Emerging Methods For Early Detection Of Forest Fires

**Team ID: PNT2022TMID03339**

**Team Size: 4 Team Members**

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**INDEX**

###### INTRODUCTION 4

* 1. Project Overview
  2. Purpose

###### LITERATURE SURVEY 5

* 1. Existing problem
  2. References
  3. Problem Statement Definition

1. **IDEATION & PROPOSED SOLUTION 7**
   1. Empathy Map Canvas
   2. Ideation & Brainstorming
   3. Proposed Solution
   4. Problem Solution fit

###### REQUIREMENT ANALYSIS 12

* 1. Functional requirement
  2. Non-Functional requirements

###### PROJECT DESIGN 16

* 1. Data Flow Diagrams
  2. Solution & Technical Architecture
  3. User Stories

###### PROJECT PLANNING & SCHEDULING 19

* 1. Sprint Planning & Estimation
  2. Sprint Delivery Schedule
  3. Reports from JIRA

###### CODING & SOLUTIONING (Explain the features added in the project along with code) 21

* 1. Feature 1
  2. Feature 2

###### TESTING 28

* 1. Test Cases
  2. User Acceptance Testing

###### RESULTS 30

* 1. Performance Metrics

###### ADVANTAGES & DISADVANTAGES 35

###### CONCLUSION 36

###### FUTURE SCOPE 36

###### APPENDIX 37

Source Code

GitHub Link

# Chapter-1

## INTRODUCTION

### Project Overview

The ecological balance is maintained by the forests. It acts as an environment that enriches the diversity of various organisms. The motive of the project is to detect the forest fire as early as possible so that we can preserve the life of various species prevailing in it from the fire. Utilizing the currently available techniques of smoke sensors put in the buildings, fire detection can be incredibly challenging. Due to their outdated technology and design, they are costly and slow.

The use of artificial intelligence for identification and issuing alerts with video from CCTV footage is critically examined in this study. For this project, a self-built dataset of videoframes with fire is used. The data is then preprocessed and a machine-learning model is built using CNN. The dataset's test set is used as input to verify the method, and experiments are recorded. The goal of the project is to create a machine that is both affordable and very precise and can be applied to practically any fire-detecting situation.

### Purpose

One of the key elements in keeping the environment in balance is forests. When a fire breaks out in a forest, it can be very dangerous. However, a forest fire is typically discovered after it has spread across a significant area. It might not always be able to put out the fire. As a result, the environmental impact is worse than anticipated. The environment suffers because of the forest fire's large-scale carbon dioxide (CO2) emissions. It would result in the global extinction of rare species. Additionally, it may have an effect on the weather, which may lead to serious problems like earthquakes, excessive rain, floods, and so forth. The forest is a big surface area covered with trees, tonnes of dried leaves, woodlands, and other things. When the fire first ignites, these substances help it grow. Fire might start from various causes, including smoking, fireworks-themed events, or high summer temperatures. Once a fire starts, it won't stop until it has entirely burned itself out. When the fire is noticed as early as feasible, the damage and the cost associated with identifying it due to a forest fire can be minimized. Therefore, in this case, fire detection is crucial. A good effect can be had by locating the fire's specific location and notifying the fire authorities as soon as the fire occurs. Thus it is crucial to implement a system to identify fires as soon as possible.

# Chapter 2

## LITERATURE SURVEY

### Existing problem

Smoke alarms and heat alarms are being used to detect fires. One module is not enough to monitor all of the potential fire-prone areas, which is the fundamental drawback of smoke sensor alarms and heat sensor alarms. The only way to avoid a fire is to exercise caution at all times. Even if they are installed in every nook and cranny, it is not enough to constantly produce an efficient output. As the number of smoke sensors required rises, the price will rise by a factor of multiples. The suggested system can generate reliable and highly accurate alerts within seconds of an accident or a fire. One piece of software powers the entire surveillance network, which lowers costs. Data scientists and machine learning experts are actively conducting

research in this area.

### References

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3. Official webpage of the DJI Matrice 200 series of UAVs at: http[s://w](http://www.dji.com/matrice-200-series)ww[.dji.com/matrice-200-series](http://www.dji.com/matrice-200-series)
4. Official webpage of Movidius at: http[s://w](http://www.movidius.com/)ww[.movidius.c](http://www.movidius.com/)om [16] Official webpage of the IMST iC880A LoRaWAN concentrator at:

https://wireless-solutions.de/products/long-range-radio/ic880a.html

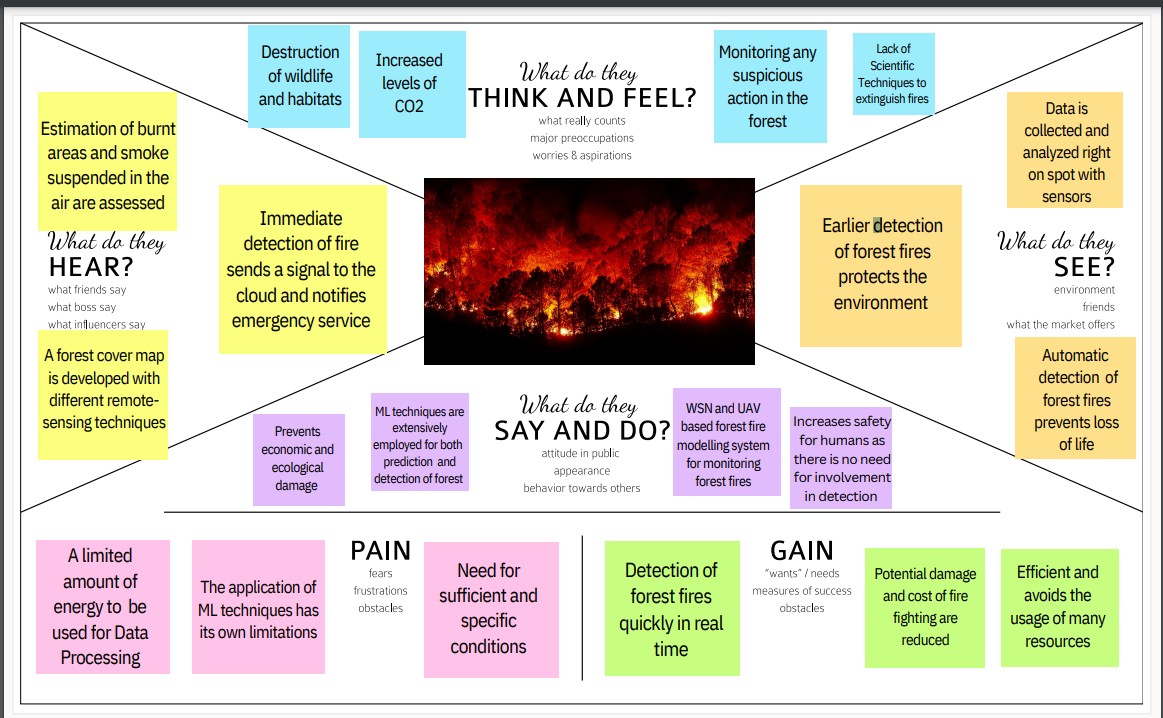
### Problem Statement Definition

Forest fires result in a wide range of negative effects, including the destruction of wildlife habitat, the extinction of plants and animals, the destruction of nutrient-rich top soil, the reduction of forest cover, the loss of valuable timber resources, the ozone layer being destroyed, the loss of livelihood for tribal and poor people, the acceleration of global warming, the increase in atmospheric carbon dioxide concentration, the degradation of catchment areas, the loss of biodiversity, the spread of disease, etc. Thus, Develop a system to detect forest fires at the earliest stage possible using the latest technologies.

# Chapter 3

## IDEATION & PROPOSED SOLUTION

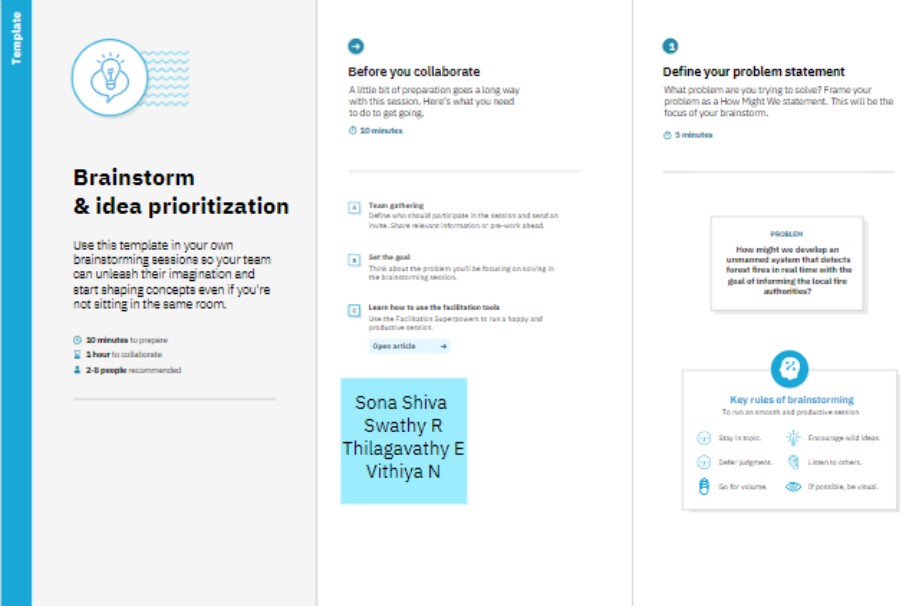
### Empathy Map Canvas

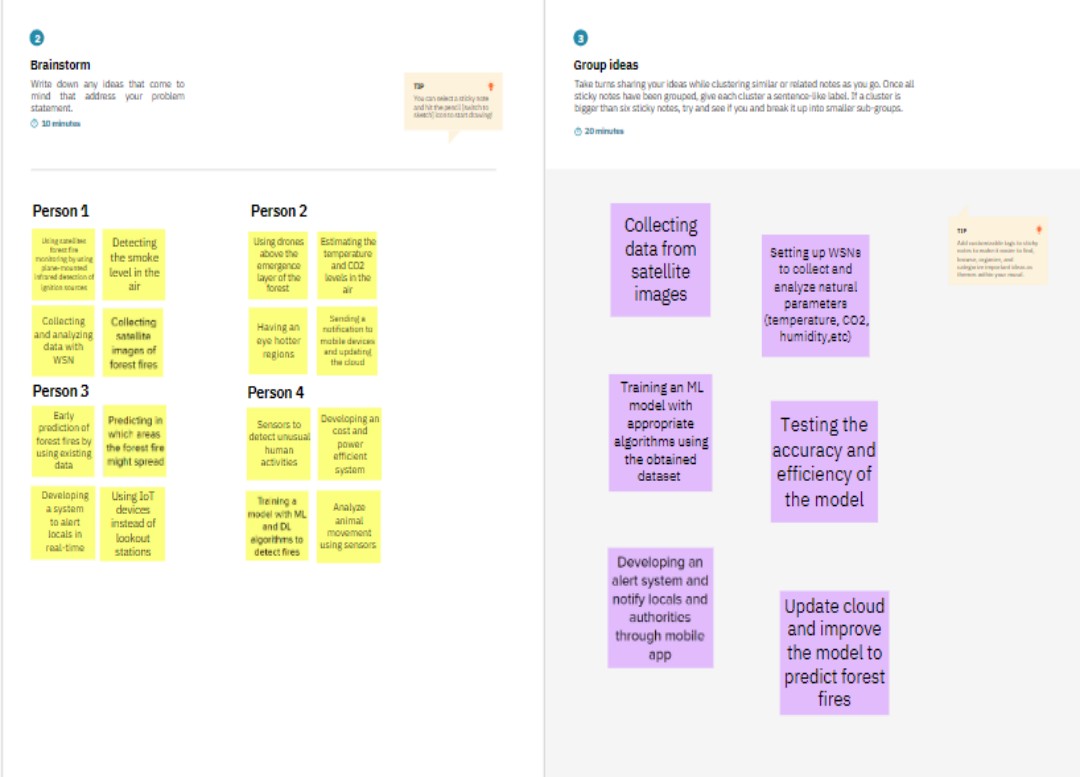
An empathy map is a simple, easy-to-digest visual that captures knowledge about a user’s behaviors and attitudes. It is a useful tool to help teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise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

### Ideation And Brainstorming

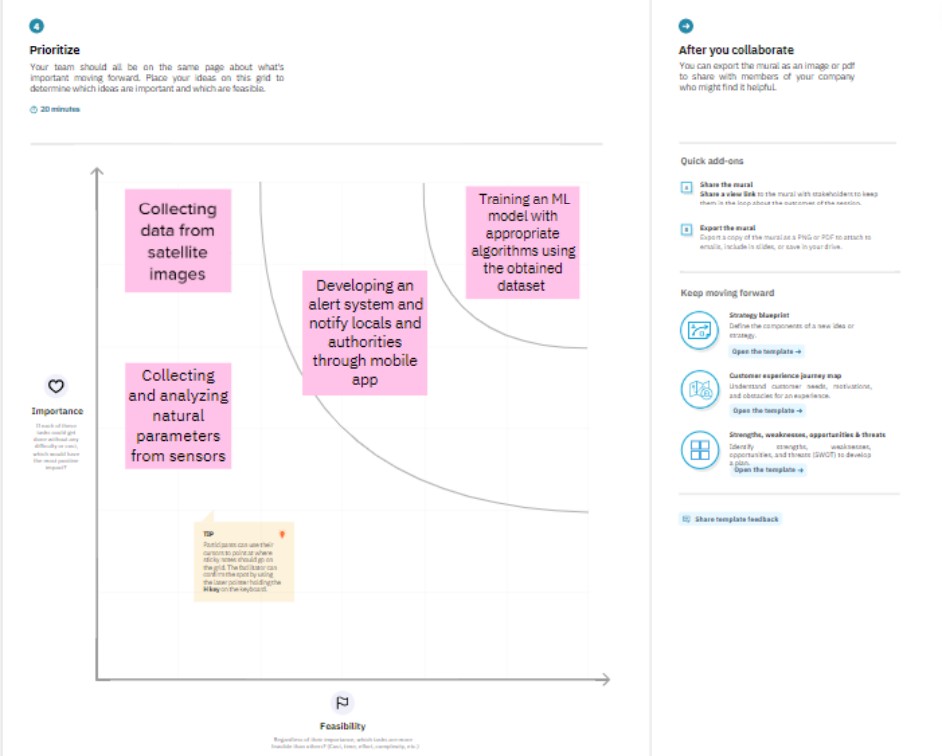
Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem-solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are

encouraged to collaborate, helping each other develop a rich amount of creative solutions.



**Brainstorm, Idea Listing and Grouping**

**Idea Prioritization**



### Proposed Solution

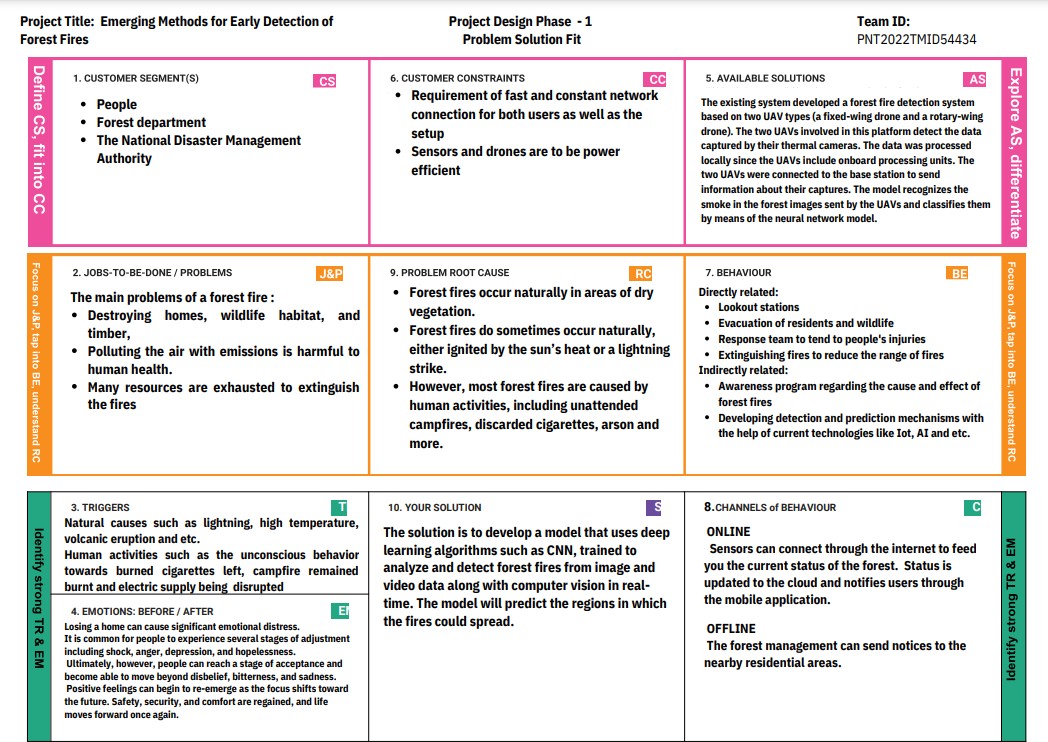
**Proposed Solution:**

|  |  |  |
| --- | --- | --- |
| **S.No**  **.** | **Parameter** | **Description** |

|  |  |  |
| --- | --- | --- |
| 1. | Problem Statement (Problem to be solved) | Forest fires occur yearly with increasing intensity in the summer and autumn periods. Regardless of the reasons for the ignition of forest fires, they usually cause devastating damage to both nature and humans. Forest fires are also considered the main contributor  to air pollution. |
| 2. | Idea / Solution description | Our solution is to develop a model that uses deep learning algorithms such as CNN, trained to analyse and detect forest fires from image and video data along with computer vision in real-time. The model will predict the regions in which the fires could spread. |
| 3. | Novelty / Uniqueness | The model is then used in unmanned aerial  vehicles (UAVs) with specialized cameras to monitor vulnerable regions. A mobile application is developed as an alerting system to notify residents and forest departments once a forest fire is detected. WSNs can be used to monitor parameters that can cause forest fires. |

|  |  |  |
| --- | --- | --- |
| 4. | Social Impact / Customer Satisfaction | As the forests are prevented beforehand, huge  catastrophes can be prevented such as ecological and economical losses.  Habitats of flora and fauna can be conserved. Air pollution can be reduced. The livelihood of residents living in or nearby the forests can be sustained. |
| 5. | Business Model (Revenue Model) | We believe that the mobile application would  provide efficient service for the people, forest department, and as well as the government in the long term. |
| 6. | Scalability of the Solution | Sparsely populated areas typically encounter  complications during detection. However,  the solution can monitor enormous forests and detect forest fires even in sparsely populated regions. |

* 1. **Problem Solution Fit**



# Chapter 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 | Video/Image surveillance | Capture surveillance through cameras. |
| FR-2 | WSN | Continuous monitoring of forests through sensors. |
| FR-3 | Detection of Fire | Fire is detected via a CNN model and Computer Vision. |
| FR-4 | Cloud | Detected values are sent to the cloud. |
| FR-5 | Alert | Alert the people through a fire alarm system. |
| FR-6 | Mobile app | Users get a notification when the 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** | By detecting the Forest Fire earlier. Alerts according to the user location. |
| NFR-2 | **Security** | This project doesn’t contain any secured information so there is no role of security factors. There are no requirements for privacy. |
| NFR-3 | **Reliability** | Since we are using a deep learning algorithm, the  system is really good and has better accuracy. |
| NFR-4 | **Performance** | The performance mostly depends on monitoring the forest by WSNs and giving alerts immediately without any delay. |
| NFR-5 | **Availability** | The system shall take real input images of the  surveillance camera and it should be helpful in a great way to suppress the fire without any great damage. |
| NFR-6 | **Scalability** | The cost of establishing the cameras for the entire  forest may be high. The system can be fitted anywhere in the forest. |

# Chapter 5

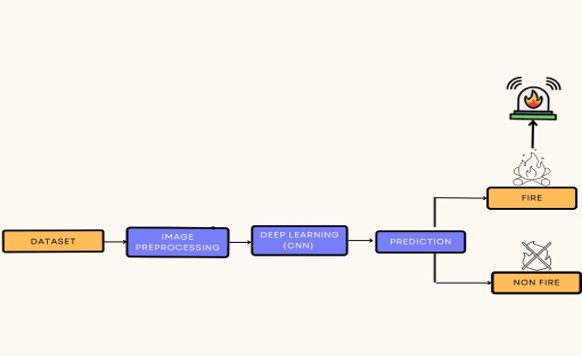
## PROJECT DESIGN

### Data Flow Diagrams

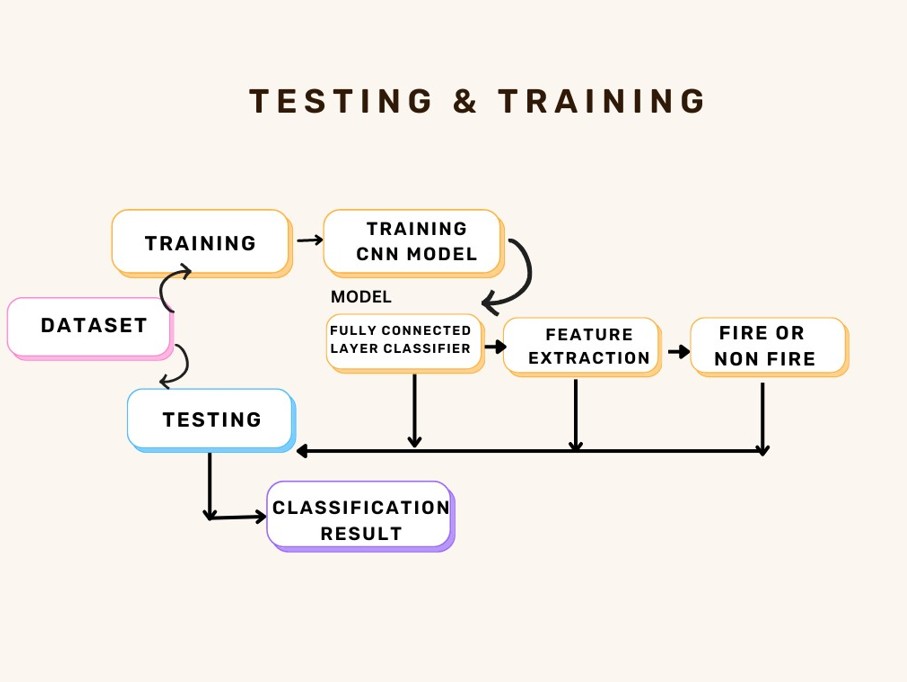
A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

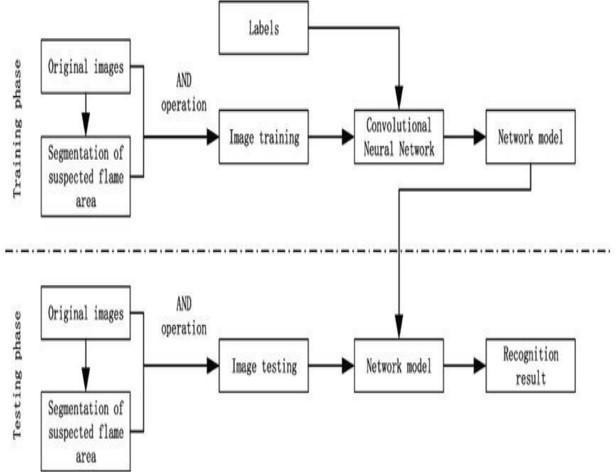
**FLOW:**

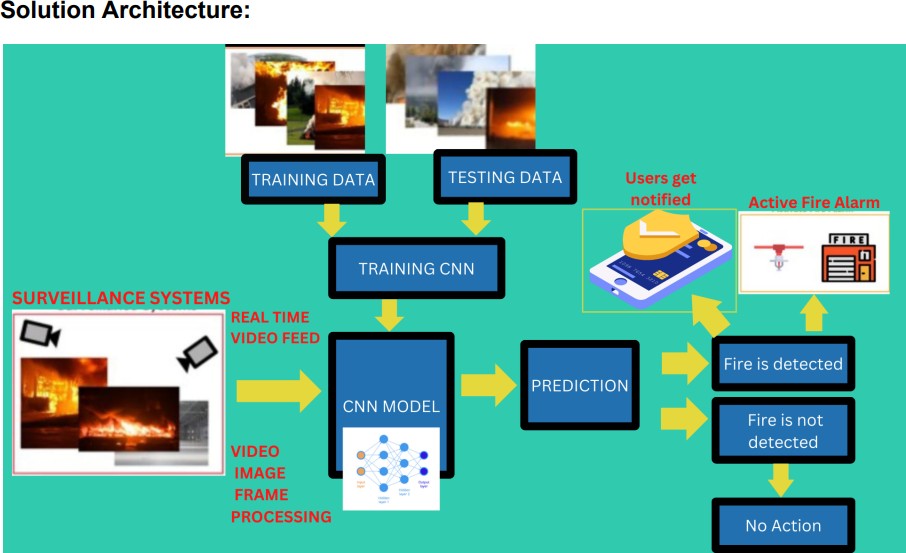
* Data is collected through surveillance video or image-based approaches. The image is preprocessed by using ImageDataGenerator.
* The various real-time forest fire detection and prediction approaches, with the goal of informing the local fire authorities.
* If the fire is not detected, it will send the result to the framing camera.
* If the forest fire is detected, the alert will send notification messages through a mobile app.
* The various real-time forest fire detection and prediction approaches, with the goal of informing the local fire authorities.

**DIAGRAM**

### Solution & Technical Architecture:







* 1. **User Stories**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **User Type** | **Functional Requirement (Epic)** | **User Story Number** | **User Story / Task** | **Acceptan ce Criteria** | **Priority** | **Releas e** |
| Enviro |  |  |  |  |  |  |
| nment al list | Collect the data | USN-1 | As an | It is necessar | High | Sprin  t 1 |
|  |  |  | Environmentalis | y to |  |  |
|  |  |  | t.it is necessary | collect |  |  |
|  |  |  | to collect the | the right |  |  |
|  |  |  | data of the | data else |  |  |
|  |  |  | forest which | the |  |  |
|  |  |  | includes data | predictio |  |  |
|  |  |  | else the | n may of |  |  |
|  |  |  | temperature,hu | the |  |  |
|  |  |  | midity,wind and | forest |  |  |
|  |  |  | rain prediction | become |  |  |
|  |  |  | may of the  forest | wrong |  |  |
|  | Preprocessing | USN-2 | Dataset is further | The aim | High | Sprin |
|  |  | preprocessed by | of |  | t 2 |
|  |  | ImageDataGenera | pre-proc |  |  |
|  |  | tor. | essing is |  |  |
|  |  |  | an |  |  |
|  |  |  | improve |  |  |
|  |  |  | ment of |  |  |
|  |  |  | the |  |  |
|  |  |  | image |  |  |
|  |  |  | data that |  |  |
|  |  |  | suppress |  |  |
|  |  |  | es |  |  |
|  |  |  | unwilling |  |  |
|  |  |  | distortio |  |  |
|  |  |  | ns or |  |  |
|  |  |  | enhance |  |  |
|  |  |  | s some |  |  |
|  |  |  | image |  |  |
|  |  |  | features |  |  |
|  |  |  | importan |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | t for further processi ng. |  |  |
|  | Splitting the dataset | USN-3 | The collected dataset is split into train and test. | Separati ng data into training and testing sets is an importan t part of evaluatin g data mining models. | High | Sprin t 3 |

# Chapter 6

## PROJECT PLANNING & SCHEDULING

### Sprint Planning & Estimation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sprint** | **Functional Requirement (Epic)** | **User Story Number** | **User Story / Task** | **Story Points** | **Priority** | **Team Members** |
| Sprint | Collect the | USN-1 |  | 3 | High |  |
| -1 | data |  | As an Environmentalist.it  is necessary to collect the data of the forest which includes data else the temperature, humidity, wind and rain prediction may of the forest |  |  | SONA SHIVA  SWATHY R THILAGAVATHY E VITHIYA N |
| Sprint | Splitting the | USN-2 | The collected dataset is | 3 | High | SONA SHIVA |
| -1 | dataset |  | split into train and test. |  |  |  |
|  |  |  |  |  |  | SWATHY R |
|  |  |  |  |  |  | THILAGAVATHY E |
|  |  |  |  |  |  | VITHIYA N |
| Sprint  -1 | Image | USN-3 | Dataset is further  pre-processed by Image | 3 | High | SONA SHIVA |
|  | Pre-processin  g |  | Data Generator. |  |  | SWATHY R  THILAGAVATHY E VITHIYA N |
| Sprint  -2 | Model Building | USN-4 | Importing the model building libraries, | 3 | High | SONA SHIVA |
|  |  |  | Initializing, the model and adding the CNN and dense |  |  | SWATHY R  THILAGAVATHY E VITHIYA N |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | layers. Configuring the learning process |  |  |  |
| Sprint  -2 | Model Building | USN-5 | Training and saving the model | 3 | High | SONA SHIVA |
|  |  |  |  |  |  | SWATHY R  THILAGAVATHY E VITHIYA N |
| Sprint  -2 | Model Building | USN-6 | Predictions | 3 | High | SONA SHIVA |
|  |  |  |  |  |  | SWATHY R  THILAGAVATHY E |
|  |  |  |  |  |  | VITHIYA N |
| Sprint |  |  |  |  |  |  |
| -3 | Video  Analysis | USN-7 | OpenCV for Video  Processing | 3 | High | SONA SHIVA |
|  |  |  |  |  |  | SWATHY R |
|  |  |  |  |  |  | THILAGAVATHY E |
|  |  |  |  |  |  | VITHIYA N |
|  |  |  |  |  |  |  |
| Sprint  -3 | Video Analysis | USN-8 | Creating an account in Twilio Service | 3 | High | SONA SHIVA SWATHY R THILAGAVATHY E  VITHIYA N |

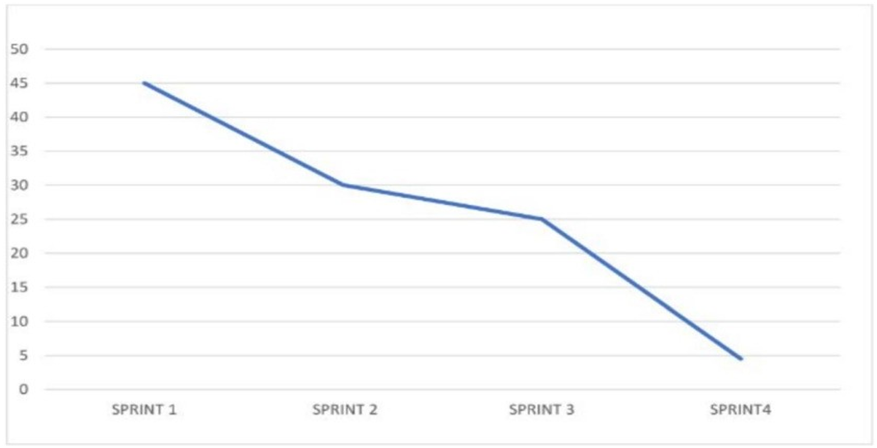
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sprint  -3 | Video Analysis | USN-9 | Sending Alert Message | 3 | High | SONA SHIVA SWATHY R THILAGAVATHY E VITHIYA N |
| Sprint  -4 | Training CNN Model | USN-10 | Registering on Cloud, Train Image Classification | 5 | High | SONA SHIVA |
|  | on Cloud |  | Miodel |  |  | SWATHY R  THILAGAVATHY E VITHIYA N |
| Sprint  -4 | Implementati on | USN-11 | Implementation of the model on real-time data | 4 | High | SONA SHIVA |
|  |  |  |  |  |  | SWATHY R  THILAGAVATHY E VITHIYA N |

* 1. **Sprint Delivery Schedule**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sprint** | **Total Story Points** | **Duration** | **Sprint Start Date** | **Sprint End Date (Planned)** | **Story Points Completed (as on Planned End Date)** | **Sprint Release Date (Actual)** |
| Sprint- | 9 | 2 Days | 11 | 12 Nov 2022 | 9 | 12 Nov 2022 |
| 1 |  |  | Nov |  |  |  |
|  |  |  | 2022 |  |  |  |
| Sprint- | 9 | 2 Days | 13 | 14 Nov 2022 | 9 | 14 Nov 2022 |
| 2 |  |  | Nov |  |  |  |
|  |  |  | 2022 |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sprint- | 9 | 2 Days | 15 | 16 Nov 2022 | 9 | 16 Nov 2022 |
| 3 |  |  | Nov |  |  |  |
|  |  |  | 2022 |  |  |  |
| Sprint- | 9 | 2 Days | 17 | 18 Nov 2022 | 9 | 18 Nov 2022 |
| 4 |  |  | Nov |  |  |  |
|  |  |  | 2022 |  |  |  |

* 1. **Reports from JIRA**



# Chapter 7

## CODING & SOLUTIONING

* 1. ***Feature 1***

1. **Preprocessing the dataset which consists of two classes of data(fire, no fire).**

**Image Preprocessing**

##### #1. Importing the ImageDataGenerator Library

**from** tensorflow.keras.preprocessing.image **import** ImageDataGenerator

##### #2. Define parameters for ImageDataGenerator Class

train\_datagen **=**

ImageDataGenerator(rescale**=**1.**/**255,shear\_range**=**0.2,zoom\_range**=**0.2,horizontal\_flip**=True**,vertical\_flip**=True**)

*#rescale => rescaling pixel value from 0 to 255 to 0 to 1 #shear\_range=> counter clock wise rotation(anti clock) test\_datagen* ***=*** *ImageDataGenerator(rescale****=****1.****/****255)*

##### #3. Applying ImageDataGenerator Functionality to Trainset and Testset

x\_train **=** train\_datagen**.**flow\_from\_directory(r"D:\FFDDataset\train\_set", target\_size**=**(256,256),

batch\_size**=**32, class\_mode**=**"binary")

x\_test **=** test\_datagen**.**flow\_from\_directory(r"D:\FFDDataset\test\_set", target\_size**=**(256,256),

batch\_size**=**32, class\_mode**=**"binary")



**Building the Model**

#### Building up a sequential model to train the dataset.

*# 1.Importing the Model Building Libraries*

#Importing model libraries

**from** tensorflow.keras.layers **import** Convolution2D **from** tensorflow.keras.layers **import** MaxPooling2D **from** tensorflow.keras.layers **import** Flatten

**from** tensorflow.keras.optimizers **import** Adam , SGD, RMSprop

***# 2.Initializing the Model***

model=Sequential()

##### # 3.Adding CNN Layers

# a. Adding Convolutional layer

model**.**add(Convolution2D(32,(3,3),input\_shape**=**(256,256,3),activation**=**"relu"))

# b. Adding Pooling Layer

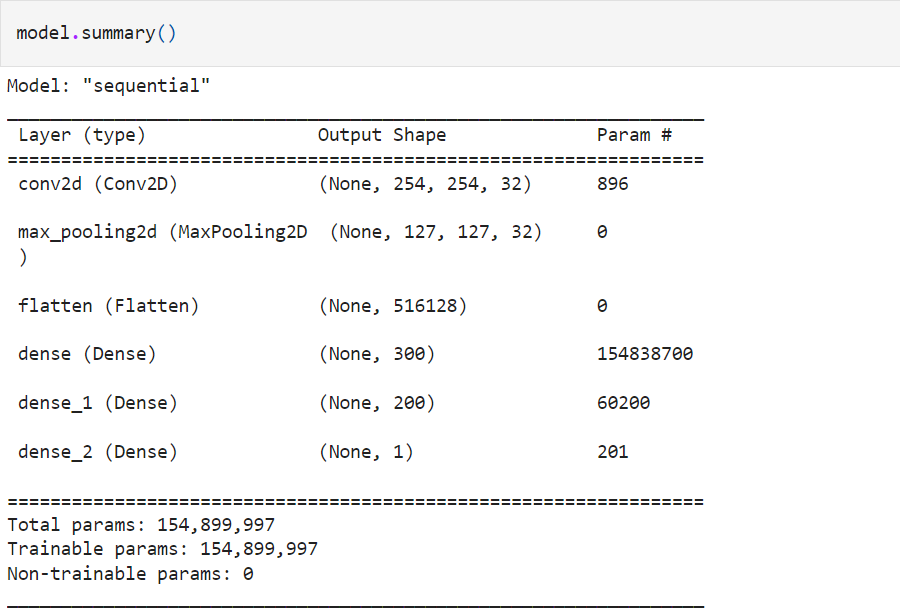
model**.**add(MaxPooling2D(pool\_size**=**(2,2)))

# c. Adding Flatten Layer model.add(Flatten)

model**.**add(Flatten())

**#Summary of model**

model.summary()



### Prediction of data

**from** tensorflow.keras.models **import** load\_model

**from** tensorflow.keras.preprocessing **import** image

I

model **=** load\_model("fire.h5")

I

img **=** image**.**load\_img(r"C:\Users\Isha\Pictures\Saved Pictures\egnofire.jpg",target\_size**=**(256,256))

img



type(img)

PIL.Image.Image

x **=** image**.**img\_to\_array(img)

I

x

array([[[ 12., 14., 0.],

[ 21., 24., 7.],

[ 43., 46., 27.],

...,

|  |  |  |
| --- | --- | --- |
| [ 21., | 19., | 7.], |
| [ 13., | 15., | 2.], |
| [ 52., | 60., | 11.]], |
| [[ 13., | 15., | 2.], |
| [ 12., | 14., | 0.], |
| [ 18., | 21., | 4.], |
| ..., |  |  |
| [ 17., | 15., | 2.], |
| [ 10., | 11., | 3.], |
| [ 58., | 65., | 23.]], |
| [[ 14., | 15., | 7.], |
| [ 11., | 13., | 2.], |
| [ 10., | 12., | 0.], |
| [ 19., 18., | 0.], |  |
| [ 17., | 18., | 13.], |
| [ 62., | 66., | 39.]], |
| ..., |  |  |
| [[ 14., | 15., | 7.], |
| [ 51., | 56., | 26.], |
| [ 48., | 57., | 2.], |
| ..., |  |  |
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| [ 58., | 75., | 30.], |
| [ 54., | 73., | 27.]], |
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| [103., 112., 57.],  ..., | | |
| [ 65., | 80., | 41.], |
| [ 61., | 78., | 33.], |
| [ 64., | 83., | 37.]], |

|  |  |  |
| --- | --- | --- |
| [[ 18., | 18., | 8.], |
| [ 36., | 39., | 8.], |
| [ 77., | 85., | 28.], |
| ...,  [ 79., | 94., | 55.], |
| [ 50., | 67., | 22.], |
| [ 52., | 71., | 25.]]], dtype=float32) |

x**.**shape (256, 256, 3)

**import** numpy **as** np

*# convolution expects 4D*

x **=** np**.**expand\_dims(x,axis**=**0)

x**.**shape

(1, 256, 256, 3)

pred\_prob **=** model**.**predict(x)

1/1 [==============================] - 0s 111ms/step

pred\_prob

array([[0.]], dtype=float32)

**if**(pred\_prob**==**0): print("There is no fire")

else:

print("There is a fire") There is no fire

**4. Accurancy:**

**Epoch 1/30**

**13/13 [==============================] - 36s 2s/step - loss: 2.2809 -**

**accuracy: 0.5965 - val\_loss: 0.6385 - val\_accuracy: 0.5938 Epoch 2/30**

**13/13 [==============================] - 53s 4s/step - loss: 0.4557 -**

**accuracy: 0.7822 - val\_loss: 0.1618 - val\_accuracy: 0.9062 Epoch 3/30**

**13/13 [==============================] - 44s 3s/step - loss: 0.2581 -**

**accuracy: 0.8762 - val\_loss: 0.0857 - val\_accuracy: 0.9688 Epoch 4/30**

**13/13 [==============================] - 28s 2s/step - loss: 0.2146 -**

**accuracy: 0.9059 - val\_loss: 0.1209 - val\_accuracy: 0.9688 Epoch 5/30**

**13/13 [==============================] - 31s 2s/step - loss: 0.1683 -**

**accuracy: 0.9332 - val\_loss: 0.0789 - val\_accuracy: 0.9688 Epoch 6/30**

**13/13 [==============================] - 34s 3s/step - loss: 0.1468 -**

**accuracy: 0.9381 - val\_loss: 0.0531 - val\_accuracy: 0.9896 Epoch 7/30**

**13/13 [==============================] - 35s 3s/step - loss: 0.1569 -**

**accuracy: 0.9406 - val\_loss: 0.1668 - val\_accuracy: 0.9375 Epoch 8/30**

**13/13 [==============================] - 36s 3s/step - loss: 0.1830 -**

**accuracy: 0.9158 - val\_loss: 0.0514 - val\_accuracy: 0.9896 Epoch 9/30**

**13/13 [==============================] - 32s 2s/step - loss: 0.1455 -**

**accuracy: 0.9356 - val\_loss: 0.0378 - val\_accuracy: 0.9896 Epoch 10/30**

**13/13 [==============================] - 34s 3s/step - loss: 0.1761 -**

**accuracy: 0.9307 - val\_loss: 0.0352 - val\_accuracy: 1.0000 Epoch 11/30**

**13/13 [==============================] - 35s 3s/step - loss: 0.1391 -**

**accuracy: 0.9530 - val\_loss: 0.0413 - val\_accuracy: 0.9896 Epoch 12/30**

**13/13 [==============================] - 37s 3s/step - loss: 0.1264 -**

**accuracy: 0.9505 - val\_loss: 0.0580 - val\_accuracy: 0.9792 Epoch 13/30**

**13/13 [==============================] - 34s 3s/step - loss: 0.1306 -**

**accuracy: 0.9406 - val\_loss: 0.0191 - val\_accuracy: 1.0000 Epoch 14/30**

**13/13 [==============================] - 35s 3s/step - loss: 0.1083 -**

**accuracy: 0.9554 - val\_loss: 0.0361 - val\_accuracy: 0.9792 Epoch 15/30**

**13/13 [==============================] - 35s 3s/step - loss: 0.0869 -**

**accuracy: 0.9678 - val\_loss: 0.0203 - val\_accuracy: 0.9896 Epoch 16/30**

**13/13 [==============================] - 31s 2s/step - loss: 0.1200 -**

**accuracy: 0.9579 - val\_loss: 0.0275 - val\_accuracy: 0.9896 Epoch 17/30**

**13/13 [==============================] - 31s 2s/step - loss: 0.1556 -**

**accuracy: 0.9233 - val\_loss: 0.0402 - val\_accuracy: 0.9896 Epoch 18/30**

**13/13 [==============================] - 33s 3s/step - loss: 0.1405 -**

**accuracy: 0.9406 - val\_loss: 0.0595 - val\_accuracy: 0.97**

Epoch 19/30

**13/13 [==============================] - 34s 3s/step - loss: 0.1334 - accuracy: 0.9356 - val\_loss: 0.0559 - val\_accuracy: 0.9896**

Epoch 20/30

**13/13 [==============================] - 33s 3s/step - loss: 0.1130 - accuracy: 0.9530 - val\_loss: 0.0251 - val\_accuracy: 0.9896**

Epoch 21/30

**13/13 [==============================] - 39s 3s/step - loss: 0.1073 - accuracy: 0.9406 - val\_loss: 0.0313 - val\_accuracy: 0.9896**

Epoch 22/30

**13/13 [==============================] - 29s 2s/step - loss: 0.1091 - accuracy: 0.9480 - val\_loss: 0.0170 - val\_accuracy: 1.0000**

Epoch 23/30

**13/13 [==============================] - 30s 2s/step - loss: 0.0939 - accuracy: 0.9567 - val\_loss: 0.0128 - val\_accuracy: 1.0000**

Epoch 24/30

**13/13 [==============================] - 29s 2s/step - loss: 0.0759 - accuracy: 0.9728 - val\_loss: 0.0037 - val\_accuracy: 1.0000**

Epoch 25/30

**13/13 [==============================] - 35s 3s/step - loss: 0.0758 - accuracy: 0.9777 - val\_loss: 0.0118 - val\_accuracy: 1.0000**

Epoch 26/30

**13/13 [==============================] - 34s 3s/step - loss: 0.0707 - accuracy: 0.9802 - val\_loss: 0.0079 - val\_accuracy: 1.0000**

Epoch 27/30

**13/13 [==============================] - 36s 3s/step - loss: 0.1081 - accuracy: 0.9480 - val\_loss: 0.0235 - val\_accuracy: 0.9896**

Epoch 28/30

**13/13 [==============================] - 35s 3s/step - loss: 0.0975 - accuracy: 0.9678 - val\_loss: 0.0092 - val\_accuracy: 1.0000**

Epoch 29/30

**13/13 [==============================] - 34s 3s/step - loss: 0.0746 - accuracy: 0.9752 - val\_loss: 0.0072 - val\_accuracy: 1.0000**

Epoch 30/30

**13/13 [==============================] - 35s 3s/step - loss: 0.0695 - accuracy: 0.9777 - val\_loss: 0.0720 - val\_accuracy: 0.9583**

**Training and Deploying the model in cloud**

pwd

'

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='EHmhit2MD64AQnqYijN7mrXyaEYoh02jLsiuzU5mzGbt', 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 = 'ffdcnnmodelbook-donotdelete-pr-giva0vdmx0opfa'

object\_key = 'forestfiredataset.zip'

streaming\_body\_3 = 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\_3.read()),'r') file\_paths=unzip.namelist()

for path in file\_paths: unzip.extract(path)

ls

Dataset/ fire-classification-model.tgz forest1.h5 fie-classification-model.tgz fire.h5

Import the libraries

import keras

from tensorflow.keras.models import Sequential from tensorflow.keras.layers import Dense

from matplotlib import pyplot as plt

Importing ImageDataGenerator from Keras

# image preprocessing (or) image augmentation

from tensorflow.keras.preprocessing.image import ImageDataGenerator #import the cnn layers

Defining the Parameters

train\_datagen = ImageDataGenerator(rescale=1./255,shear\_range=0.2,zoom\_range=0.2,horizontal\_flip=True,vertical\_flip=Tr ue)

#rescale => rescaling pixel value from 0 to 255 to 0 to 1 #shear\_range=> counter clock wise rotation(anti clock) test\_datagen = ImageDataGenerator(rescale=1./255)

Applying ImageDataGenerator functionality to train dataset

x\_train = train\_datagen.flow\_from\_directory(r"/home/wsuser/work/Dataset/Dataset/train\_set", target\_size=(256,256),

batch\_size=32, class\_mode="binary")

*Found 436 images belonging to 2 classes.*

Applying ImageDataGenerator functionality to test dataset

x\_test = test\_datagen.flow\_from\_directory(r"/home/wsuser/work/Dataset/Dataset/test\_set", target\_size=(256,256),

batch\_size=32, class\_mode="binary")

*Found 121 images belonging to 2 classes.*

Importing Model Building Libraries

from tensorflow.keras.layers import Convolution2D from tensorflow.keras.layers import MaxPooling2D from tensorflow.keras.layers import Flatten

from tensorflow.keras.optimizers import Adam , SGD, RMSprop x\_train.class\_indices

{'forest': 0, 'with fire': 1} **Intializing the model** model = Sequential()

Adding CNN layers

# add convolution layer model.add(Convolution2D(32,(3,3),input\_shape=(256,256,3),activation="relu"))

# 32 indicates => no of feature detectors #(3,3)=> kernel size (feature detector size) #add max pooling layer model.add(MaxPooling2D(pool\_size=(2,2))) #add flatten layer => input to your ANN model.add(Flatten())

Add Dense layers

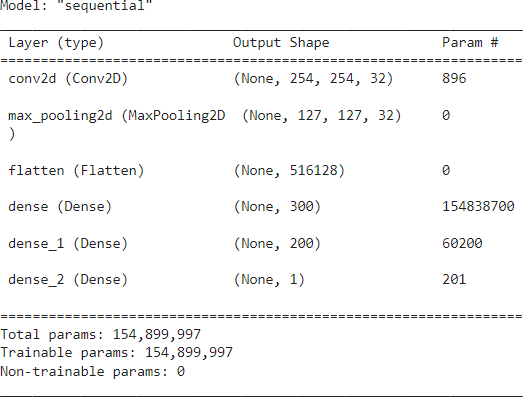
#hidden layer model.add(Dense(units=300,kernel\_initializer="random\_uniform",activation="relu")) model.add(Dense(units=200,kernel\_initializer="random\_uniform",activation="relu")) #output layer model.add(Dense(units=1,kernel\_initializer="random\_uniform",activation="sigmoid"))

Configuring the learning process

#compile the model model.compile(loss=keras.losses.binary\_crossentropy,optimizer="adam",metrics=['accuracy'])

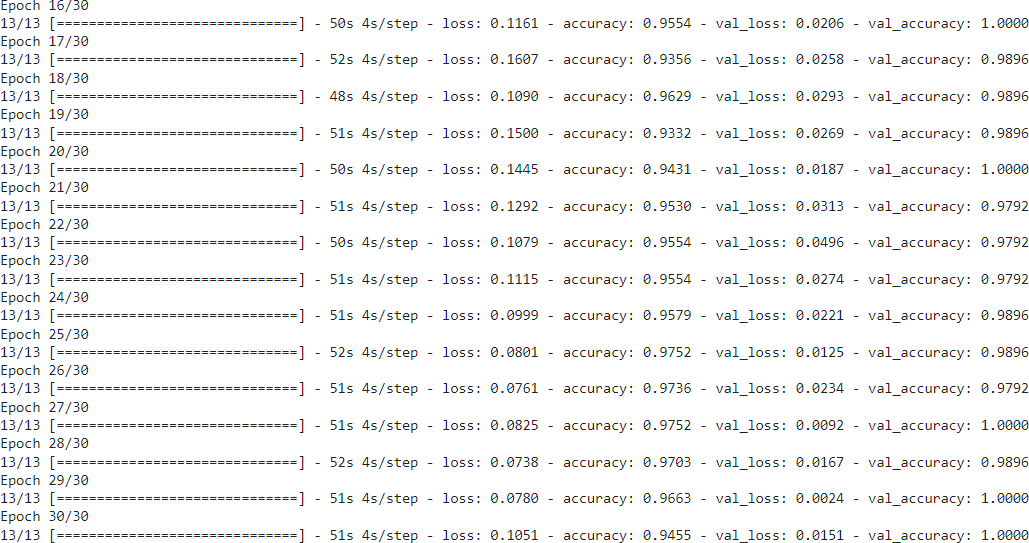
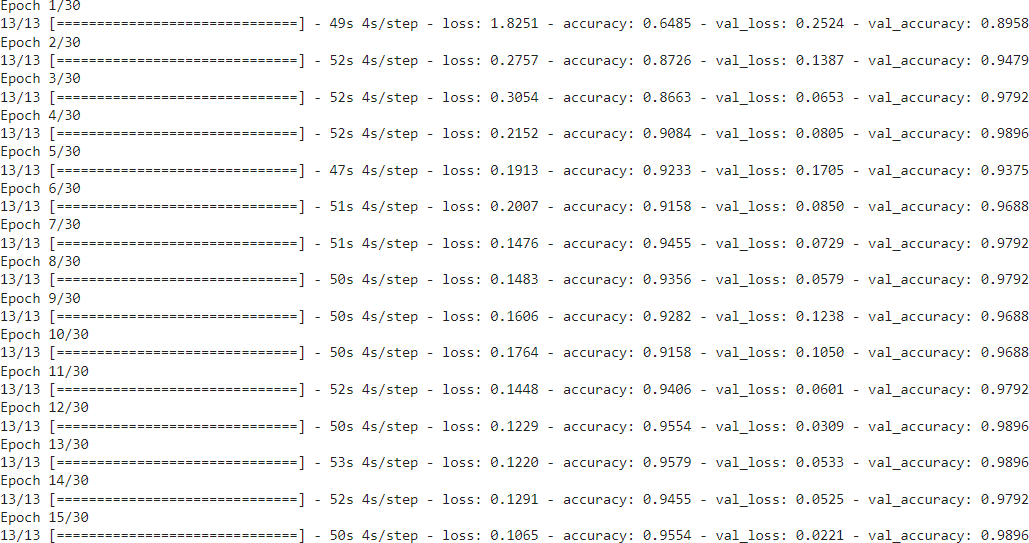
Summarize the model

model.summary()



**Training the model** model.fit(x\_train,steps\_per\_epoch=13,epochs=30,validation\_data=x\_test,validation\_steps=3) #steps\_per\_epoch = no of training images/batch size

#validation\_steps = no of testing images/batch size



**Saving the model** model.save("fire.h5") **IBM Deployment**

!pip install watson-machine-learning-client



from ibm\_watson\_machine\_learning import APIClient wml\_credentials={

"url":"https://us-south.ml.cloud.ibm.com", "apikey":"1AfypwQwqeHikzD7u4LIKT6DMnD-RPDTyYLRBofzNBPp"

}

client=APIClient(wml\_credentials) client

def guid\_space\_name(client,fire\_deploy): space=client.spaces.get\_details()

return(next(item for item in space['resources'] if item['entity']['name']==fire\_deploy)['metadata']['id']) space\_uid=guid\_space\_name(client,'cnn\_fire')

print("Space UID "+space\_uid)

*Space UID def3a2d0-3dd4-4f16-9ba5-cb9feb7700a1*

client.set.default\_space(space\_uid)

*'SUCCESS'*

client.software\_specifications.list(200)

NAME ASSET\_ID TYPE

default\_py3.6 0062b8c9-8b7d-44a0-a9b9-46c416adcbd9 base kernel-spark3.2-scala2.12 020d69ce-7ac1-5e68-ac1a-31189867356a base pytorch-onnx\_1.3-py3.7-edt 069ea134-3346-5748-b513-49120e15d288 base scikit-learn\_0.20-py3.6 09c5a1d0-9c1e-4473-a344-eb7b665ff687 base spark-mllib\_3.0-scala\_2.12 09f4cff0-90a7-5899-b9ed-1ef348aebdee base pytorch-onnx\_rt22.1-py3.9 0b848dd4-e681-5599-be41-b5f6fccc6471 base ai-function\_0.1-py3.6 0cdb0f1e-5376-4f4d-92dd-da3b69aa9bda base shiny-r3.6 0e6e79df-875e-4f24-8ae9-62dcc2148306 base

tensorflow\_2.4-py3.7-horovod 1092590a-307d-563d-9b62-4eb7d64b3f22 base pytorch\_1.1-py3.6 10ac12d6-6b30-4ccd-8392-3e922c096a92 base tensorflow\_1.15-py3.6-ddl 111e41b3-de2d-5422-a4d6-bf776828c4b7 base autoai-kb\_rt22.2-py3.10 125b6d9a-5b1f-5e8d-972a-b251688ccf40 base runtime-22.1-py3.9 12b83a17-24d8-5082-900f-0ab31fbfd3cb base

scikit-learn\_0.22-py3.6 154010fa-5b3b-4ac1-82af-4d5ee5abbc85 base default\_r3.6 1b70aec3-ab34-4b87-8aa0-a4a3c8296a36 base pytorch-onnx\_1.3-py3.6 1bc6029a-cc97-56da-b8e0-39c3880dbbe7 base kernel-spark3.3-r3.6 1c9e5454-f216-59dd-a20e-474a5cdf5988 base pytorch-onnx\_rt22.1-py3.9-edt 1d362186-7ad5-5b59-8b6c-9d0880bde37f base tensorflow\_2.1-py3.6 1eb25b84-d6ed-5dde-b6a5-3fbdf1665666 base spark-mllib\_3.2 20047f72-0a98-58c7-9ff5-a77b012eb8f5 base tensorflow\_2.4-py3.8-horovod 217c16f6-178f-56bf-824a-b19f20564c49 base runtime-22.1-py3.9-cuda 26215f05-08c3-5a41-a1b0-da66306ce658 base do\_py3.8 295addb5-9ef9-547e-9bf4-92ae3563e720 base

autoai-ts\_3.8-py3.8 2aa0c932-798f-5ae9-abd6-15e0c2402fb5 base tensorflow\_1.15-py3.6 2b73a275-7cbf-420b-a912-eae7f436e0bc base kernel-spark3.3-py3.9 2b7961e2-e3b1-5a8c-a491-482c8368839a base pytorch\_1.2-py3.6 2c8ef57d-2687-4b7d-acce-01f94976dac1 base spark-mllib\_2.3 2e51f700-bca0-4b0d-88dc-5c6791338875 base pytorch-onnx\_1.1-py3.6-edt 32983cea-3f32-4400-8965-dde874a8d67e base spark-mllib\_3.0-py37 36507ebe-8770-55ba-ab2a-eafe787600e9 base spark-mllib\_2.4 390d21f8-e58b-4fac-9c55-d7ceda621326 base autoai-ts\_rt22.2-py3.10 396b2e83-0953-5b86-9a55-7ce1628a406f base xgboost\_0.82-py3.6 39e31acd-5f30-41dc-ae44-60233c80306e base pytorch-onnx\_1.2-py3.6-edt 40589d0e-7019-4e28-8daa-fb03b6f4fe12 base pytorch-onnx\_rt22.2-py3.10 40e73f55-783a-5535-b3fa-0c8b94291431 base default\_r36py38 41c247d3-45f8-5a71-b065-8580229facf0 base autoai-ts\_rt22.1-py3.9 4269d26e-07ba-5d40-8f66-2d495b0c71f7 base autoai-obm\_3.0 42b92e18-d9ab-567f-988a-4240ba1ed5f7 base pmml-3.0\_4.3 493bcb95-16f1-5bc5-bee8-81b8af80e9c7 base spark-mllib\_2.4-r\_3.6 49403dff-92e9-4c87-a3d7-a42d0021c095 base xgboost\_0.90-py3.6 4ff8d6c2-1343-4c18-85e1-689c965304d3 base pytorch-onnx\_1.1-py3.6 50f95b2a-bc16-43bb-bc94-b0bed208c60b base autoai-ts\_3.9-py3.8 52c57136-80fa-572e-8728-a5e7cbb42cde base spark-mllib\_2.4-scala\_2.11 55a70f99-7320-4be5-9fb9-9edb5a443af5 base spark-mllib\_3.0 5c1b0ca2-4977-5c2e-9439-ffd44ea8ffe9 base

autoai-obm\_2.0 5c2e37fa-80b8-5e77-840f-d912469614ee base spss-modeler\_18.1 5c3cad7e-507f-4b2a-a9a3-ab53a21dee8b base cuda-py3.8 5d3232bf-c86b-5df4-a2cd-7bb870a1cd4e base runtime-22.2-py3.10-xc 5e8cddff-db4a-5a6a-b8aa-2d4af9864dab base autoai-kb\_3.1-py3.7 632d4b22-10aa-5180-88f0-f52dfb6444d7 base pytorch-onnx\_1.7-py3.8 634d3cdc-b562-5bf9-a2d4-ea90a478456b base spark-mllib\_2.3-r\_3.6 6586b9e3-ccd6-4f92-900f-0f8cb2bd6f0c base

tensorflow\_2.4-py3.7 65e171d7-72d1-55d9-8ebb-f813d620c9bb base spss-modeler\_18.2 687eddc9-028a-4117-b9dd-e57b36f1efa5 base pytorch-onnx\_1.2-py3.6 692a6a4d-2c4d-45ff-a1ed-b167ee55469a base spark-mllib\_2.3-scala\_2.11 7963efe5-bbec-417e-92cf-0574e21b4e8d base spark-mllib\_2.4-py37 7abc992b-b685-532b-a122-a396a3cdbaab base caffe\_1.0-py3.6 7bb3dbe2-da6e-4145-918d-b6d84aa93b6b base pytorch-onnx\_1.7-py3.7 812c6631-42b7-5613-982b-02098e6c909c base cuda-py3.6 82c79ece-4d12-40e6-8787-a7b9e0f62770 base tensorflow\_1.15-py3.6-horovod 8964680e-d5e4-5bb8-919b-8342c6c0dfd8 base hybrid\_0.1 8c1a58c6-62b5-4dc4-987a-df751c2756b6 base

pytorch-onnx\_1.3-py3.7 8d5d8a87-a912-54cf-81ec-3914adaa988d base caffe-ibm\_1.0-py3.6 8d863266-7927-4d1e-97d7-56a7f4c0a19b base runtime-22.2-py3.10-cuda 8ef391e4-ef58-5d46-b078-a82c211c1058 base spss-modeler\_17.1 902d0051-84bd-4af6-ab6b-8f6aa6fdeabb base do\_12.10 9100fd72-8159-4eb9-8a0b-a87e12eefa36 base

do\_py3.7 9447fa8b-2051-4d24-9eef-5acb0e3c59f8 base spark-mllib\_3.0-r\_3.6 94bb6052-c837-589d-83f1-f4142f219e32 base cuda-py3.7-opence 94e9652b-7f2d-59d5-ba5a-23a414ea488f base nlp-py3.8 96e60351-99d4-5a1c-9cc0-473ac1b5a864 base cuda-py3.7 9a44990c-1aa1-4c7d-baf8-c4099011741c base hybrid\_0.2 9b3f9040-9cee-4ead-8d7a-780600f542f7 base spark-mllib\_3.0-py38 9f7a8fc1-4d3c-5e65-ab90-41fa8de2d418 base autoai-kb\_3.3-py3.7 a545cca3-02df-5c61-9e88-998b09dc79af base spark-mllib\_3.0-py39 a6082a27-5acc-5163-b02c-6b96916eb5e0 base runtime-22.1-py3.9-do a7e7dbf1-1d03-5544-994d-e5ec845ce99a base default\_py3.8 ab9e1b80-f2ce-592c-a7d2-4f2344f77194 base tensorflow\_rt22.1-py3.9 acd9c798-6974-5d2f-a657-ce06e986df4d base kernel-spark3.2-py3.9 ad7033ee-794e-58cf-812e-a95f4b64b207 base

autoai-obm\_2.0 with Spark 3.0 af10f35f-69fa-5d66-9bf5-acb58434263a base

runtime-22.2-py3.10 b56101f1-309d-549b-a849-eaa63f77b2fb base default\_py3.7\_opence c2057dd4-f42c-5f77-a02f-72bdbd3282c9 base tensorflow\_2.1-py3.7 c4032338-2a40-500a-beef-b01ab2667e27 base do\_py3.7\_opence cc8f8976-b74a-551a-bb66-6377f8d865b4 base spark-mllib\_3.3 d11f2434-4fc7-58b7-8a62-755da64fdaf8 base autoai-kb\_3.0-py3.6 d139f196-e04b-5d8b-9140-9a10ca1fa91a base spark-mllib\_3.0-py36 d82546d5-dd78-5fbb-9131-2ec309bc56ed base autoai-kb\_3.4-py3.8 da9b39c3-758c-5a4f-9cfd-457dd4d8c395 base kernel-spark3.2-r3.6 db2fe4d6-d641-5d05-9972-73c654c60e0a base autoai-kb\_rt22.1-py3.9 db6afe93-665f-5910-b117-d879897404d9 base

tensorflow\_rt22.1-py3.9-horovod dda170cc-ca67-5da7-9b7a-cf84c6987fae base autoai-ts\_1.0-py3.7 deef04f0-0c42-5147-9711-89f9904299db base tensorflow\_2.1-py3.7-horovod e384fce5-fdd1-53f8-bc71-11326c9c635f base default\_py3.7 e4429883-c883-42b6-87a8-f419d64088cd base do\_22.1 e51999ba-6452-5f1f-8287-17228b88b652 base

autoai-obm\_3.2 eae86aab-da30-5229-a6a6-1d0d4e368983 base runtime-22.2-r4.2 ec0a3d28-08f7-556c-9674-ca7c2dba30bd base tensorflow\_rt22.2-py3.10 f65bd165-f057-55de-b5cb-f97cf2c0f393 base do\_20.1 f686cdd9-7904-5f9d-a732-01b0d6b10dc5 base

pytorch-onnx\_rt22.2-py3.10-edt f8a05d07-e7cd-57bb-a10b-23f1d4b837ac base scikit-learn\_0.19-py3.6 f963fa9d-4bb7-5652-9c5d-8d9289ef6ad9 base tensorflow\_2.4-py3.8 fe185c44-9a99-5425-986b-59bd1d2eda46 base

software\_space\_uid=client.software\_specifications.get\_uid\_by\_name('tensorflow\_rt22.1-py3.9') software\_space\_uid

*'acd9c798-6974-5d2f-a657-ce06e986df4d'*

ls

Dataset/ fire-classification-model.tgz forest1.h5 fie-classification-model.tgz fire.h5

!tar -zcvf fire-classification-model.tgz fire.h5 fire.h5

model\_details=client.repository.store\_model(model='fire-classification-model.tgz',meta\_props={ client.repository.ModelMetaNames.NAME:"CNN Model Building", client.repository.ModelMetaNames.TYPE:'tensorflow\_2.7', client.repository.ModelMetaNames.SOFTWARE\_SPEC\_UID:software\_space\_uid

})

model\_id=client.repository.get\_model\_id(model\_details) model\_id

*'babd0250-5274-4923-850c-7fe9ce7e2409'*

client.repository.download(model\_id,'fire.tar.gb')

*Successfully saved model content to file: 'fire.tar.gb' '/home/wsuser/work/fire.tar.gb'*

ls

*Dataset/ fire-classification-model.tgz fire.tar.gb fie-classification-model.tgz fire.h5 forest1.h5*

### Feature 2

#### Creation of twilio account

To send an outgoing SMS message from your Twilio account you’ll need to make an HTTP POST to Twilio's Message resource.

Twilio's Python library helps you to create a new instance of the Message resource, specifying the To, From, and Body parameters of your message.

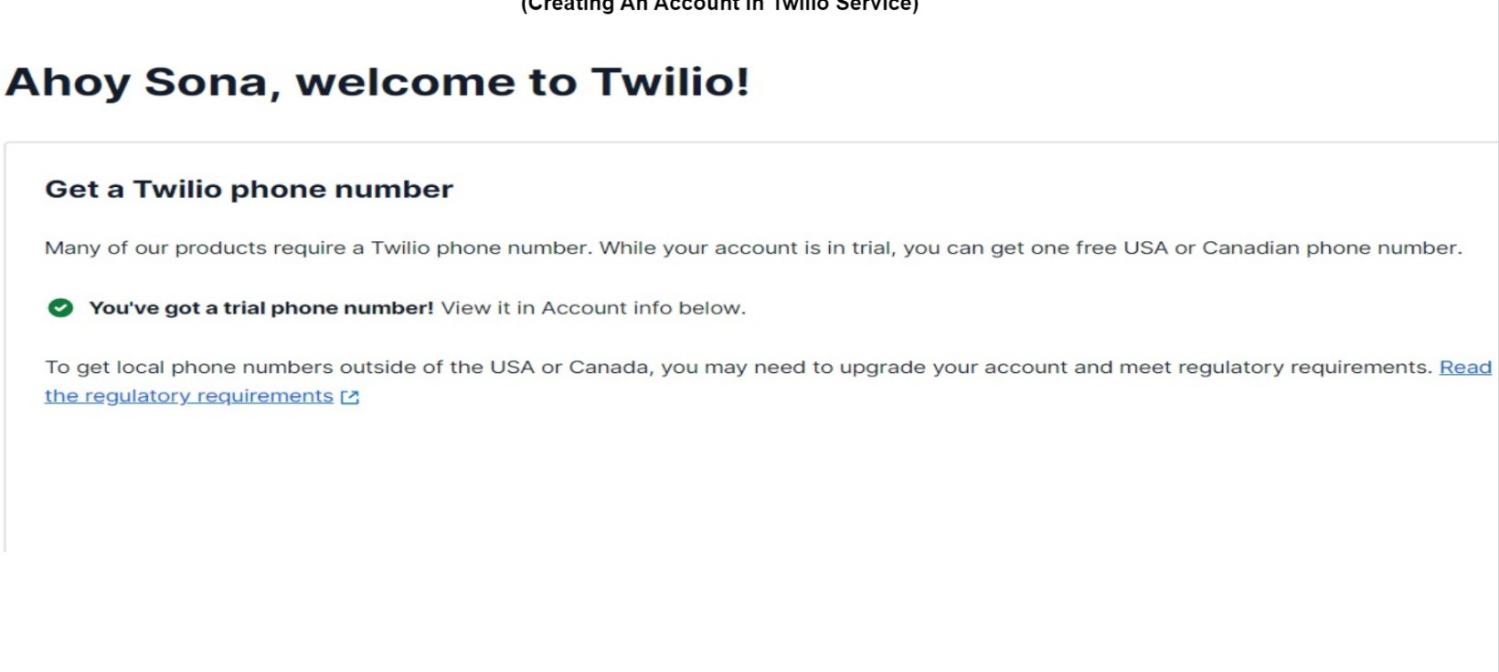
Replace the placeholder values for account\_sid and auth\_token with your unique values. You can find these in your Twilio console.

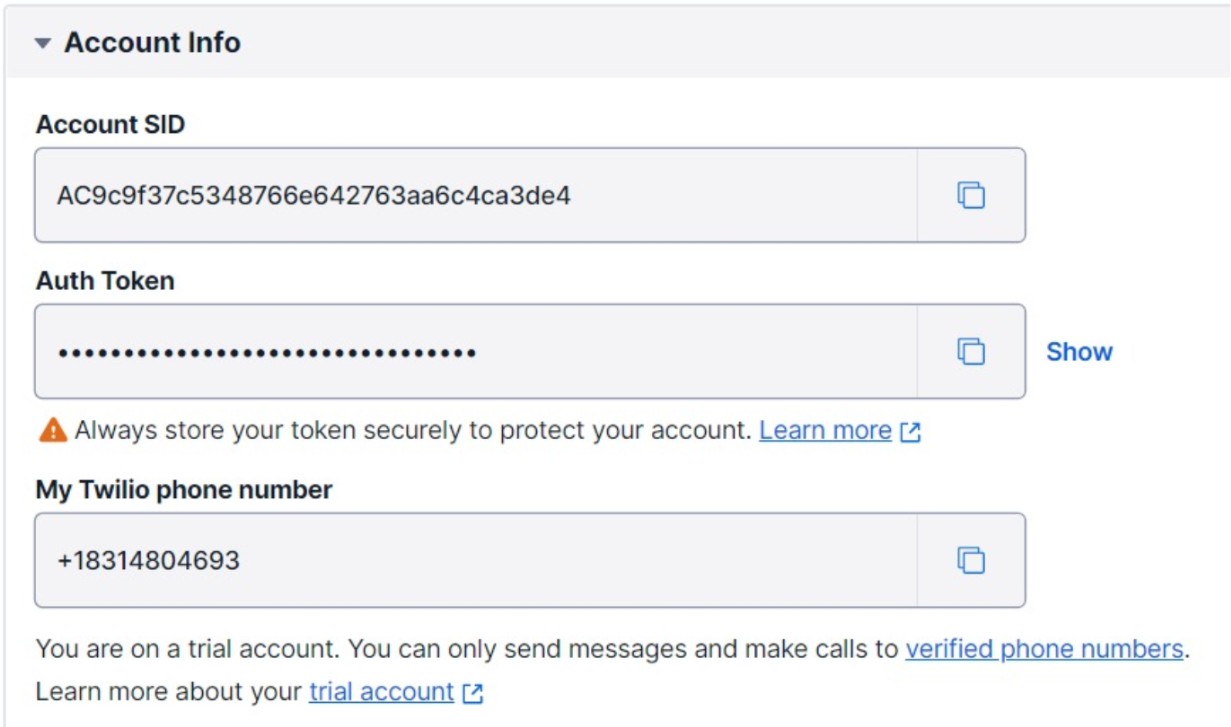
You’ll tell Twilio which phone number to use to send this message by replacing the from\_ number with the Twilio phone number you purchased earlier.

Next, specify yourself as the message recipient by replacing the to number with your mobile phone number. Both of these parameters must use [E.164](https://www.twilio.com/docs/glossary/what-e164) formatting (+ and a country code, e.g.,

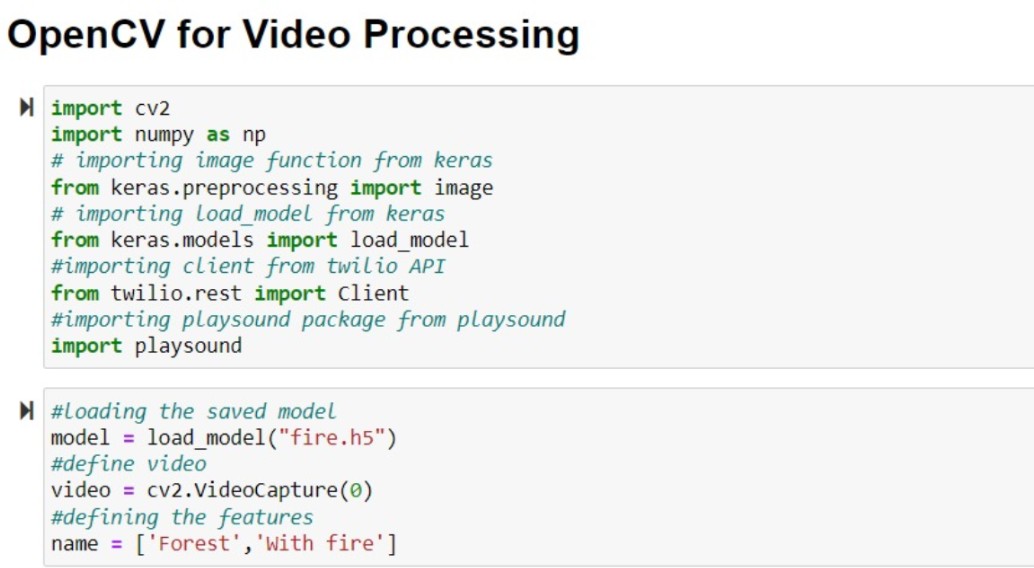
+16175551212)

We also include the body parameter, which contains the content of the SMS we’re going to send.

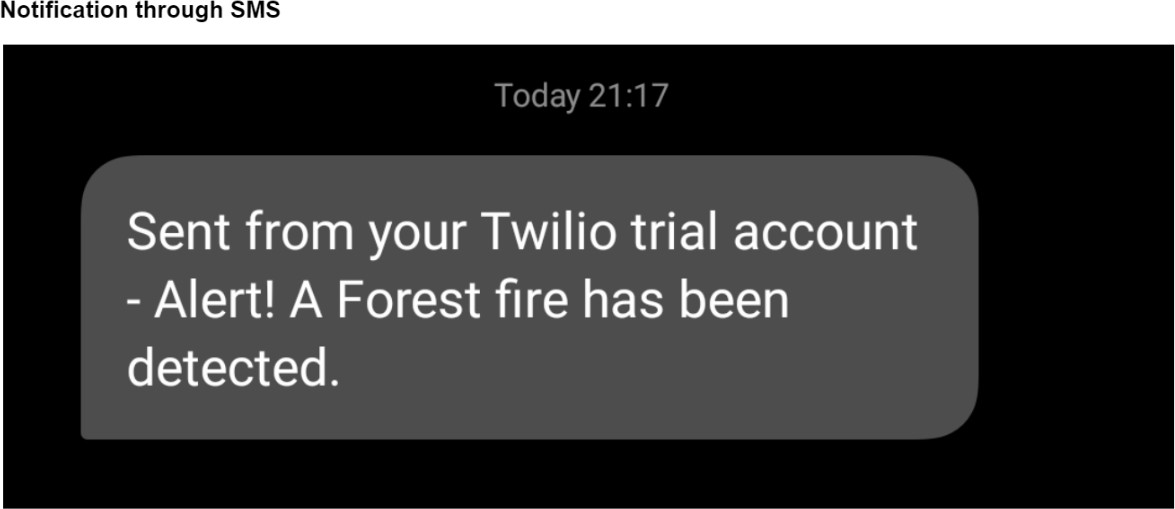




1. **Sending SMS alert** 👍







# Chapter 8

## TESTING

### Test Cases

Panel switches and keypads: TEST the operation of each control.

Visual indicators: TEST the operation of each visual indicator and alphanumeric display.

Battery: MEASURE system quiescent and maximum alarm currents in accordance with Appendix. Calculate the required battery capacity and CHECK the nominal capacity of the installed batteries is not less than the calculated capacity.

Verify that the measured currents are the same as recorded in the baseline data.

### User Acceptance Testing

#### Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the project at the time of the release to User Acceptance Testing (UAT).

#### Defect Analysis

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Resolution** | **Severity 1** | **Severity 2** | **Severity 3** | **Severity 4** | **Subtotal** |
| By Design | 9 | 5 | 1 | 2 | 17 |
| Duplicate | 1 | 0 | 2 | 0 | 3 |
| External | 3 | 3 | 0 | 1 | 7 |
| Fixed | 10 | 2 | 3 | 20 | 35 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Not Reproduced | 0 | 0 | 1 | 0 | 1 |
| Skipped | 0 | 0 | 1 | 1 | 2 |
| Won't Fix | 0 | 4 | 2 | 1 | 7 |
| Totals | 13 | 15 | 10 | 25 | 7  2 |

#### Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

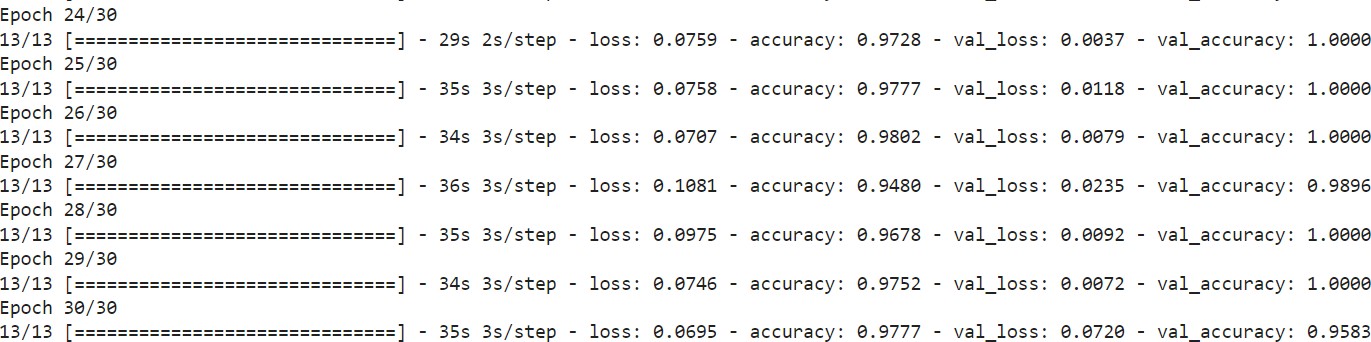
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Section** | **Total Cases** | **Not Tested** | **Fail** | **Pass** |
| Print Engine | 7 | 0 | 0 | 7 |
| Client Application | 53 | 0 | 0 | 53 |
| Security | 2 | 0 | 0 | 2 |
| Outsource Shipping | 4 | 0 | 0 | 4 |
| Exception Reporting | 7 | 0 | 0 | 7 |
| Final Report Output | 3 | 0 | 0 | 3 |
| Version Control | 1 | 0 | 0 | 1 |

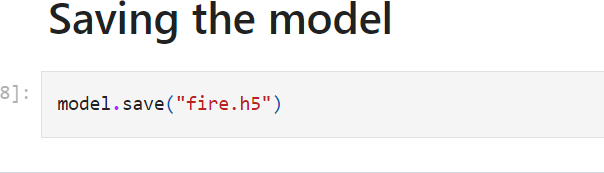
# Chapter 9

## RESULTS

### 9.1 Performance Metrics

#### Training the Model

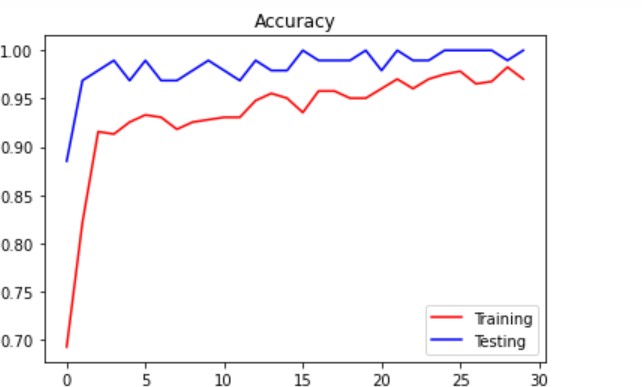




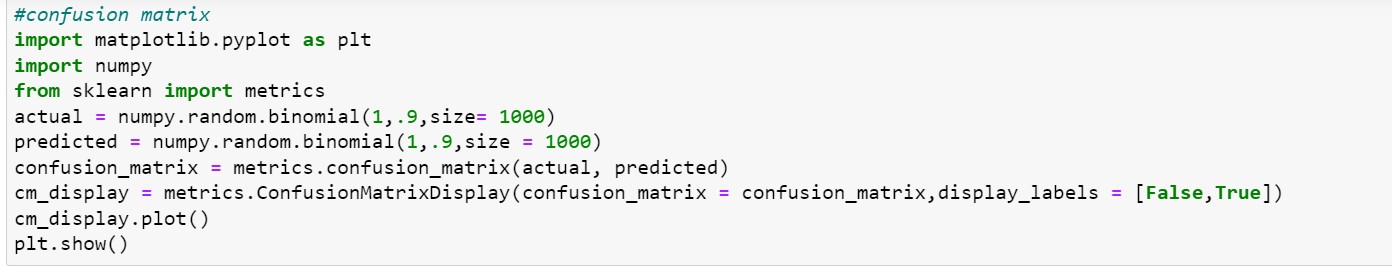
1. **Loss or No loss**

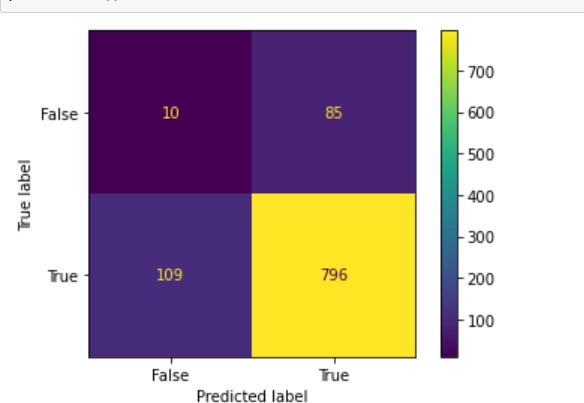
#### Accuracy Value





1. **Confusion matrix**





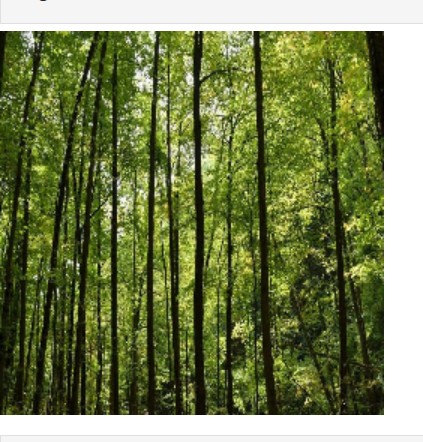
#### Predictions

**from** tensorflow.keras.models **import** load\_model

**from** tensorflow.keras.preprocessing **import** image model **=** load\_model("fire.h5")

img **=** image**.**load\_img(r"C:\Users\Isha\Pictures\Saved Pictures\egnofire.jpg",target\_size**=**(256,256))

img



type(img)

PIL.Image.Image

x **=** image**.**img\_to\_array(img)

x

array([[[ 12., 14., 0.],

|  |  |  |
| --- | --- | --- |
| [ 21., | 24., | 7.], |
| [ 43., | 46., | 27.], |
| ...,  [ 21., | 19., | 7.], |
| [ 13., | 15., | 2.], |
| [ 52., | 60., | 11.]], |
| [[ 13., | 15., | 2.], |
| [ 12., | 14., | 0.], |
| [ 18., | 21., | 4.], |
| ...,  [ 17., | 15., | 2.], |
| [ 10., | 11., | 3.], |
| [ 58., | 65., | 23.]], |
| [[ 14., | 15., | 7.], |
| [ 11., | 13., | 2.], |
| [ 10., | 12., | 0.], |
| ...,  [ 19., | 18., | 0.], |
| [ 17., | 18., | 13.], |
| [ 62., | 66., | 39.]], |
| [[ 14., | 15., | 7.], |
| [ 51., | 56., | 26.], |
| [ 48., | 57., | 2.], |
| ...,  [ 50., | 65., | 26.], |
| [ 58., | 75., | 30.], |
| [ 54., | 73., | 27.]], |

...,

[[ 17., 19., 8.],

[ 49., 54., 24.],

[103., 112., 57.],

...,

|  |  |  |
| --- | --- | --- |
| [ 65., | 80., | 41.], |
| [ 61., | 78., | 33.], |
| [ 64., | 83., | 37.]], |
| [[ 18., | 18., | 8.], |
| [ 36., | 39., | 8.], |
| [ 77., | 85., | 28.], |
| ...,  [ 79., | 94., | 55.], |
| [ 50., | 67., | 22.], |
| [ 52., | 71., | 25.]]], dtype=float32) |

x**.**shape

(256, 256, 3)

**import** numpy **as** np

*# convolution expects 4D*

x **=** np**.**expand\_dims(x,axis**=**0)

x**.**shape

(1, 256, 256, 3)

pred\_prob **=** model**.**predict(x)

1/1 [==============================] - 0s 111ms/step

pred\_prob

array([[0.]], dtype=float32)

**if**(pred\_prob**==**0): print("There is no fire")

else:

print("There is a fire") There is no fire

# Chapter 10

## ADVANTAGES & DISADVANTAGES

#### ADVANTAGES:

* The proposed system detects the forest fire at a faster rate compared to the existing system. It has an enhanced data collection feature.
* The major aspect is that it reduces false alarms and also has accuracy due to the various sensors present.
* It minimizes human effort as it works automatically.
* This is very affordable due to which it can be easily accessed.
* The main objective of our project is to receive an alert message through an app to the respective user.
* The arrangement is fire-proof and can withstand high temperatures, rugged, reliable, cost-effective, and easy to install.
* It is also easy to decode the data from satellites at the ground station and no experts are required to understand or decode the data from the satellite.
* All the components like the temperature sensor and the GPS are easy to interface.
* The approximate value of temperature and the GPS coordinates are obtained. Since we are using wireless sensing networks, the attenuation during the transmission of the signal or the data is minimised.
* It is More Reliable

#### DISADVANTAGES:

* The electrical interference diminishes the effectiveness of the radio receiver.
* The main drawback is that it has less coverage range areas.
* Even a small fault would cause the whole system to fail.

# Chapter 11

## CONCLUSION

The proposed system for forest fire detection using wireless sensor networks and machine learning was found to be an effective method for fire detection in forests that provides more accurate results. Here, to obtain a more accurate outcome within the lowest latency, the analysis should take place continuously and camera monitoring should be effectively done. This system is well developed to fit any weather condition, climatic condition, or area. In the case of node deployment, cameras can be mounted at any place in the forest even with good connectivity and built-in network infrastructure. IR frame sensors are used to enhance the efficiency of the system. A unique feature that sends alert messages to the concerned authorities when the fire is detected is also added. Thus, By detecting forest fires we can reduce air pollution, landslides, and soil erosion by protecting strong-rooted trees, and the emission of CO2 into the air during fire causing no loss of life and resources.

# Chapter 12

## FUTURE SCOPE

* Right now we have designed the project for the control of two devices but it can be designed for more numbers of devices.
* It can be further expanded with a voice interactive system facility.
* A feedback system can also be included which provides the state of the device to the remote users.

# Chapter 13

## APPENDIX

### Source Code

#### #Download the Dataset

pwd

*#Load the Image Dataset* from google.colab import drive drive.mount('/content/drive')

*# call load\_data with allow\_pickle implicitly set to true* import numpy as np

data **=** np**.**load('/content/drive/My Drive/Forest-Dataset/Dataset.zip', allow\_pickle**=True**) print('data loaded') cd **//**content**/**drive**/**MyDrive**/**Forest**-**Dataset

*#Unzip the Dataset*

!unzip Dataset**.**zip

#### #Image Preprocessing

***#1.Importing the ImageDataGenerator Library* import** numpy **as** np **import** keras **from** sklearn.model\_selection **import** train\_test\_split **from** keras.models **import** Sequential, load\_model **from** keras.preprocessing.image **import** ImageDataGenerator **from** keras.callbacks **import** ModelCheckpoint, EarlyStopping, TensorBoard **from** keras.callbacks **import** ReduceLROnPlateau

**from** keras.layers **import** Conv2D, Dropout, Dense, Flatten, MaxPooling2D, SeparableConv2D, Activation, BatchNormalization **import** matplotlib.pyplot **as** plt **import** time **import** os

**import** tensorflow **as** tf

***#2.Define parameters for ImageDataGenerator Class*** train\_datagen**=**ImageDataGenerator(rescale**=**1.**/**255, shear\_range**=**0.2,

rotation\_range**=**180, zoom\_range**=**0.2,

horizontal\_flip**=True**) test\_datagen**=**ImageDataGenerator(rescale**=**1.**/**255)

#3.Applying ImageDataGenerator Functionality to Trainset and Testset #*a. For Dataset*

x\_dataset

=train\_datagen.flow\_from\_directory(r"/content/drive/MyDrive/ForestDataset/forest\_fir e",target\_size = (128,128), class\_mode = "binary",batch\_size=32)

#*b. For Trainset*

x\_train

=train\_datagen.flow\_from\_directory(r"/content/drive/MyDrive/ForestDataset/forest\_fir e/Training and Validation",target\_size = (128,128), class\_mode = "binary",batch\_size=32) # *c. For Testset*

x\_test

=test\_datagen.flow\_from\_directory(r"/content/drive/MyDrive/ForestDataset/for est\_fire/Testing",target\_size = (128,128), class\_mode = "binary", batch\_size=32) x\_train.class\_indices

#### # Model Building

**# 1.Importing the Model Building Libraries**

#Importing model libraries

from tensorflow.keras.models import Sequential from tensorflow.keras.layers import Dense from tensorflow.keras.layers import Convolution2D from tensorflow.keras.layers import MaxPooling2D from tensorflow.keras.layers import Flatten

import warnings warnings.filterwarnings('ignore') ***##2.Initializing the Model***

model=Sequential()

***# 3.Adding CNN Layers***

#a. adding convolutional layer model.add(Convolution2D(32,(3,3),input\_shape=(256,256,3),activation="relu")) #b. adding max pooling layer

model.add(MaxPooling2D(pool\_size=(2,2))) #c. adding flatten layer model.add(Flatten())

#### #Model Summary

model.summary()

***# 4.Adding Dense Layers***

#a. Adding Hidden layers model.add(Dense(units=300,kernel\_initializer="random\_uniform",activation="relu")) model.add(Dense(units=200,kernel\_initializer="random\_uniform",activation="relu"))

#b. Adding Output layer model.add(Dense(units=1,kernel\_initializer="random\_uniform",activation="sigmoid")) ***# 5.Configuring the Learning Process***

model.compile(loss='binary\_crossentropy', optimizer='adam', metrics=['accuracy'])

#### # 6.Summarize the model

model.summary()

#### # 7.Training the Model

#fit or train the model r=model.fit\_generator(x\_train,steps\_per\_epoch=13,

epochs=30,validation\_data=x\_test, validation\_steps=3)

#plotting loss value import matplotlib.pyplot as plt plt.plot(r.history['loss'],label='loss') plt.plot(r.history['val\_loss'],label='val\_loss')

plt.legend()

#plotting accuracy value plt.plot(r.history['accuracy'],label='acc') plt.plot(r.history['val\_accuracy'],label='val\_acc') plt.legend()

***# 8.Save the Model***

model.save("fire.h5")

#### #Training and Deploying the model in cloud

pwd

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='EHmhit2MD64AQnqYijN7mrXyaEYoh02jLsiuzU5mzGbt', 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 = 'ffdcnnmodelbook-donotdelete-pr-giva0vdmx0opfa'

object\_key = 'forestfiredataset.zip'

streaming\_body\_3 = 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\_3.read()),'r') file\_paths=unzip.namelist()

for path in file\_paths: unzip.extract(path)

print(ls)

#Import the libraries

import keras

from tensorflow.keras.models import Sequential from tensorflow.keras.layers import Dense

from matplotlib import pyplot as plt

#Importing ImageDataGenerator from Keras

# image preprocessing (or) image augmentation

from tensorflow.keras.preprocessing.image import ImageDataGenerator #import the cnn layers

#Defining the Parameters

train\_datagen = ImageDataGenerator(rescale=1./255,shear\_range=0.2,zoom\_range=0.2,horizontal\_flip=True,vertical\_flip=Tr ue)

#rescale => rescaling pixel value from 0 to 255 to 0 to 1 #shear\_range=> counter clock wise rotation(anti clock) test\_datagen = ImageDataGenerator(rescale=1./255) **#Applying ImageDataGenerator functionality to train dataset**

x\_train = train\_datagen.flow\_from\_directory(r"/home/wsuser/work/Dataset/Dataset/train\_set", target\_size=(256,256),

batch\_size=32, class\_mode="binary")

#Applying ImageDataGenerator functionality to test dataset

x\_test = test\_datagen.flow\_from\_directory(r"/home/wsuser/work/Dataset/Dataset/test\_set", target\_size=(256,256),

batch\_size=32, class\_mode="binary")

#Importing Model Building Libraries

from tensorflow.keras.layers import Convolution2D from tensorflow.keras.layers import MaxPooling2D from tensorflow.keras.layers import Flatten

from tensorflow.keras.optimizers import Adam , SGD, RMSprop print(x\_train.class\_indices)

**#Intializing the model** model = Sequential() **#Adding CNN layers** # add convolution layer

model.add(Convolution2D(32,(3,3),input\_shape=(256,256,3),activation="relu")) # 32 indicates => no of feature detectors

#(3,3)=> kernel size (feature detector size) #add max pooling layer model.add(MaxPooling2D(pool\_size=(2,2))) #add flatten layer => input to your ANN model.add(Flatten())

#Add Dense layers

#hidden layer model.add(Dense(units=300,kernel\_initializer="random\_uniform",activation="relu")) model.add(Dense(units=200,kernel\_initializer="random\_uniform",activation="relu")) #output layer model.add(Dense(units=1,kernel\_initializer="random\_uniform",activation="sigmoid")) **#Configuring the learning process**

#compile the model model.compile(loss=keras.losses.binary\_crossentropy,optimizer="adam",metrics=['accuracy']) **#Summarize the model**

model.summary()

**#Training the model** model.fit(x\_train,steps\_per\_epoch=13,epochs=30,validation\_data=x\_test,validation\_steps=3) #steps\_per\_epoch = no of training images/batch size

#validation\_steps = no of testing images/batch size

**#Saving the model** model.save("fire.h5") **#IBM Deployment**

!pip install watson-machine-learning-client

from ibm\_watson\_machine\_learning import APIClient wml\_credentials={

"url":"https://us-south.ml.cloud.ibm.com", "apikey":"1AfypwQwqeHikzD7u4LIKT6DMnD-RPDTyYLRBofzNBPp"

}

client=APIClient(wml\_credentials) print(client)

def guid\_space\_name(client,fire\_deploy): space=client.spaces.get\_details()

return(next(item for item in space['resources'] if item['entity']['name']==fire\_deploy)['metadata']['id']) space\_uid=guid\_space\_name(client,'cnn\_fire')

print("Space UID "+space\_uid) client.set.default\_space(space\_uid) client.software\_specifications.list(200)

software\_space\_uid=client.software\_specifications.get\_uid\_by\_name('tensorflow\_rt22.1-py3.9') print(software\_space\_uid)

print(ls)

!tar -zcvf fire-classification-model.tgz fire.h5 model\_details=client.repository.store\_model(model='fire-classification-model.tgz',meta\_props={

client.repository.ModelMetaNames.NAME:"CNN Model Building", client.repository.ModelMetaNames.TYPE:'tensorflow\_2.7', client.repository.ModelMetaNames.SOFTWARE\_SPEC\_UID:software\_space\_uid

})

model\_id=client.repository.get\_model\_id(model\_details) print(model\_id) *'*client.repository.download(model\_id,'fire.tar.gb') print(ls)

#### # Predictions

#import load model from keras.model from keras.models import load\_model #import image from keras

from tensorflow.keras.preprocessing import image import numpy as np

#import cv2 import cv2

#load the saved model model=load\_model("fire.h5")

img=image.load\_img('/home/wsuser/work/Dataset/test\_set/with fire/forest\_fire\_2268729\_1280.jpg')

x=image.img\_to\_array(img) res=cv2.resize(x,dsize=(64,64),interpolation=cv2.INTER\_CUBIC) #expand the image shape

x=np.expand\_dims(res,axis=0) pred=model.predict(x)

pred = int(pred[0][0]) print(pred)

if pred==1:

print('Forest fire') elif pred==0:

print('No Fire')

#### #OpenCV for Video Processing

import cv2

import numpy as np

# importing image function from keras from keras.preprocessing import image # importing load\_model from keras from keras.models import load\_model #importing client from twilio API

from twilio.rest import Client

#importing playsound package from playsound import playsound

model=load\_model('/content/forest1.h5')

video = cv2.VideoCapture(0) name = ['forest','with fire']

#### #Sending an Alert Message through Twilio

from twilio.rest import Client from playsound import playsound if pred==1:

print('Forest fire') account\_sid='AC0919212286ee0fa7e4228913458e863f' auth\_token='be43a0e16f576d34aad641b0cec546ef' client=Client(account\_sid,auth\_token) message=client.messages \

.create(

body='forest fire is detected,stay alert', #use twilio free number from\_='+19803934024',

#to number to='+919962082226')

print(message.sid) print("Fire detected") print("SMS Sent!")

### GitHub Link

[Go to Github](https://github.com/IBM-EPBL/IBM-Project-1695-1658409969)