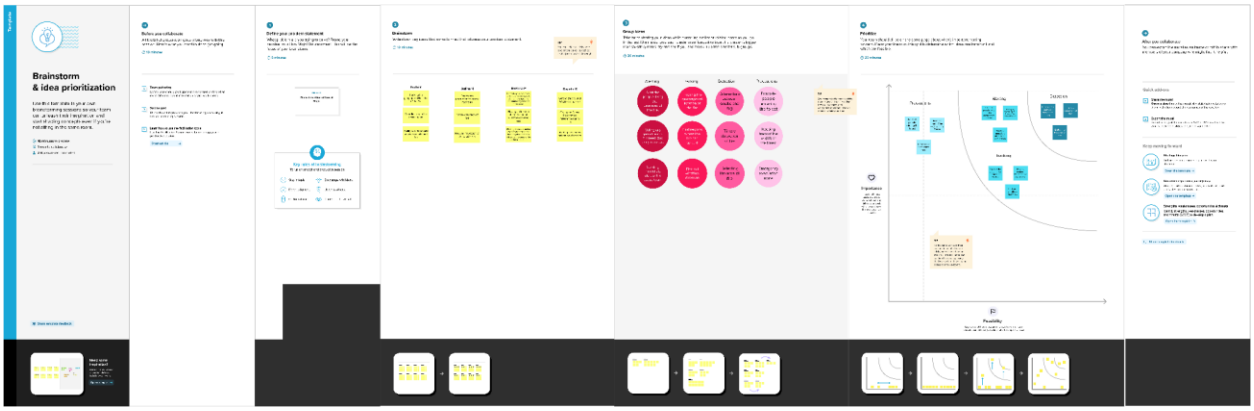
Forest fire is a natural disaster, which causes deforestation and loss of habitat for flora, fauna and people living around. So, Early Detection of Forest fire will prove advantageous not only for the flora and fauna in the forest, but also for the people, government and firefighters. Alerting the officials and people in and around the forest is also as important as detection. So, the aim is to alert the officials by sending messages. To alert the people in and around the forest alarm sound is also incorporated.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming

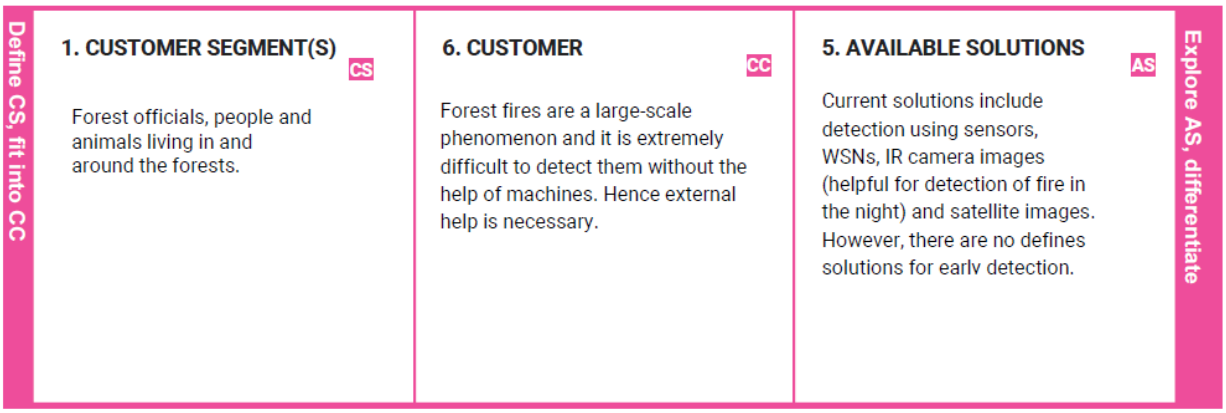


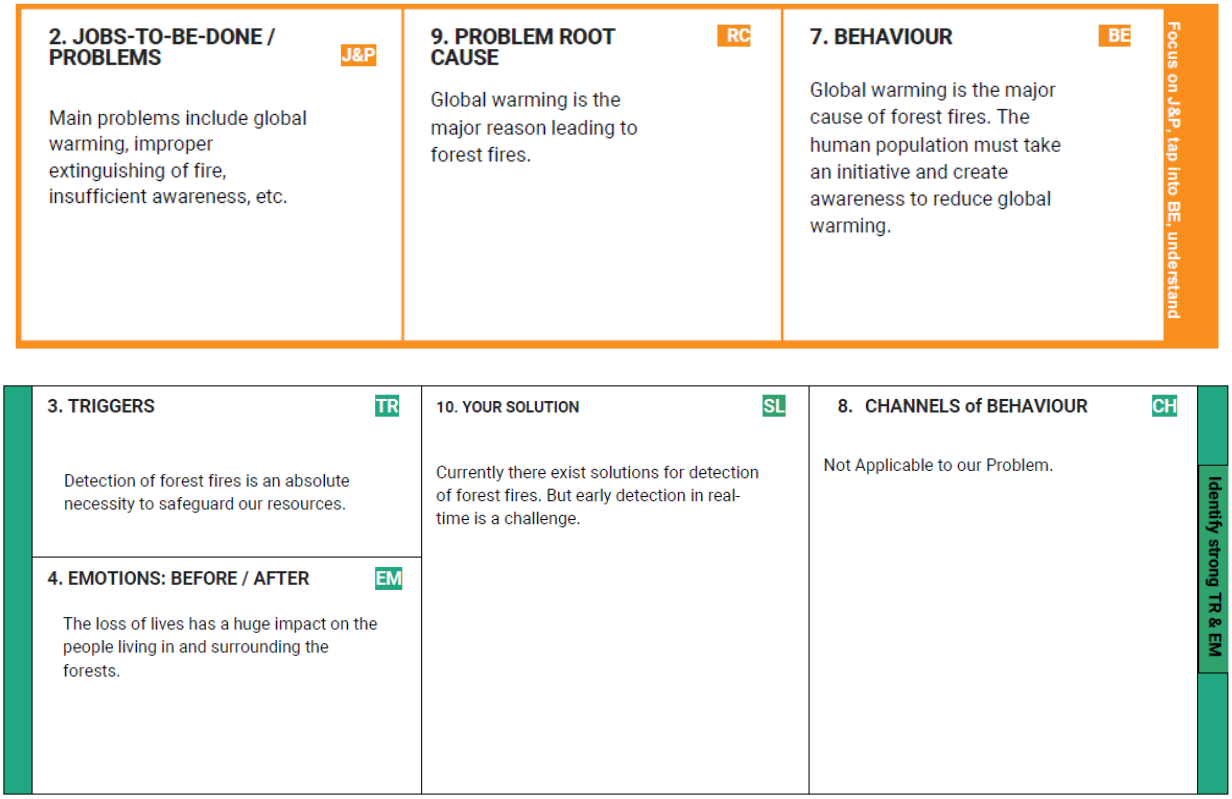
3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Detection of smoke/fire which may lead to forest fires and eventually destroy forest and wildlife.
2.	Idea / Solution description	The solution consists of Analysis of frames from the video clip captured by the camera using an Algorithm. Our Solution aims to solve the problem efficiently and leaving no chances for the mishap to occur.
3.	Novelty / Uniqueness	Differentiating clouds, fog and smoke
4.	Social Impact / Customer Satisfaction	Early Detection of forest fire can prevent degradation of large forest areas. Through early detection and alerting, lives of people and animals living around the area can be saved. It also proves to be less harmful for the forest officers.

5.	Business Model (Revenue Model)	Forest fires lead to loss of animal and plant life. Forests are a huge source of resources and minerals which are essential for our daily life. Hence, loss of forests impacts us economically. Hence early detection is essential as prevention is better than cure. Therefore, implementing this will be a huge benefit for our economy.
6.	Scalability of the Solution	Here the usage of cameras makes the solution scalable. In case of sensors appropriate placement of sensors is necessary and they should be effective even at high temperatures. Presence of animals in the forest is also an important consideration to be taken for the placement of sensors. Whereas, detection using images and videos is better. Image or video capture can be done using drones mounted with cameras which are not affected by temperatures nor forest inhabitants. Satellites can be an important source of data prior to and also during the Fire due to its reliability and efficiency. Hence usage of satellites and capturing images using drones is feasible compared to sensors and can be implemented on a wide scale.

3.4 Problem Solution fit





4. REQUIREMENT ANALYSIS

4.1 Functional requirements

FR No.	Functional Requirement	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	• Registration Form • Registration with Gmail • Registration through Linkedin
FR-2	User Confirmation	• Confirmation via Email • Confirmation via OTP
FR-3	User Login	• Login with the given credentials
FR-4	User Profile	• Profile with emergency contacts and live activities in the forest

FR-5	User Application	• Application to intimate and alert the forest officer and rescue team

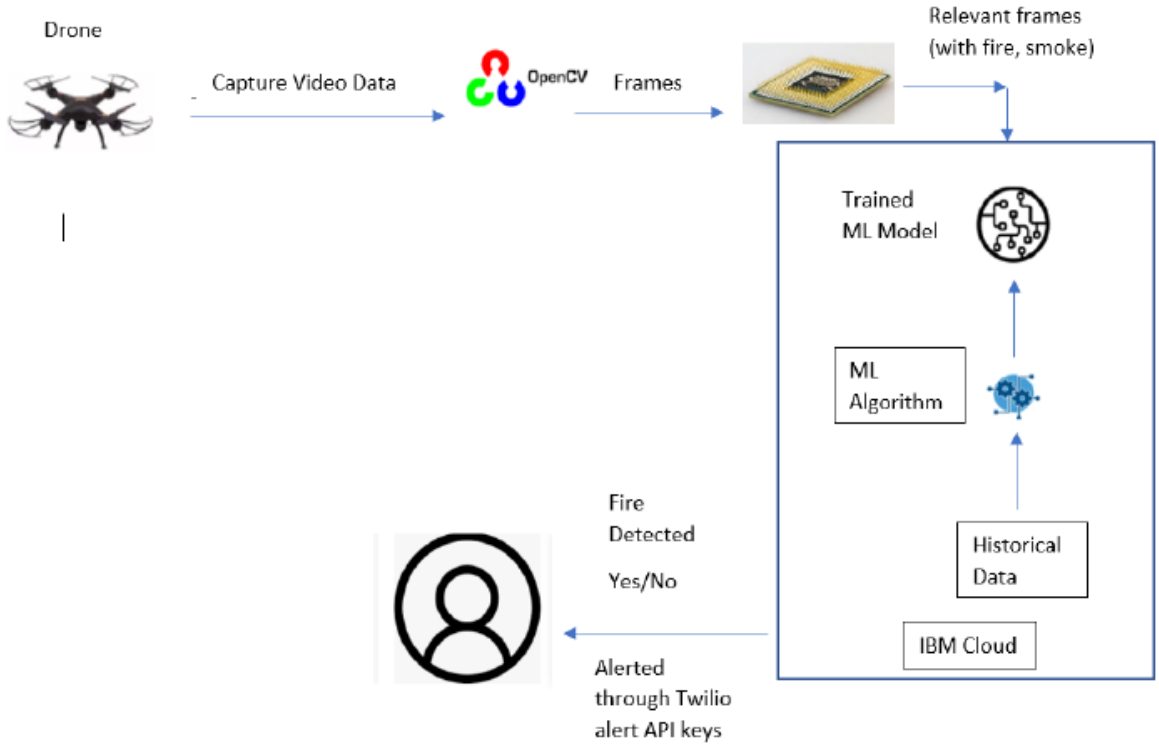
4.2 Non-Functional requirements

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Alerts to prevent massive damage
NFR-2	**Security**	Live monitoring of forests from trespassers
NFR-3	**Reliability**	Detection will be accurate even in snowy regions
NFR-4	**Performance**	The project will enable an alert system for early detection
NFR-5	**Availability**	Available to forest officials, Rescue team and government organizations
NFR-6	**Scalability**	Will be able to scale for larger range of inhabited forests

5. PROJECT DESIGN

5.1 Data Flow Diagrams

DATA FLOW DIAGRAM:



5.2 Solution & Technical Architecture

Solution architecture describes the method for early forest fire detection using drones and Machine learning algorithm.

- Early detection and high accuracy of the localization of forest fire are necessary for a rapid intervention of firefighting personnel at the correct place. Fires can differ in size and shape and the differentiation between smoke and fog is important. These constraints can influence the possibility to detect fire. Therefore, it is necessary to find the optimum size of target area coverage.

- The drone captures video and then the video is converted to frames using open CV. The image consists of a number of pixels, where the processing unit tracks the motion in images and checks how many pixels contain smoke or fire glow and then the processing unit sends the results for another algorithm to decide whether or not to produce an alarm for the operator.

- The fire detection can be categorized into two phases, offline and online shown The offline process produces predefined patterns (the model) from the forest

environment for the two cases that fire is present or not, using classification technique and learning from historical data. The model obtained from learning needs to be known before the detection. The second phase (online process) consists in finding the correspondence between the predefined model from previous processes and image prediction instances. This process provides a fast detection and reduces the response time. The output from this process is a possibility to detect fire or not.

- Once the fire is detected , alarm is sent to the forest officials using Twilio alert API Keys.

5.3 User Stories

User Type	Functional Requirement	User Story	User Story / Task	Acceptance criteria	Priority
People living in and around the forests and Tribals	Alerts	USN-1	As a user, they require immediate alerts in case of forest fires so that they can leave the place immediately	Proper and timely alerts are essential	High
	Assistance	USN-1	As a user, external assistance is required so that their safety is ensured.	Timely assistance is needed so that evacuation can be done.	High
	Early Detection	USN-1	As an user Early Detection, will ensure safety relocation.	Along with the detection they should get alerted. They should also get assistance.	high
Hikers/Tourists	Alerts	USN-1	As a user, they should get alerted when there is likely a fire.	I can register & access the dashboard with Facebook Login	Low

	Assistance	USN-1	As a user, external assistance is required so that their safety is ensured.	Timely assistance is needed so that evacuation can be done.	High
Environmentalists	Means for data collection	USN-1	As a user, they can use this data for analyzing purposes.	Access to data is needed, so that proper use can be made out of it.	Low
Forest Officials	Early Detection	USN-1	As a user they can get the forest area under suspicion covered up and prevent more spread, as forest fires tend to spread more faster.	They should get the detected area and alert.	High
	Getting the Geographical Area	USN-1	As a user they should get the exact location of fire.	They should get the exact geographical area for them to reach there and prevent fire spread.	High

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

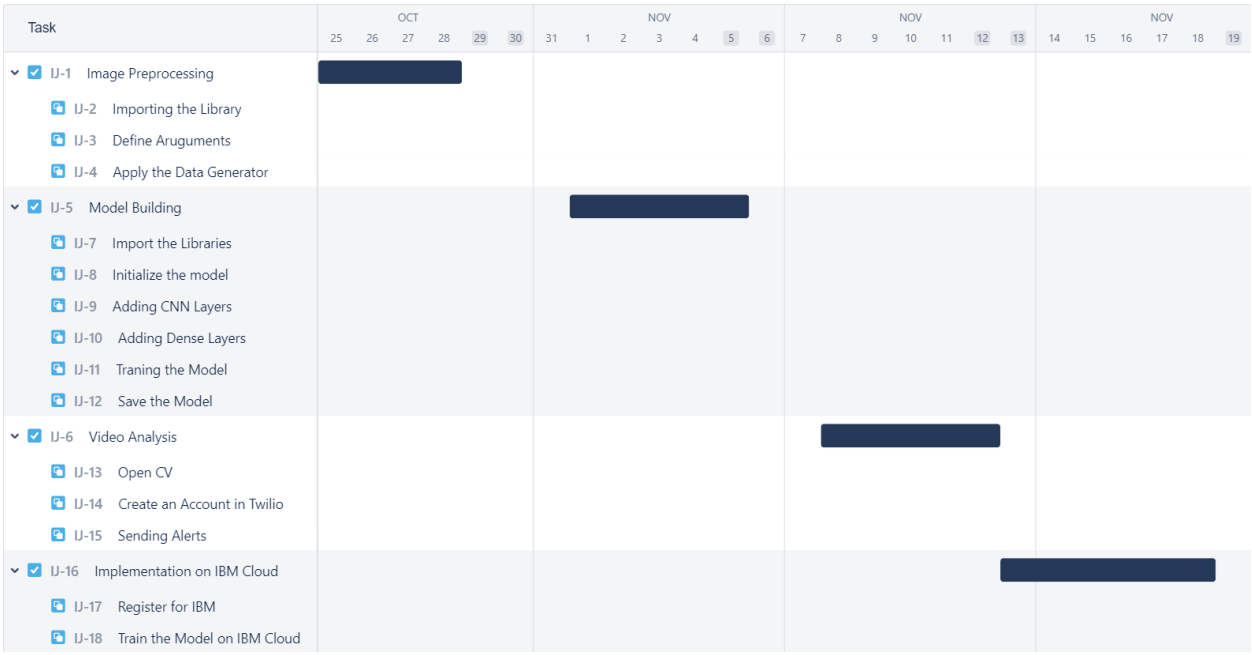
Sprint	Total Story Points	Duration	Sprint Start Days	Sprint End Date	Story points completed	Sprint Release Date
Sprint-1	20	6 Days	25 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	01 Nov 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	08 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	15 Nov 2022	19 Nov 2022	20	19 Nov 2022

6.2 Sprint Delivery Schedule

Sprint	Functional Requirement	User Story	User Story / Task	Story Points	Priority
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	20	Medium
		USN-2	As a user, I will receive confirmation email once I have registered for the application usage.	20	Medium
Sprint-2	Input	USN-3	Whenever the fire is detected, the information is given to the database.	20	High
		USN-4	When it is the wildfire then the alarming system is activated.	20	Medium
Sprint-3	Output	USN-5	And the alarm also sent to the corresponding departments and	20	High

			made them know that the wildfire is erupted.		
Sprint-4	Action	USN-6	Required actions will be taken in order to control erupted wildfire by reaching as early as possible to the destination with the help of detecting systems.	20	High

6.3 Reports from JIRA



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

7.1 Feature 1

Immediate detection of forest fire.

```
predictImage("/content/drive/MyDrive/IBM/Dataset/Dataset/test_set/with fire/19464620_401.jpg")
```

```
1/1 [==============================] - 0s 423ms/step
[[1.]]
 Fire Detected
```

```
predictImage("/content/drive/MyDrive/IBM/Dataset/Dataset/test_set/forest/_101542074_gettyimages_956391468.jpg")
```

```
1/1 [==============================] - 0s 38ms/step
[[0.]]
No Fire Detected
```

7.2 Feature 2

Our code includes activating an alarm system in the forest on the onset of fire to alert people in and around the forest. This alarm is switched ON when the alert is sent to the forest officials so as to enable the people and animals in the forest to evacuate as soon as possible.

```
pred = model.predict(x)
if pred[0]==1:
  account_sid = 'AC12ef9f733c3649941ba805aee56562a1'
  auth_token = 'fa1181691095d6353e4a349f489d6e91'
  client = Client(account_sid, auth_token)

  message = client.messages \
      .create(
          body='Forest fire is detected , stay alert',
          from_='+13467038066',
          to='+919150447026'
      )
  print(message.sid)
  print("SMS Sent!!!")
else:
  print("No Danger")
```

7.3 Database Schema (if Applicable)

The dataset contains train and test data.

- **Train Data:** There are 436 images belonging to 2 classes
- **Test Data:** 121 images belonging to 2 classes in the testing dataset.

8. TESTING

8.1 Test Cases

Sample result images illustrated in the Figure contains forest images with and without fire captured from a close distance. The prediction of images with fire is assigned as 1 and the ones without fire are assigned as 0.

```
test_dataset.class_indices
```

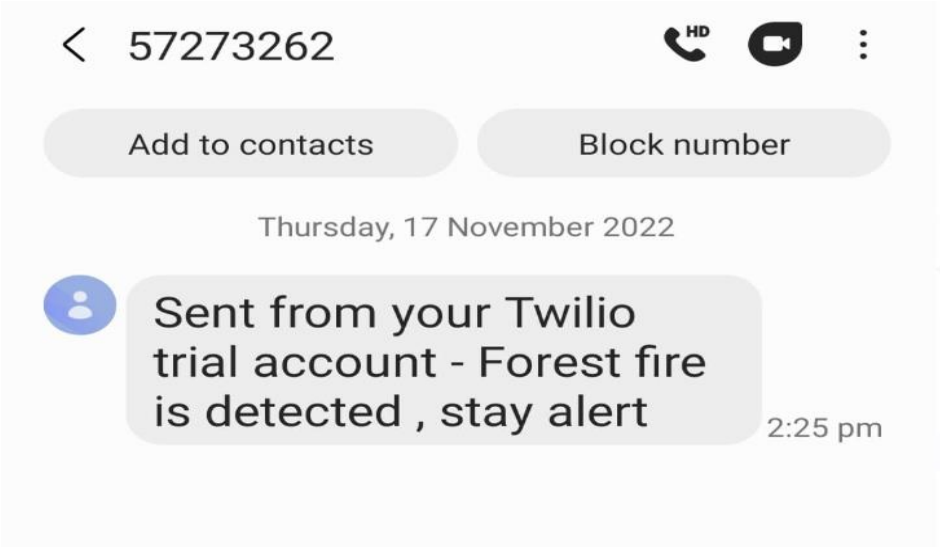
```
{'forest': 0, 'with fire': 1}
```

```
1/1 [==============================] - 0s 423ms/step
[[1.]]
 Fire Detected
```

```
1/1 [==============================] - 0s 38ms/step
[[0.]]
No Fire Detected
```

8.2 User Acceptance Testing

When the fire is detected an alert message is sent to the forest officials ,fire fighting and rescue service departments. This is done by integrating the CNN model with Twilio to send alert messages. This Figure shows the alert message received after detecting the forest fire.



9. RESULTS

9.1 Performance Metrics

Criteria	Accuracy
Validation	93.8%
Testing	92.8%

10. ADVANTAGES & DISADVANTAGES

The advantages of real time video based fire detection techniques are:

- Video processing and image classification gives the response to fires.
- The captured video can be analyzed and it can be used for future purposes and storage.

- The alert system is used to send alerts to the forest officials and a localized alarm system is set for alerting the people living nearby the forest area.
- The location of the forest fire can be found out using the IP address of the drones used to capture the video.

The disadvantages are:

- Drone operation comes with local regulatory restrictions concerning privacy, public safety, avoiding collisions, security, etc.
- Signal delay during the transmission of video and unreliability of detection in case of cloud cover.
- Drones may not be able to detect all fires because some are too small to detect from the air.
- Does not enable fire detection at night.

11. CONCLUSION

Fires threaten forests which results in enormous material and environmental damage. Protection of forests against fire is based on a variety of preventive measures and measures for fighting against forest fires, in order to minimize the total damage. In addition to other preventive measures, early detection and fire extinguishing in the initial stage are important in the protection of forests against biotic and abiotic factors. The existing surveillance of forest areas is unreliable and inefficient; therefore, forest fires are a serious threat to the development of forestry. Thus, we have developed an efficient early forest fire detection system by training using CNN. An alarm system is also deployed to alert the people in and around the forest. This will prove helpful for the government, flora, fauna, people living in forests and the firefighters.

12. FUTURE SCOPE

Further this system can be developed to detect fire in any type of forest. In addition to image data, weather and wind direction data can also be used to build a more efficient system, and give a holistic prediction. Steps can also be taken to make the system efficient in such a way that it can differentiate between fire and fog. An extended alarm network can be developed, alarming the areas where there is a possibility of spread of fire in a short time.

13. APPENDIX

Source Code

GitHub & Project Demo Link