

# EMERGING METHOD FOR EARLY DETECTION OF FOREST FIRE

## PROJECT REPORT

### 1.1 INTRODUCTION:

Impact of environment is based by five elements those are land, water, air, sky and fire. Natural disasters are caused by all of these. Earthquake through land and, Tsunami through water, Cyclone through wind, heavy rains are caused by sky and forest destruction is caused by fire. It is up to us as humans to correct the destruction caused by nature. Detection and prevention is more important than thinking about fixing after the event. So, e, we have come together as an engineering team to propose and develop a prototype solution to these issues using our acquired technical knowledge as computer science engineering students for our senior design project this semester. Our project idea entitled, "Forrest Fire Detection System," will be comprised of multiple systems working in tandem: In summary, we aim to reduce the social, economical, and environmental impacts brought on by forest fires.

#### 1.1 Project Overview:

The importance of forest environment in the perspective of the biodiversity as well as from the economic resources which forests enclose is more than evident. Any threat posed to this critical component of the environment should be identified and attacked through the use of the most efficient available technological means. Early warning and immediate response to a fire event are critical in avoiding great environmental damages. Fire risk assessment, reliable detection and localization of fire as well as motion planning, constitute the most vital ingredients of a fire protection system. Through our prior knowledge Supervised and unsupervised learning, Regression Classification and Clustering Artificial Neural Networks and Convolution Neural Networks our team has an overall idea about Emerging Methods for Early Detection of Forest Fires. The first task is to collect the data because in Convolution Neural Networks, as it deals with images, we need training and testing data sets. After that we pre-process the image and train our deep-learning model. The next step is video analysis to get the prediction for the input frames then we train our Image classification Models on IBM Cloud using IBM Watson Studio Service.

#### 1.2 Purpose:

- Image Processing:  
Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, such as a photograph or video frame the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two dimensional signal and applying standard signal processing techniques to it.
- Model building:  
This stage is dedicated to training the agent to generate an accurate and flexible model. The same dataset is divided into two parts. One is used for training purpose whereas the

other is used for validation of the model. It uses a Decision tree based approach for the classification purpose.

- Video analysis:

Most important part is video analysis; in this stage we use all the Cnn and Ann models to capture and analysis the fire.

- Final deliverable:

Deployment is involved in this final deliverable, we can predict in this stage.

These all processes are to achieve our purpose

## **2. Literature Survey:**

### **2.1 Existing Problem:**

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.

### **2.2 References:**

- [1]. Chi Yuan, Zhixiang and Youmin Zhang, "UAV-based forest fire detection and tracking using image processing Techniques," Proc. of IEEE International in Image Processing, pp. 978-1-4799-6009- 5/15, 2015.
- [2]. T. Chen, P. Wu and Y. Chiou, "An early fire detection method based on image processing," Proc. of IEEE International in Image Processing, pp. 1707-1710, 2004.
- [3]. B. U. Toreyin, Y. Dedeoglu and A. E. Cetin, "Flame detection in video using hidden markov Models," Proc. of IEEE international conference on Image Processing, pp. 1230-1233, 2005.
- [4]. B. U. Toreyin, Y. Dedeoglu, U. Gudukbay and A. E. Cetin "Computer Vision based method for real time fire and flame detection", Pattern Recognition Lett.27(1) pp. 49-58, 2006.
- [5]. T. Celik, H. Demirel, and H. Ozkaramanli "Automatic fire detection in video sequences", Proc. of European signal processing Conference (EUSIPCO 2006). Florence, Italy, September 2006.
- [6]. W. Krull, I. Williams, R. R. Zakrzewski, M. Sadok, J. Shirer and B. Zeliff, "Design and test methods for video based cargo fire verification system for commercial aircraft", Fire Saf. J. 24(4), pp.290-300,

2006.

[7]. G. Marbach, T. Brupbacher, "An Image processing technique for fire detection in video", Fire saf. J. 41(4) pp. 285-289, 2006.

[8]. Wen-Bing Homg, Jim-wen Peng and ChinYuan Chen, "A new image based real time flame detection method using colour analysis", Proc. of IEEE Network sensing and Control, ICNSC, pp. 100-105, 2005.

[9]. Turgay and Hasan Demirel, "Fire detection in video sequences using a generic colour model" Fire Saf. J. 44, pp. 147-158, 2009.

[10]. V. Vipin, "Image Processing Based Forest Fire Detection", IJETAE, Vol. 2, Issue 2, Feb. 2012.

[11]. Signal detection theory and Psychophysics, Wiley Newyork, 1966.

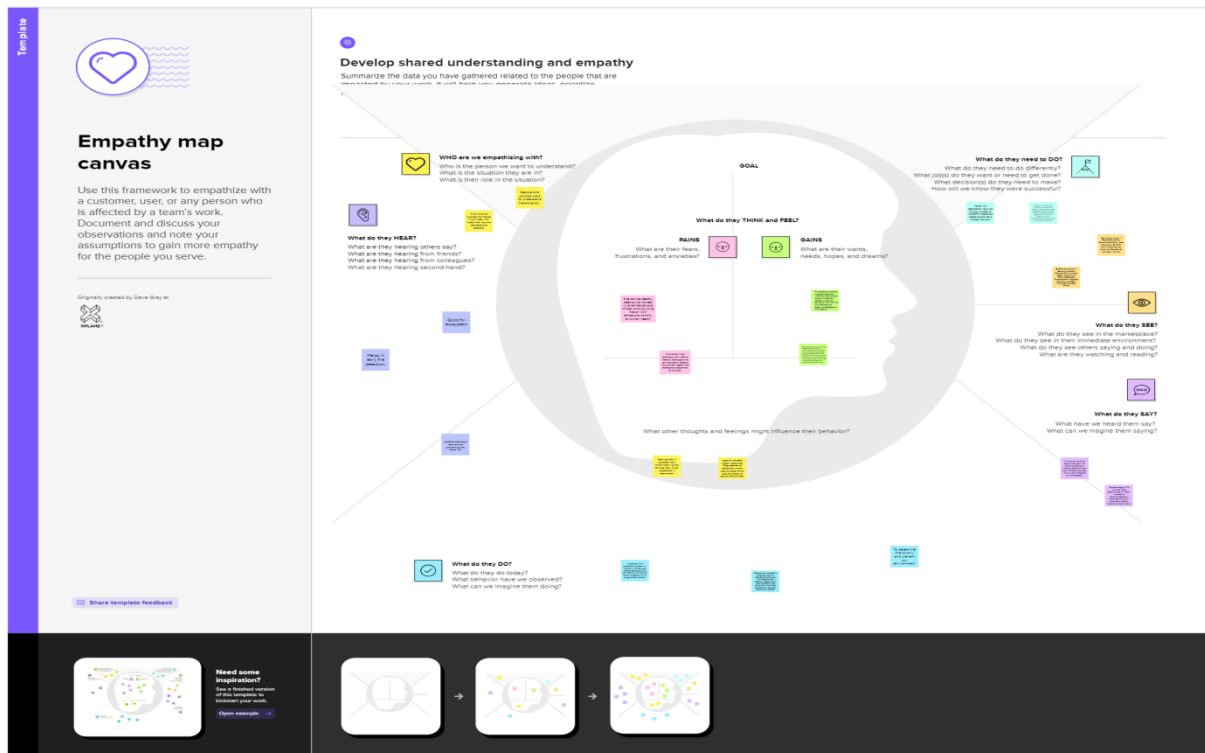
[12]. Wild fire Operations research Group Retrieved August 11, 2006.

### 2.3 Problem statement definition:

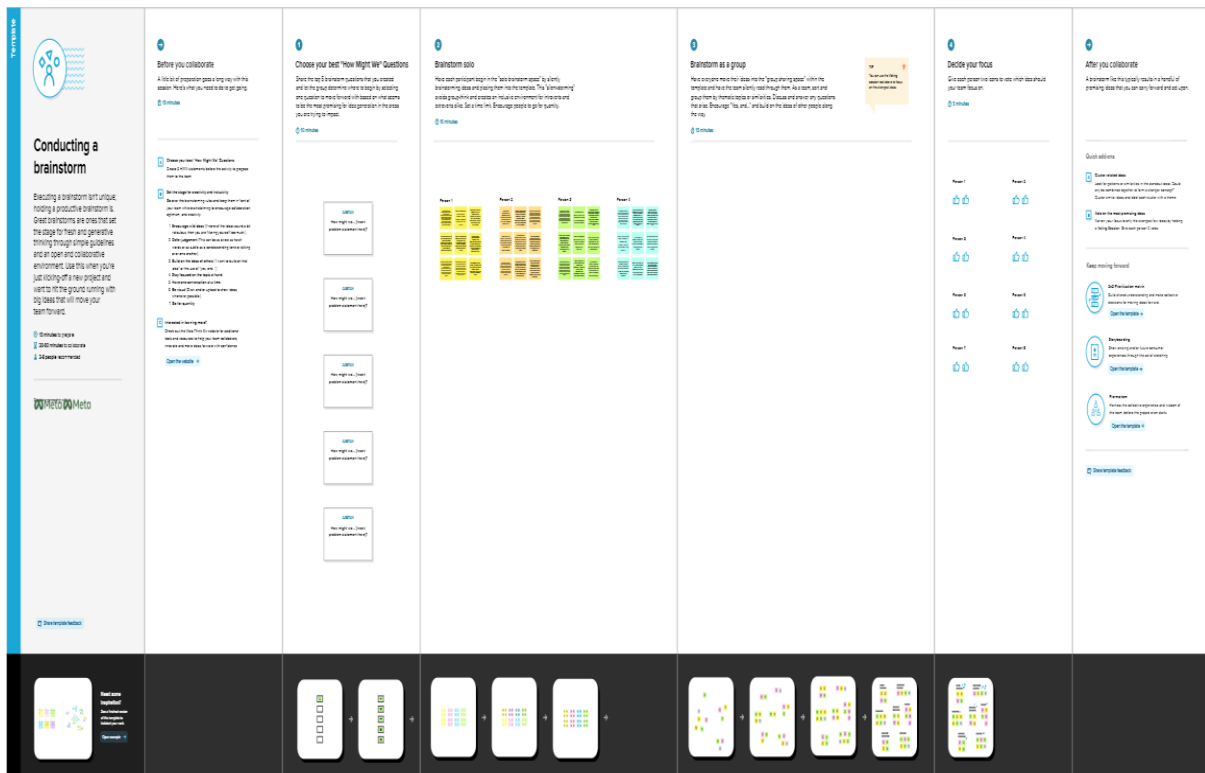
- Image processing
  - ✓ import The ImageDataGeneratorLibrary.
  - ✓ defining the parameters.
  - ✓ imagepreprocessing.
- Model building
  - ✓ Adding CNN Layer
  - ✓ Adding Dense Layers
  - ✓ Configuring the Learning Process
  - ✓ import\_Model\_Building\_Libraries
  - ✓ Initializing the model
  - ✓ Save the model
  - ✓ Training the model
  - ✓ predictions.
- Video analysis
  - ✓ Twillo\_service\_creation
  - ✓ OpenCV\_for\_videoProcessing
  - ✓ Sending\_Alert\_Message.
- Final deliverable
  - ✓ TRAIN\_CNN\_ON\_IBM\_CLOUD
  - ✓ IBM cloud Account

### 3. IDEATION AND PROPOSED SOLUTION:

## 3.1 Empathy map canvas:



## 3.2. Ideation & Brainstorming:



### 3.3 Proposed solution:

#### Project Design Phase-I Proposed Solution Template

Date	10 Nov 2022
Team ID	PNT2022TMID11893
Project Name	Emerging Methods for Early Detection Of Forest Fires
Maximum Marks	2 Marks

#### Proposed Solution Template:

Project team shall fill the following information in proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	<p><b>Statement:</b> To find emerging methods for early detection of forest fires using artificial intelligence.</p> <p><b>Description:</b> This technology is to be implemented to locate a forest or a bush fire based on the concept of deep learning and YOLO algorithm. After detecting, authorities are to be alerted immediately to mitigate any damage.</p>
2.	Idea / Solution description	<ol style="list-style-type: none"><li>1. In case of forest fire detection the burning substances are primarily identified as sceptical flame regions using a division strategy to expel the non-fire structures and results are verified by a deep learning model.</li><li>2. The technology used to locate a forest or a bush fire is based on the concept of deep learning and YOLO algorithm. This deep learning model is deployed on a UAV which help in detection of fire, meanwhile it can be monitored by web application in order to prevent it at advance.</li></ol>
3.	Novelty / Uniqueness	<ol style="list-style-type: none"><li>1. Accurate and reliable recognition of sceptical flame regions by means of using YOLO v3 algorithm.</li><li>2. Unlike previous algorithms, the exact location of the origin of the forest fire is also detected and sent to the web-app.</li></ol>
4.	Social Impact / Customer Satisfaction	<ol style="list-style-type: none"><li>1. Because of earlier prediction, loses of life, destruction of various environmental, geographical and essential resources can be avoided.</li><li>2. By detecting a fire quickly and accurately, this system can limit the emission of toxic products created by combustion, as well as global-warming gases produced by the fire itself.</li></ol>
5.	Business Model (Revenue Model)	<ol style="list-style-type: none"><li>1. The software platform to provide the fully autonomous processing of data received from the camera of UAV to obtain live feed in web-App.</li><li>2. This can also be implemented as a mobile application where the services can be accessed on subscription basis.</li></ol>

		combustion, as well as global-warming gases produced by the fire itself.
4.	Social Impact / Customer Satisfaction	Early detection of forest fire can minimize the costs of fire extinguishing and the damage caused in the woods.
5.	Business Model (Revenue Model)	1. To produce and commercialize bio foams at a national level, decreasing the cost of companies for purchases abroad of this equipment for fire control. 2. Retail sale of bio foam to the general public 3. Wholesale to distributors and manufacturers 4. Licenses for the use of the modified bacteria.
6.	Scalability of the Solution	96% scalability is possible in our solution.

### 3.4 Problem solution fit:

## Problem-Solution fit canvas 2.0

Project Title : Emerging Methods for Early Detection of Forest Fires

Team ID: PNT2022TMID11893

Focus on J&P, TR	<b>1. CUSTOMER SEGMENT(S)</b> <span>CS</span> Who is your customer?  1.Federal agencies(forest fire management) such as National Disaster Management Authority (NDMA) USDA's Forest Service.  2.The Department of the Interior's Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, and National Park Service.	<b>6. CUSTOMER</b> <span>CC</span> 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.  1.The triple constraint theory says that every project will include three constraints: budget/cost, time, and scope. And these constraints are tied to each other. Any change made to one of the triple constraints will have an effect on the other two.  2.With any project, there are limitations and risks that need to be addressed to ensure the project's ultimate success.	<b>5. AVAILABLE SOLUTIONS</b> <span>AS</span> 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  From previous studies the available prototype model uses common sensors like Flame sensor, temperature sensor, gas sensor for fire detection those sensors are attached to trees animals and birds in the forest to detect the forest fire.  Pros of existing solutions: 1.The forest fire area can be detected and can be located precisely.  Cons of existing solutions: 1. Complicated to manage. 2. Sensor attached to the animals and birds will affect their habitat and the comfortable way of migration	Explore AS, CC
	<b>2. JOBS-TO-BE-DONE / PROBLEMS</b> <span>J&amp;P</span> Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.  The process provides broad and detailed customer insights that are superior to typical market research methods and critical to developing better solutions for customers. It helped us understand a new space and identify the underserved needs so we could enter a new market in a differentiated manner	<b>9. PROBLEM ROOT CAUSE</b> <span>RC</span> 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.  1. The first step when performing root cause analysis is to analyze the existing situations. This is where the team identifies the factors that impact the problematic event. The outcome of this step is a statement that comprises the specific problem A small team is tasked with the definition of the problem. This could be research staff who assesses and analyzes the situation.  2. It describes the difference between the actual conditions and desired conditions.	<b>7. BEHAVIOUR</b> <span>BE</span> 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)  Popular packages encompass processes involved in the maintenance of solar panels and solar power plants. This is critical: you must try to solve the right problem. Don't try to solve a problem the customer sees as low priority or unimportant. Identify the right problem by asking the right questions and <del>phases</del> . You cannot identify the customer's problems by presenting your	Focus on J&P, BE
Identify strong TR & EM	<b>3. TRIGGERS</b> <span>TR</span> What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.  Human-caused fires are the result of abandoned campfires unattended, burning debris, equipment use and malfunctions, discarded due to negligence cigarettes and arson  <b>4. EMOTIONS: BEFORE / AFTER</b> <span>EM</span> 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.  BEFORE: Encroachment through loss of diversity, reduced wildlife AFTER: Forest surveillance systems can be used to monitor stress in the forest so we can prevent human and wildlife and economic damage	<b>10. YOUR SOLUTION</b> <span>SL</span> 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 behaviour.  In case of forest fire detection the burning substances are primarily identified as sceptical flame regions using a division strategy to expel the non-fire structures and results are verified by a deep learning model. The technology used to locate a forest or a bush fire is based on the concept of deep learning and YOLO algorithm. This deep learning model is deployed on a UAV which helps in detection of fire, meanwhile it can be monitored by web application and the forest fire area can be located in order to prevent it in advance	<b>8. CHANNELS of BEHAVIOUR</b> <span>CH</span> <b>8.1 ONLINE</b> What kind of actions do customers take online? Extract online channels from #7  Collect the date and form a dataset in order to compare the flames regions for forest fire detection  <b>8.2 OFFLINE</b> What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.  In case of forest fire detection the information is sent to forest authorities so that they will prevent it at ease.	Focus on TR, BE

Identify strong TR & EM	<b>4. EMOTIONS: BEFORE / AFTER</b> <span>EM</span> 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.  It is common for people to experience several stages of adjustment including shock, anger, depression, and hopelessness after losing a home. <b>Residential fires can lead to significant emotional distress in addition to possible physical injuries.</b>
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stop a forest fire from continue burns. The project's objective is to capture infrared image of forest fire detection using the appropriate camera, detect fire with RGB and YCbCr color model to isolate fire pixels from the background and separate luminance and chrominance from the original image, and filter image using MATLAB Analyzer to process images. The method is tested on a selected image, which captured by the camera that contains fire. Next method is used for calculating and analyzing the fire image, which to differentiate between fire detection or false detection. Other method is used to process the fire image, which the image will compute and shown in terminal nodes and graphs by using Wavelet Analyzer 5.0. The results of this system are achieved fire detection and obtain data for the fire images.

whose prime purpose is to locate and report wildfires. A network of five lookout stations is spread throughout the NWT.

Identify strong TR & EM

## 4. Requirement Analysis:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Video surveillance	Start surveillance through remote control
FR-2	Forest monitoring	Continuous Observation through Cameras
FR-3	Detect fire	CNI model detecting the fire and temperature
FR-4	Alert	Alerting the Forest Officials through message

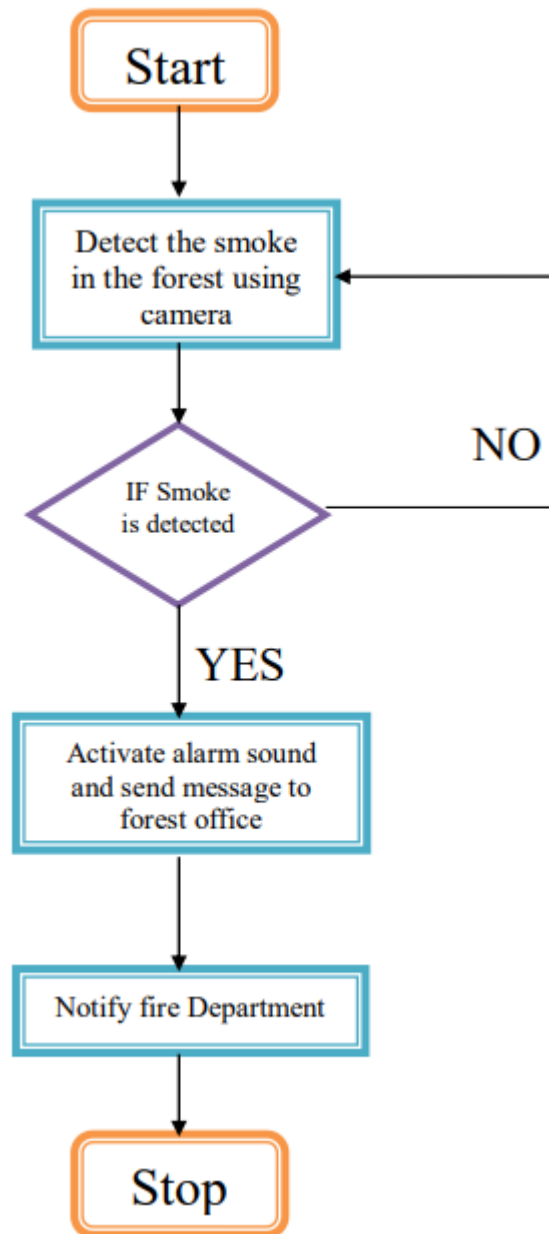
#### Non-functional Requirements:

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

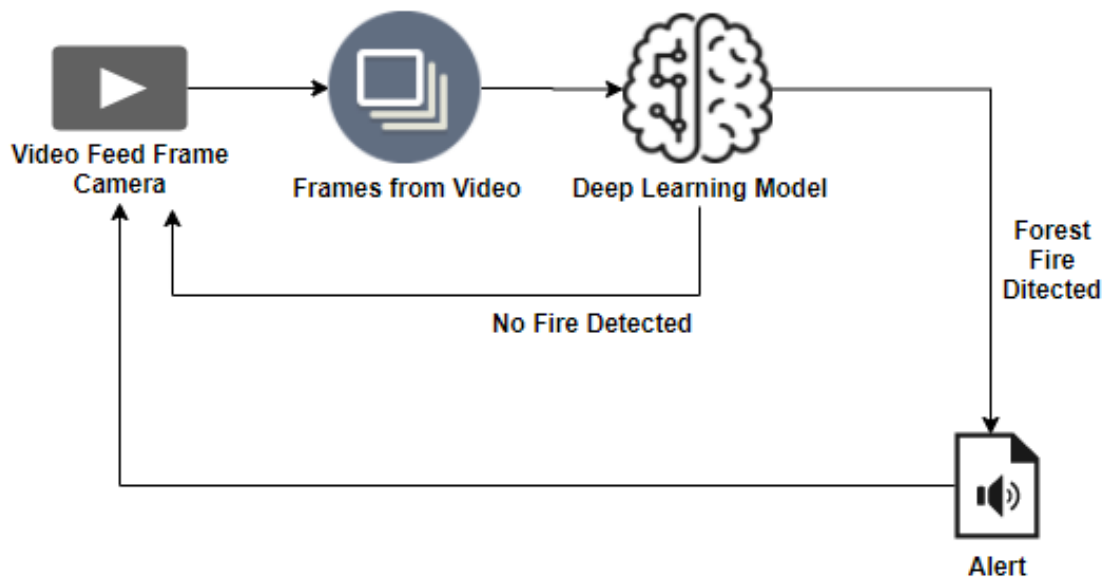
FR No.	Non-Functional Requirement	Description
NFR-1	<b>Reliability</b>	No harm (Model is very safe to install)
NFR-2	<b>Security</b>	Highly secured (Environment is very secured)
NFR-3	<b>Availability</b>	24x7 working (Build model is available all times)
NFR-4	<b>Performance</b>	Providing high degree of accuracy

#### 4.2 Data flow diagram





## 5. Solution & Technical Architecture:



- 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.

### 5.3 User stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
Customer Details	Login	USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
Customer uses	Dashboard	USN-3	As a user, I can register for the application through Facebook	I can register & access the dashboard with Facebook Login	Low	Sprint-2
Customer Options	Stay with outside fires until they are completely safe and dead out.	USN-4	As a user, I can register for the application through Gmail	I can register & access the dashboard with Facebook Login	Medium	Sprint-1
Customer Usage	Login	USN-5	As a user, I can log into the application by entering email & password	I can log in and view my dashboard at my demand on any time	High	Sprint-1
Customer Needs to go	Dashboard	USN-6	As a user I must capture images of forest fire and upload it in web portal.	I can take video of forest fire and upload	High	Sprint-2
Customer (Web user)	Details about estimated cost based on damage	USN-7	As a user I must receive detailed report of damages caused by forest fire	Estimate the cost to rebuild it	High	Sprint-3
Customer Care Executive	Provide efficient and friendly customer support and sort out the quires	USN-8	As a user, I need to get support from developers in case of forest fire and failure of service provided	I can have safe user experience and all the issues raised is sorted	Medium	Sprint-4

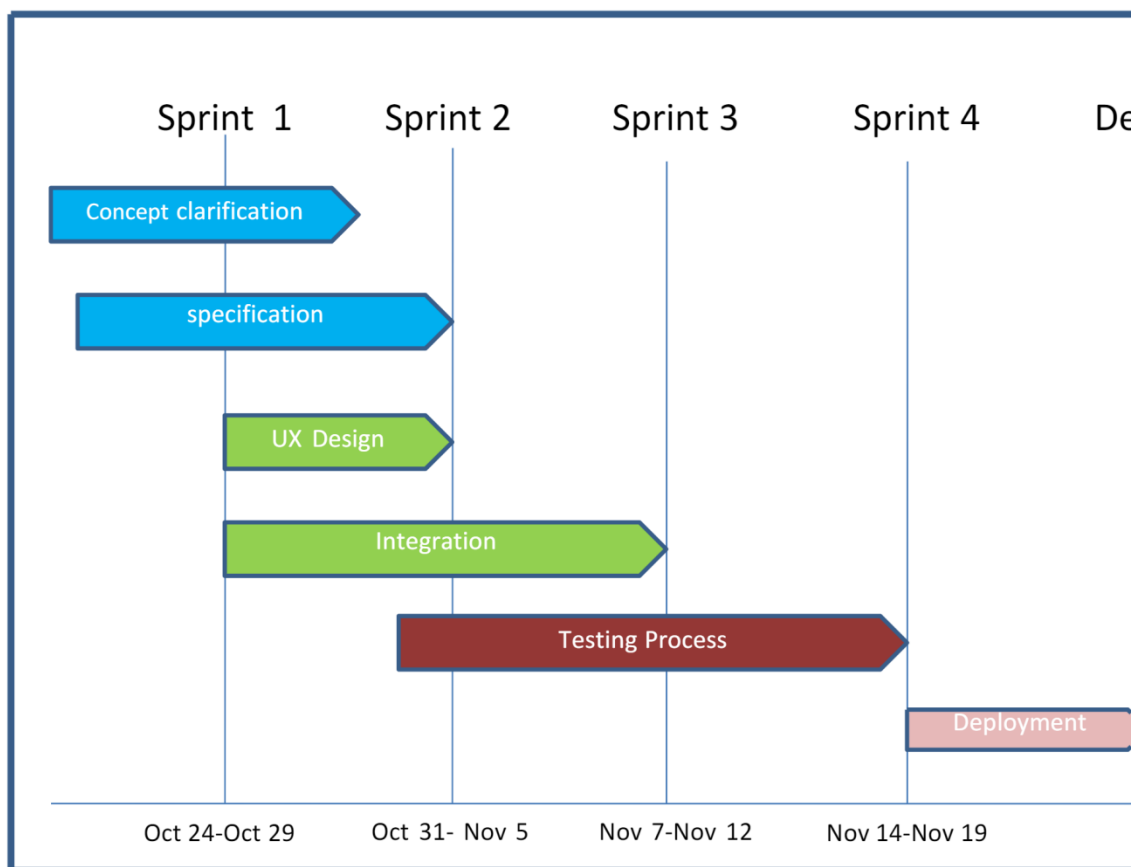
User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Administrator	Overview the entire process and act as a bridge between user and developers	USN-9	We need to satisfy customers' needs in an efficient way and make sure any sort of emergency Are fixed	I can finish the work without any problems	High	Sprint-4

## 6. Project Planning & Scheduling:

### 6.1 Sprint Delivery Schedule:

Team ID: PNT2022TMID44045

# SPRINT DELIVERY PLAN



## 7. Coding & Solution:

```

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
from google.colab import drive
drive.mount('/content/drive')
videoFile = "forest_fire.mp4"
video = cv2.VideoCapture(0)
name=['forest','with fire']
account_sid = 'ACc5aff541737ce4d5ed1695bc927ae11b'
auth_token = '0eda2526eb4c8742fbe068c07d5e4bca'
client = Client(account_sid, auth_token)
message = client.messages \
    .create(
        body='Forest Fire is detected,stay alert',
        from_='+15135069024',
        to='+919025933426')
print(message.sid)
count = 0
videoFile = "forest_fire.mp4"
cap = cv2.VideoCapture(videoFile) # capturing the video from the

```

```

    given path
frameRate = cap.get(5) #frame rate
x=1
while(cap.isOpened()):
    frameId = cap.get(1) #current frame number
    ret, frame = cap.read()
    if (ret != True):
        break
    if (frameId % math.floor(frameRate) == 0):
        filename = "frame%d.jpg" % count;count+=1
        cv2.imwrite(filename, frame)
cap.release()
img = plt.imread('/content/drive/MyDrive/frame0.jpg') # reading
        image using its name
plt.imshow(img)
model=load_model(r'firstimplementation.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:

```

```

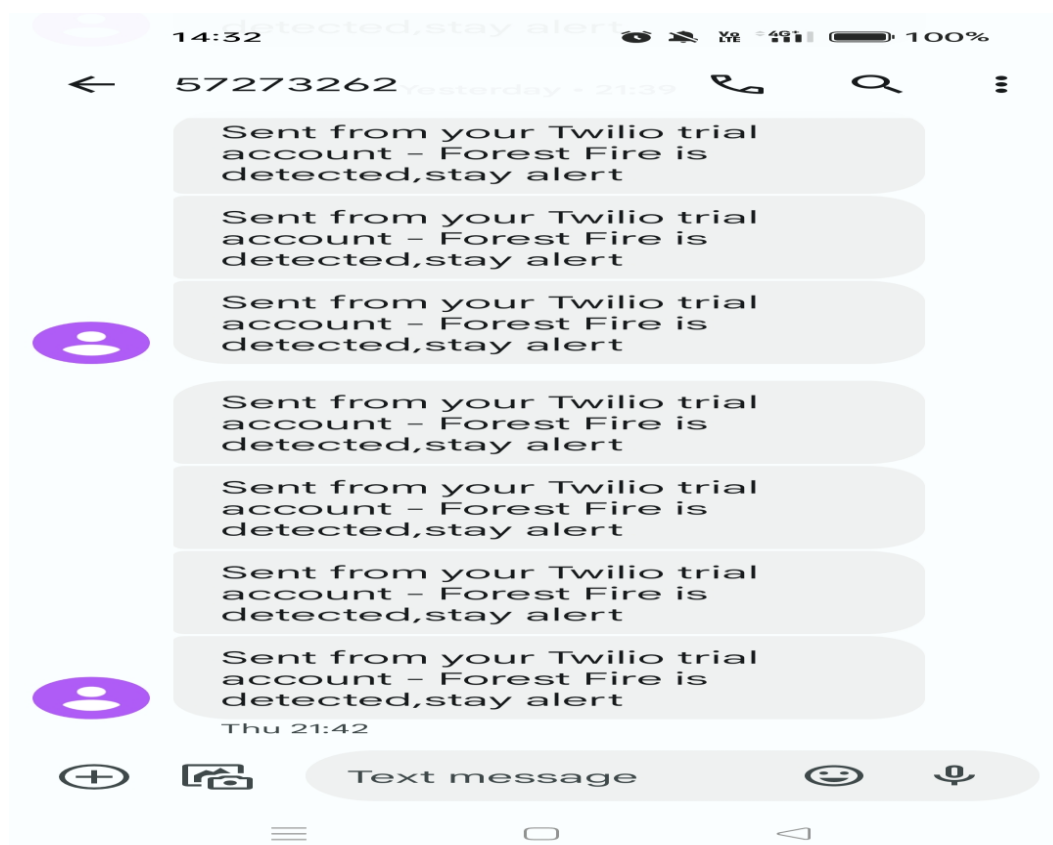
if val == 1:
    account_sid = 'ACc5aff541737ce4d5ed1695bc927ae11b'
    auth_token = '0eda2526eb4c8742fbe068c07d5e4bca'
    client = Client(account_sid, auth_token)

    message = client.messages \
        .create(
            body="Fire detected in the location",
            from_='+15135069024',
            to='+919025933426'
        )
    message = client.messages \
        .create(
            body=getLoc.address,
            from_='+15135069024',
            to='+919025933426'
        )

    print(message.sid)
    print(" fire")
elif val == 0:
    print("no fire")
    predictImage('/content/frame0.jpg')

```

Output:



## 8. Testing:

### 8.1 Test cases

Comparison	Human based observation	Satellite System	Optical cameras	Wireless sensor network
Efficiency and Practically	Low	Low	Medium	High
Fire behavior	-	<b>Yes</b>	-	<b>Yes</b>
Detection delay	Long	Very long	Long	Small
Fire detecting accuracy	Low	Medium	Medium	High
Alarm capacity	Low	Low	Medium	Medium
Cost	Low	High	High	Medium

### 8.2 User Acceptance Testing:

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By design	10	4	2	2	9
Duplicate	1	1	3	0	5
External	2	3	1	1	7
Fixed	11	2	4	20	38
Not reproduced	0	0	0	0	0
Skipped	0	0	1	1	2
Won't fixed	0	5	2	1	8
Total	24	14	13	26	77

### Testing analysis:

Section	Total cases	Not tested	Fail	Pass
Print Engine	7	0	0	7
Client application	52	0	0	52
Security	2	0	0	2
Outsource shipping	3	0	0	3
Exception reporting	9	0	0	9
Final report output	5	0	0	5
Version control	2	0	0	2

## 9. Result:

### 9.1 Performance matrices:

Sl.NO	Characteristics	Description	Technology
1.	Open-source frame work	Python flask frame work is used	Technology of open-source frame work
2.	Security implementation	MAC and preventive control security is used	Eg: SHA 256 encryption
3.	Scalable architecture	High scalability with 3-tire architecture	Web server, CSS, Java script application python, Anaconda database server-IBM DB2
4.	Availability	Use of load balancing to distribute traffic across server	IBM load balancer
5.	Performance	Enhance the performance by using IBM CDN	IBM content delivery network

## 10. Advantages:

- ✓ This system effectively detects and verifies the presence of fire in forest regions.
- ✓ The addition of Region proposals in CNN layers can result in better accuracy as well as faster execution.
- ✓ Our system can verify the presence of fire in the forest with an accuracy of 97.29% from the RCNN model.
- ✓ This will help in the beginning phases of fire identification and assist with restricting the fire to restricted regions to prevent large-scale damage.
- ✓ This system focuses on observing the forests without steady human supervision.

## Disadvantages:

- ✓ Does not have global market penetration like other competitors
- ✓ Limited battery capabilities.
- ✓ Limited data transfer and communications capabilities
- ✓ Will only be available on the west coast at product

## 11. Conclusion:

Wildfires emit billions of tones of carbon dioxide into the atmosphere which causes harm to climate and living organisms. This can also impact the carbon cycle due to excess CO<sub>2</sub> and loss of vegetation. High-intensity forest fires destroy flora and fauna. Forest fires have an immediate effect on mortality, not associated with accidental deaths, which is a significant public health problem, especially if the fire occurs near a densely populated area. So, forest fire detection system help to minimize the effect of all living beings.

## 12. Future Scope:

- Development of micro electrical system (MIES), wireless network system is expected to be widely in use.



- MEMS are the combination of electrical devices and mechanical structure at an extremely small scale. Many researcher need to be done so as to implement MEMS in WSN
- Moreover IoT is expected to have dramatic impact in our lives in nature. WSN's will be integrated into IoT and innumerable sensor nodes will join the internet. They will cooperate with other nodes to sense and to monitor the environment E.g. Smart driver system
- Change In The Micro Climate Of The Area Resulting In Healthy Living Conditions
- Soil erosion disaffecting productivity of soils and agricultural production;
- Avoid Ozone Layer Depletion

### **13. APPENDIX:**

- Source Code
- GitHub & Project Demo Link

*Submitted by, (project Id: **PNT2022TMID11893**)*

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4. *Kavikarthi K*