RAJKIYA ENGINEERING COLLEGE MAINPURI

GROUP PROJECT

FIRE DETECTION SYSTEM

Our Mentor: :

Dr. Anshuk Kumar Mishra
Head Of Department

Our Team

Akash Verma
Team Leader

Hritik Kashayp
Team Member

Chitrangee Singh
Team Member

Mansi Asthana
Team Member

Overview

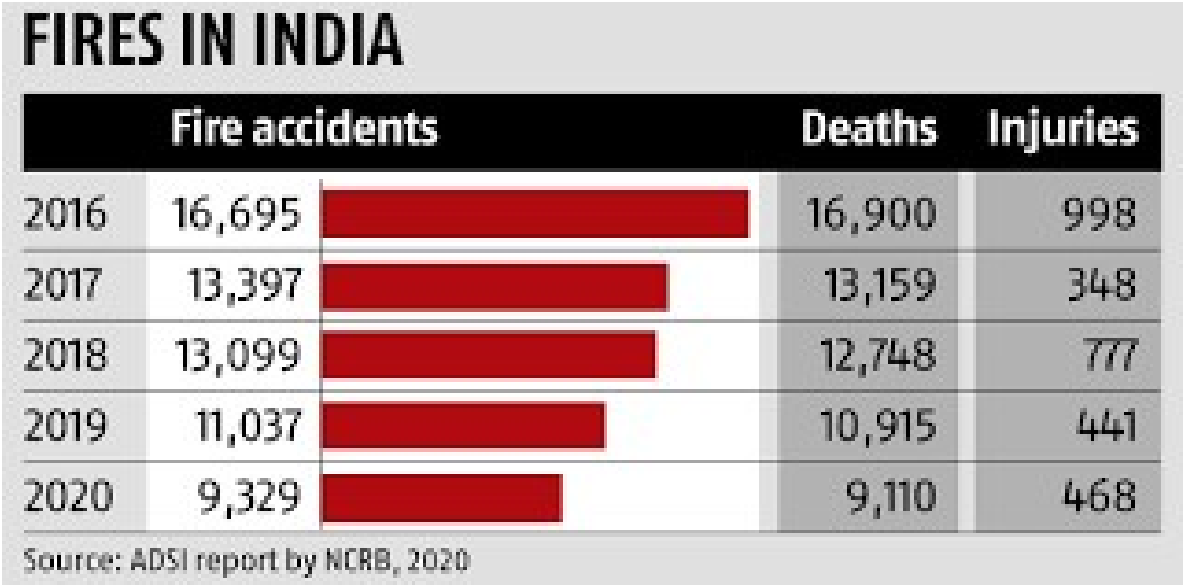
1. Project Objectives
2. Motivation
3. Types of fire detection Sensor
4. Disadvantage of Traditional Fire Detection System.
5. Data collection → Data Cleaning → Data Annotation
6. Proposed System Overview ie, Fire Detection based on-
   - Haar cascade Classifier
   - HSV fire detection
   - Deep learning
7. Testing
8. Future Scope

Project Objective

- Autonomous robotic fire detection and extinguishing system .
- Fire detection based on image processing-
  - Haar cascade Classifier
  - HSV fire detection
  - Deep learning

Motivation

- Human and Economic Loss.
- Fields on fire: 1,500 fire incidents a day in Uttar Pradesh; heavy damage to standing wheat crop. [December 21, 2022]
- Reasons for failure of Traditional Fire sensors.



Types of fire Sensor

I. Ionization-
   - constant electrical current running between two metal plates inside of the device.
   - electrical current is disrupted when smoke enters the device chamber and triggers the alarm.

II. Photoelectric –
   - work similarly to Ionization detectors, but with a beam of light instead of electricity is used.

III. Heat-
   - work by detecting an increase in air temperature caused by flames

IV. Ionization/Photoelectric –

- combination ionization and photoelectric smoke detector is a consider.

Disadvantage of Traditional Fire Detection System.

- Sensors - high false alarm rate
- Open and large areas - not suitable
- Fatal time delays
- Detects smoke not fire
- Higher density for greater precision

- Data –

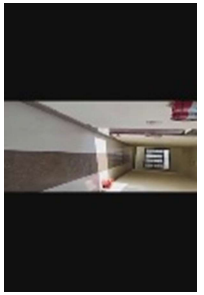
Positive data






Negative Data



Data collection

Three methods to obtain data –

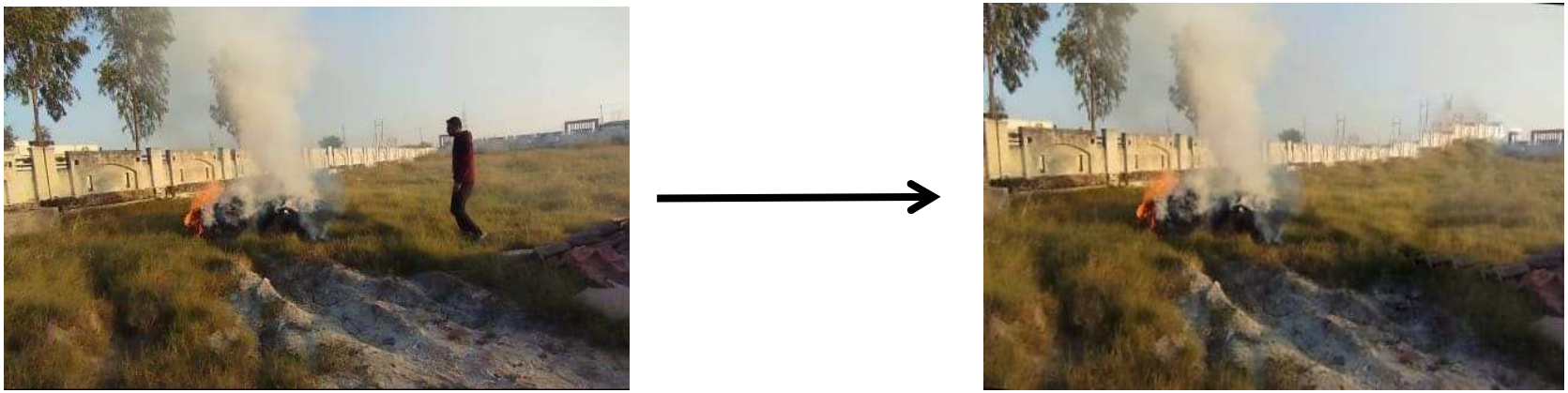
a. **Use open data -**
   - Referred to as public or open source.
   - Convenient, minimal cost.[A]
   - Data features and quality may not meet your needs
   - Spend more time validating the annotations if pre-label is not correct.[D]

b. **Make your dataset –**
   - Gather data using software solutions like web-scraping tools
   - Collect data manually using camera.
   - You can create according to your standards and feature requirements.[A]
   - Time-consuming and resource-intensive.[D]

- **Collaborate with a 3rd party-**
  - Collaborate with an organization or business that collects data on your behalf.
  - Can be costly.[D]

c. Data Cleaning –

- Remove all those frame in which positive data is not visible.
- Some Algo. Like Haar cascade require more accurate positive data so remove the useless data.



- Data Annotation –
  - Important for haar cascade classifier training.

STEPS -

i. Prepare your image dataset.

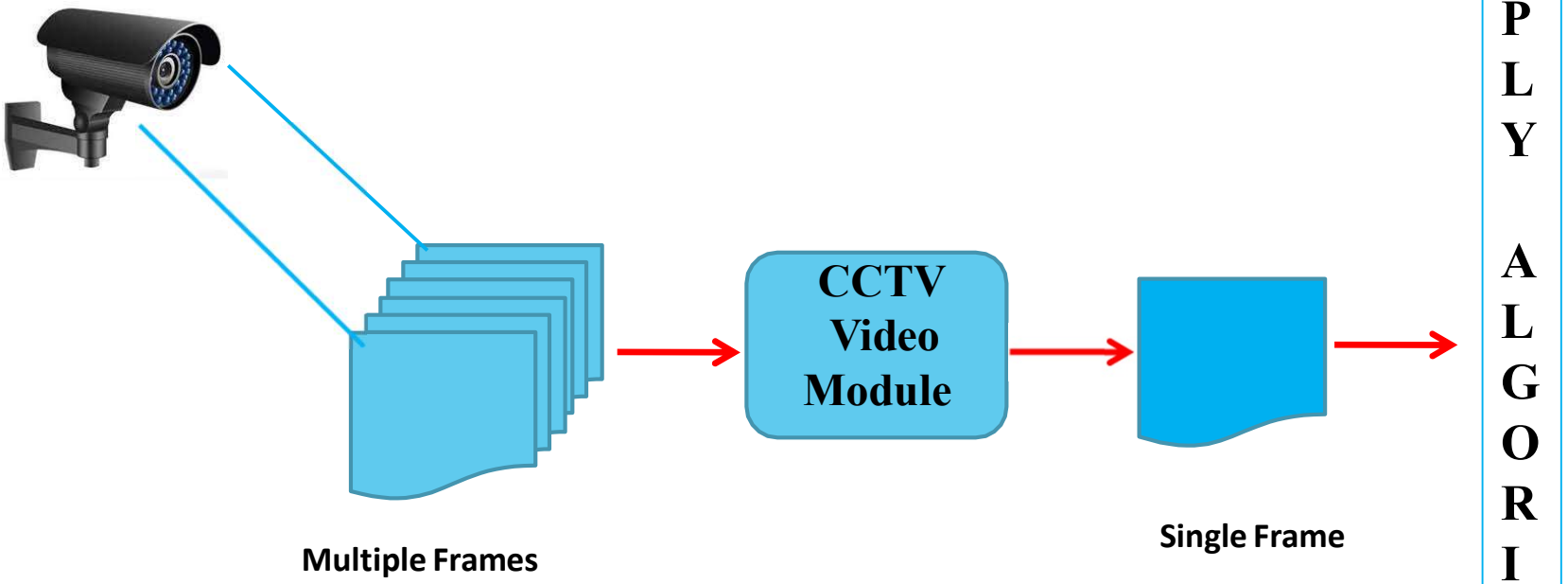
ii. Specify the class labels of objects to detect.

iii. In every image, draw a box around the object you want to detect.

iv. Select the class label for every box you drew.

Proposed System Overview

CCTV Video Module



What I see

What a computer sees

```
08 02 22 97 38 15 00 40 00 75 04 05 07 78 52 12 50 77 91 08
49 49 99 40 17 81 18 57 60 87 17 40 98 43 69 48 04 56 62 00
81 49 31 73 55 79 14 29 93 71 40 67 53 88 30 03 49 13 36 65
52 70 95 23 04 60 11 42 69 24 68 56 01 32 56 71 37 02 36 91
22 31 16 71 51 67 63 89 41 92 36 54 22 40 40 28 66 33 13 80
24 47 32 60 99 03 45 02 44 75 33 53 78 36 84 20 35 17 12 50
32 98 81 28 64 23 67 10 26 38 40 67 59 54 70 66 18 38 64 70
67 26 20 68 02 62 12 20 95 63 94 39 63 08 40 91 66 49 94 21
24 55 58 05 66 73 99 26 97 17 78 78 96 83 14 88 34 89 63 72
21 36 23 09 75 00 76 44 20 45 35 14 00 61 33 97 34 31 33 95
78 17 53 28 22 75 31 67 15 94 03 80 04 62 16 14 09 53 56 92
16 39 05 42 96 35 31 47 55 58 88 24 00 17 54 24 36 29 85 57
86 56 00 48 35 71 89 07 05 44 44 37 44 60 21 58 51 54 17 58
19 80 81 68 05 94 47 69 28 73 92 13 86 52 17 77 04 89 55 40
04 52 08 83 97 35 99 16 07 97 57 32 16 26 26 79 33 27 98 66
88 36 68 87 57 62 20 72 03 46 33 67 46 55 12 32 63 93 53 69
04 42 16 73 38 25 39 11 24 94 72 18 08 46 29 32 40 62 76 36
20 69 36 41 72 30 23 88 34 62 99 69 82 67 59 85 74 04 36 16
20 73 35 29 78 31 90 01 74 31 49 71 48 86 81 16 23 57 05 54
01 70 54 71 83 51 54 69 16 92 33 48 61 43 52 01 89 19 67 48
```

1. Haar cascade Classifier –

- Published by Paul Viola and Michael Jones.
- Histogram of Oriented Gradients (HOG) + Linear SVM and deep learning.

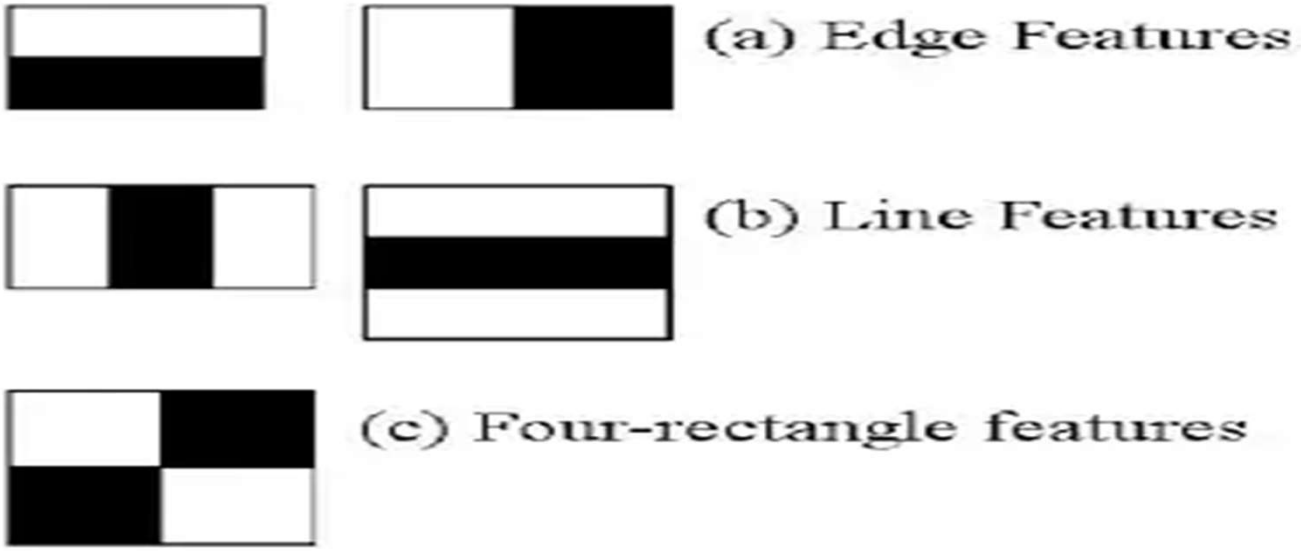
The algorithm can be explained in four stages:

i. Calculating Haar Features
ii. Creating Integral Images
iii. Using Adaboost
iv. Implementing Cascading Classifiers

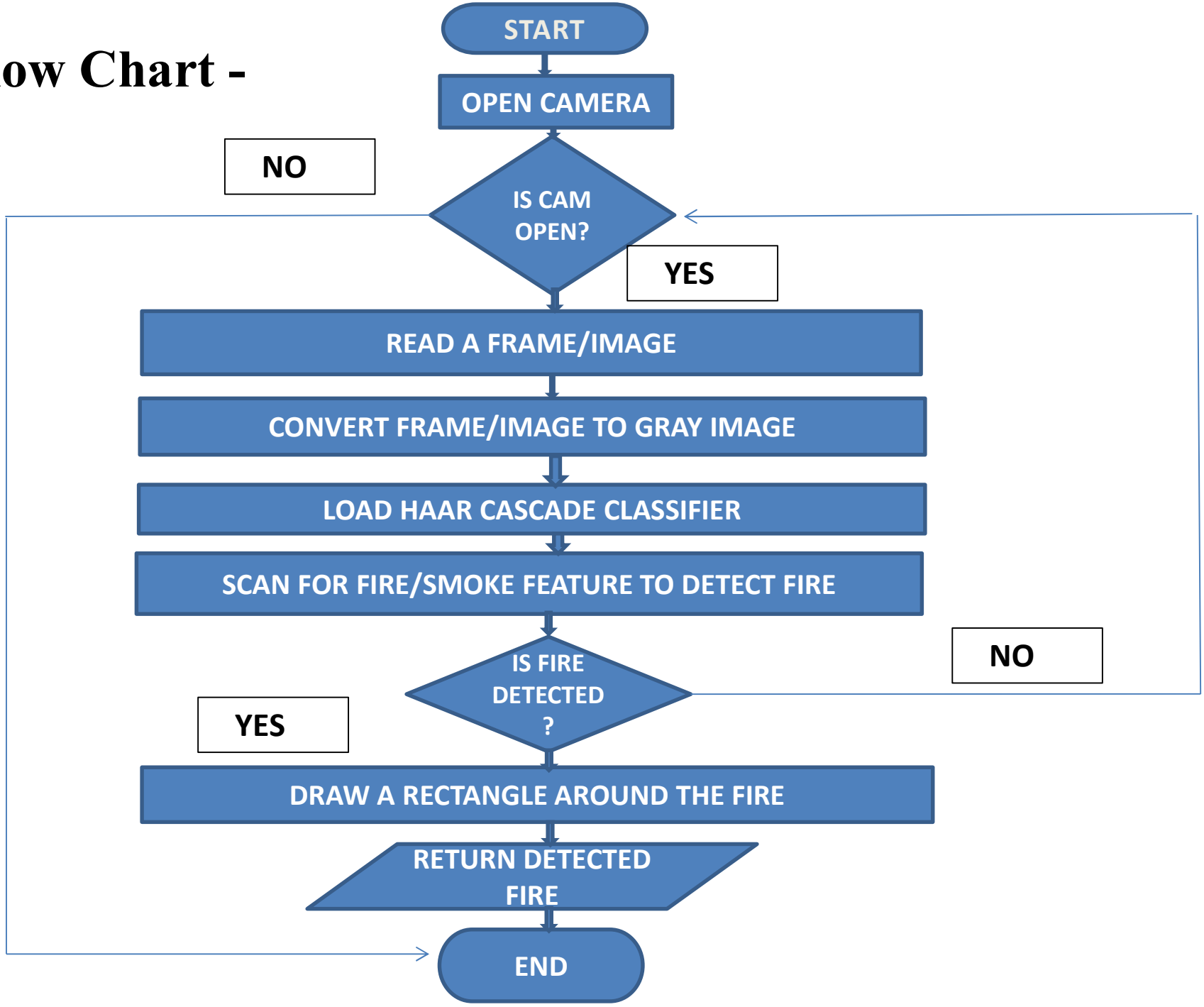
Note - Requires a lot of **positive images** of fire and **negative images** of non-fire to train the classifier.

i. Calculating Haar Features –

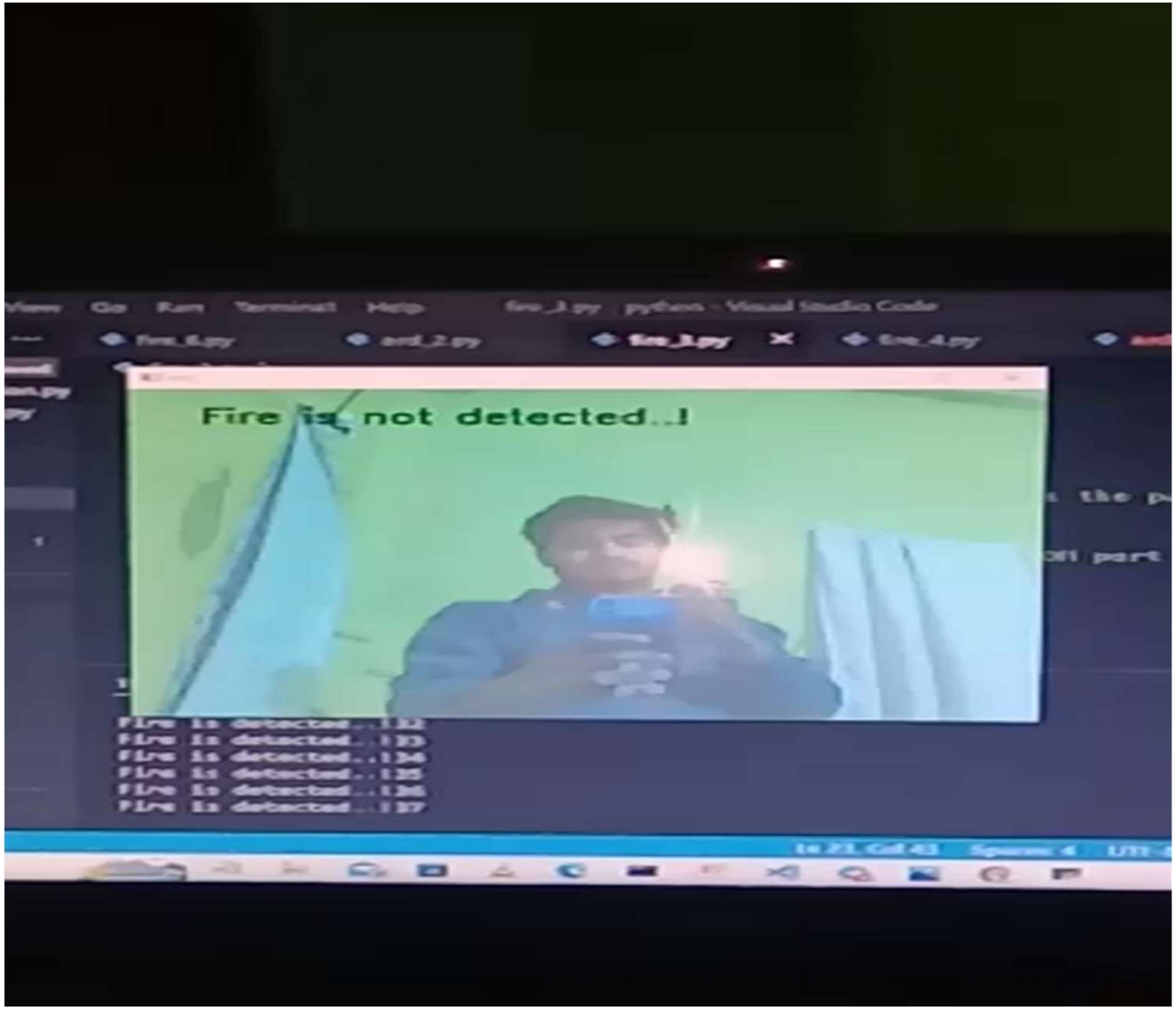
- Summing the pixel intensities in each region.
- Calculating the differences between the sums to get haar feature.



Flow Chart -

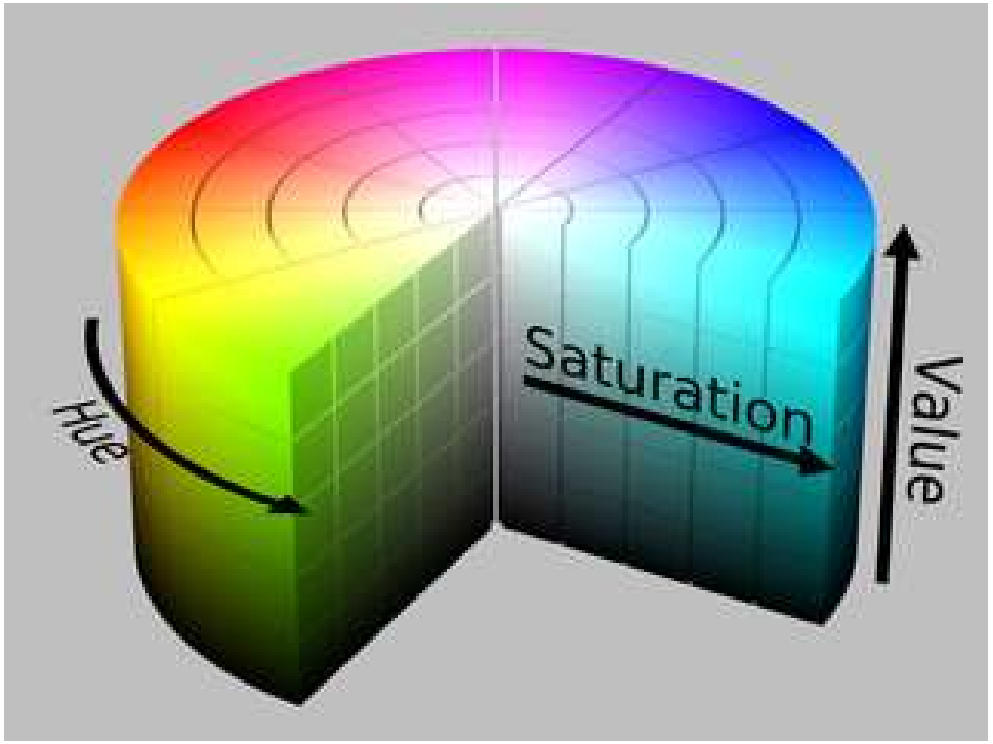

START
OPEN CAMERA
NO
IS CAM OPEN?
YES
READ A FRAME/IMAGE
CONVERT FRAME/IMAGE TO GRAY IMAGE
LOAD HAAR CASCADE CLASSIFIER
SCAN FOR FIRE/SMOKE FEATURE TO DETECT FIRE
IS FIRE DETECTED ?
NO
YES
DRAW A RECTANGLE AROUND THE FIRE
RETURN DETECTED FIRE
END

Working of Haar Cascade fire Detection -

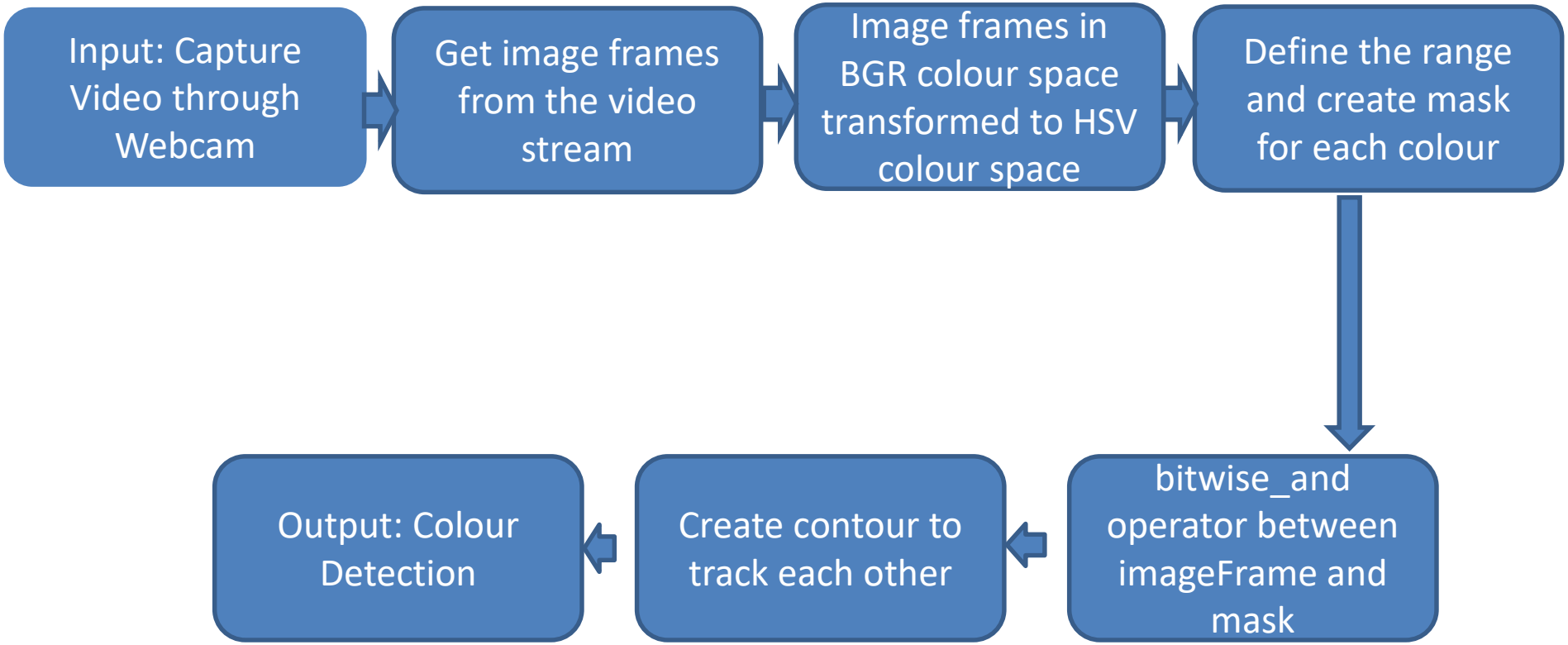


2. HSV fire detection -

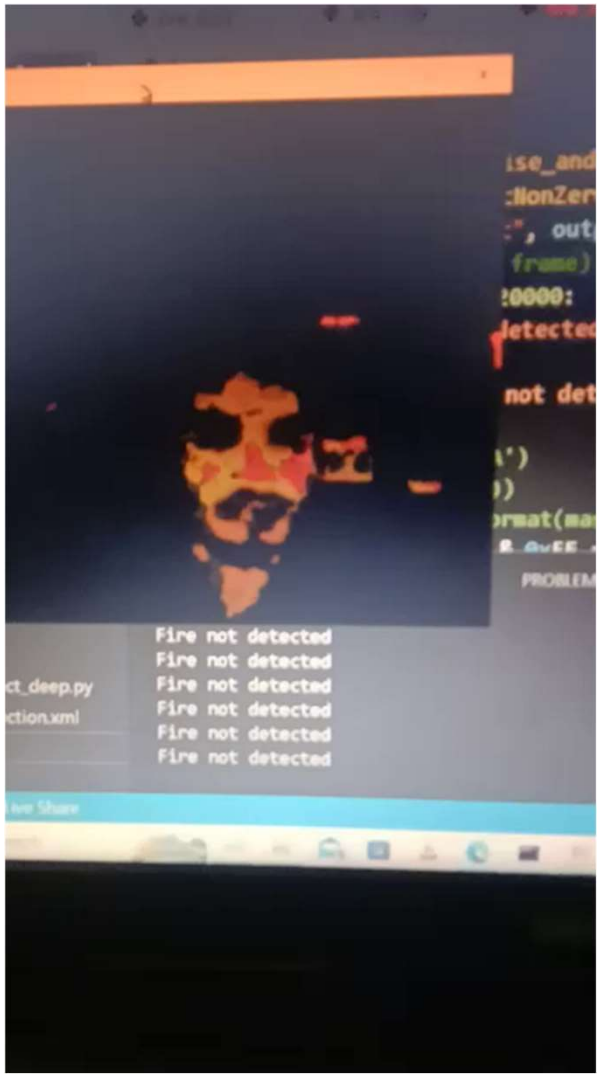
- **HSV –** (Hue Saturation Value)
  - describes colors in terms of their shade (saturation) and brightness (value).
  - Hue = color , Saturation = greyness , Value = brightness



Flow Chart -


Input: Capture Video through Webcam
Get image frames from the video stream
Image frames in BGR colour space transformed to HSV colour space
Define the range and create mask for each colour
bitwise_and operator between imageFrame and mask
Create contour to track each other
Output: Colour Detection

Working of HSV fire Detection -



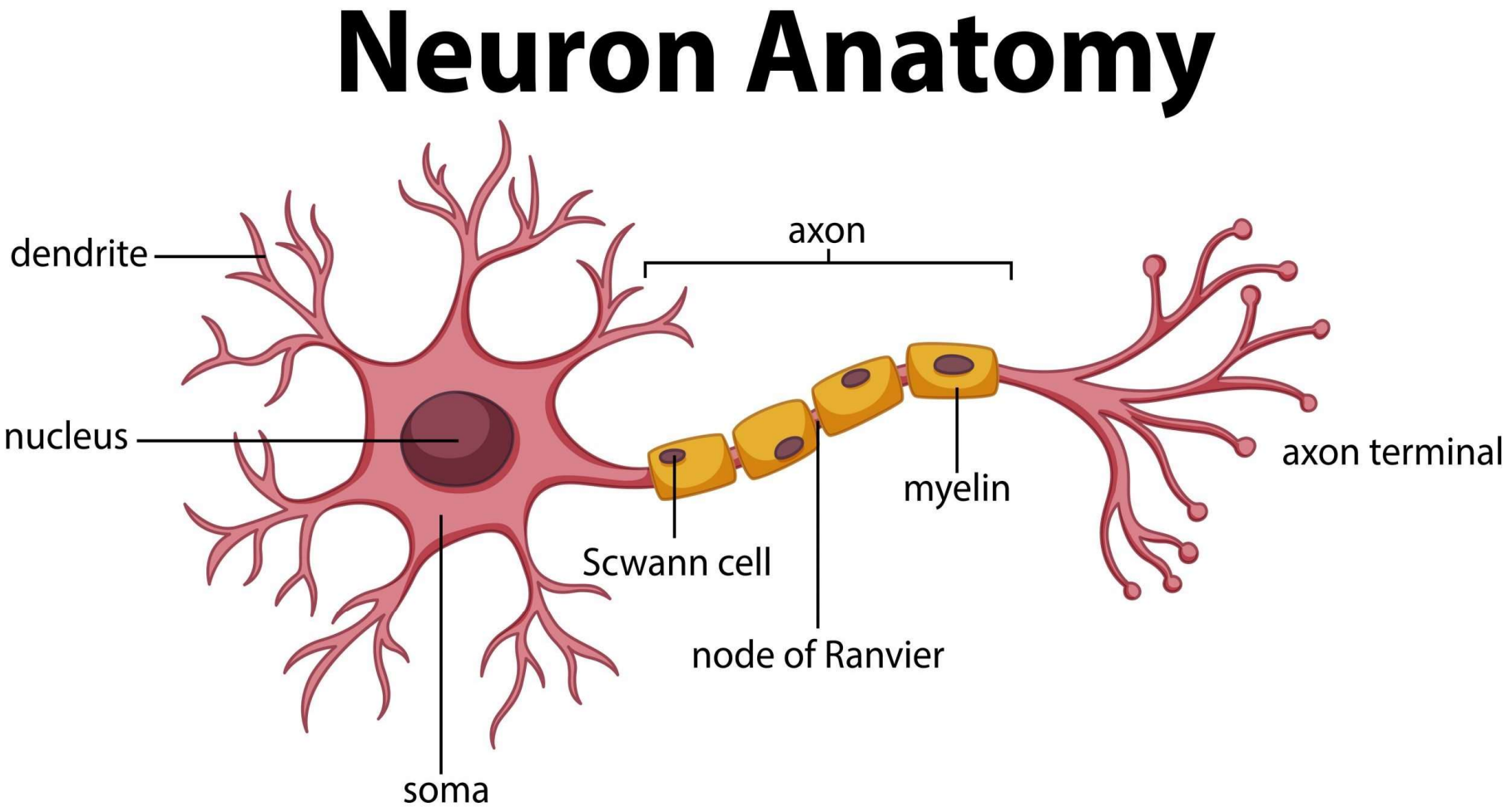
Basic of Neural Network

- Biological Neural Network
- Artificial Neural Network
- .Comparison between ANN & Biological Neural network
- Types of Neural Network
- Components of CNN

Biological Neural Network

- Specialized cell for receiving , processing and transmitting information.
- Human Brain - aprox. 10 Billion Neuron interconnected with 10 Trillion synapses.
- Processing is carried out by neurons.
- Dendrites receive signals from other neurons.
- Soma sums all the incoming signals
- Axon transmits the signals to other cells.

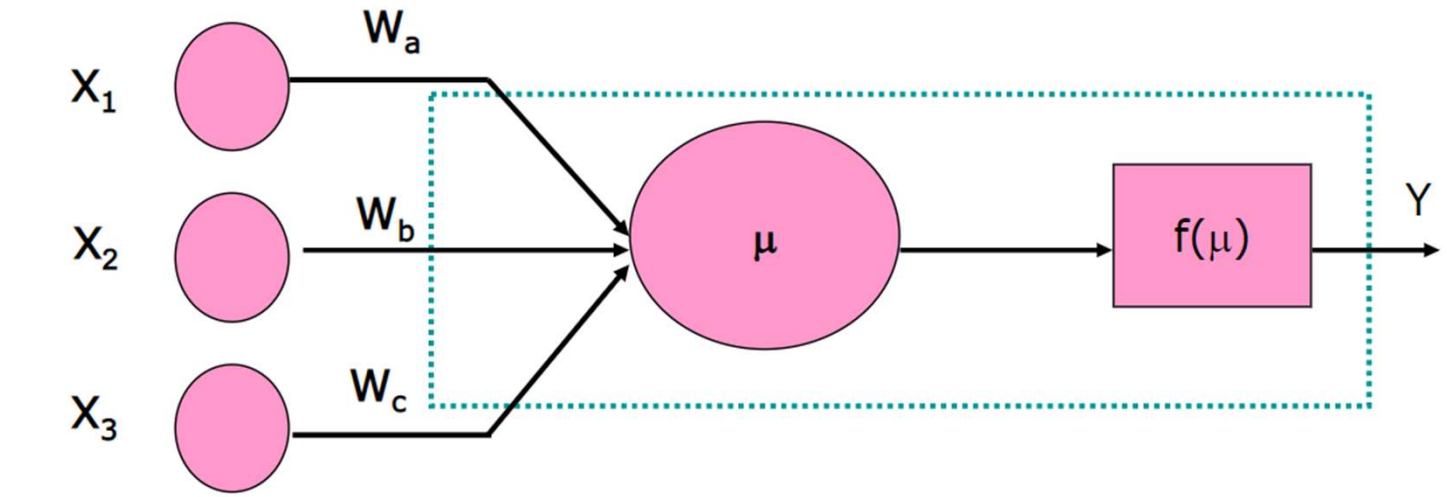
Model of a Biological Neuron



Artificial Neural Network

- Artificial system inspired by Biological Neural Network.
- Computational model & Threshold logic (Algo. &Mathematics)
- Study of Brain or on the application of N.N to artificial intelligence
- ANN is made up of 3 components - input , output ,& hidden layer.
- Input layer – used to take input
- Output layer – gives the output
- Hidden layer – used for processing..

Model of Artificial Neuron



Input units — Connection weights — Summing function — computation

(dendrite) (synapse) (soma) (axon)

. Comparison between ANN & BNN

S.No.	Artificial neural network	Biological neural network
1	Fast Processing speed.	Slow in processing information.
2	Processes operate in sequential mode.	The process can operate in massive parallel operations.
3	The activities are continuously monitored by a control unit.	There is no control unit to monitor the information being processed into the network

Types of Neural Network -

- Artificial Neural Network
- Recurrent Neural Network
- Convolution Neural Network

Convolution Neural Network

- Powerful tool because of its ability to handle large amounts of data.
- One of the most popular deep neural network.
- In CNN, the hidden layers include layers that perform convolutions.
- Includes a layer that performs the dot product of the convolution kernel with the layer's input matrix.
- Kernel slides along the input to get feature map.
- Consists - input layer, hidden layer and an output layer.

Components of CNN

1. Kernel = Filter –

i. It's a matrix that move over the input data.

ii. Perform Dot product with the sub-region of input data.

iii. Extract Feature from input image.

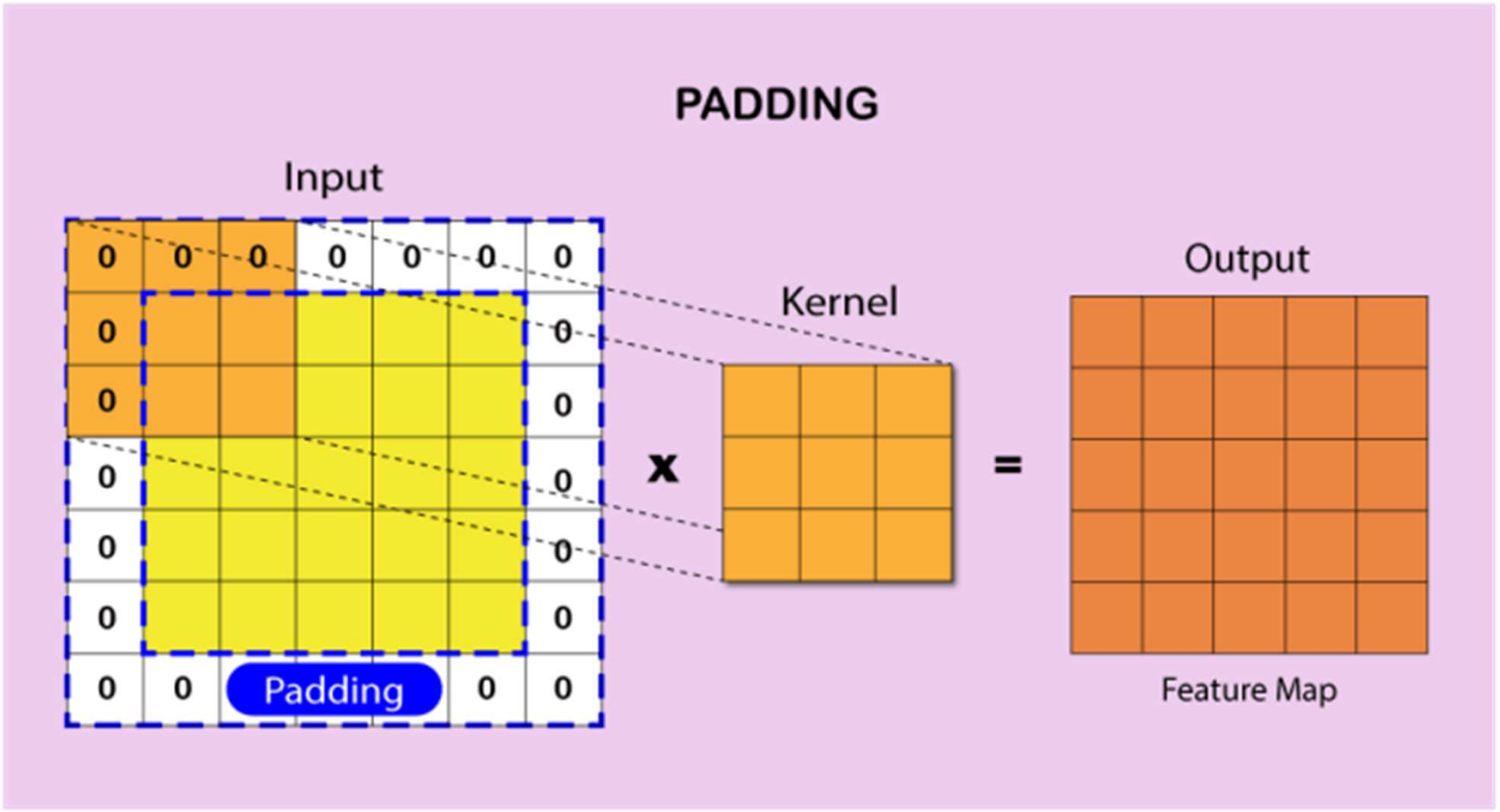
iv. $$\text{Dim.(o/p)} = \left\{ \frac{\text{Size (i/p)} - \text{Size(kernel)}}{\text{Stride}} \right\} + 1$$

2. Padding -

i. Fix Border Effect Problem.

ii. Help to preserve some lost information.

iii. $\text{Dim.(o/p)} = \left\{ \frac{\text{Size (i/p)} - \text{Size(kernel)} + 2\text{Size(P)}}{\text{Stride}} \right\} + 1$


PADDING
Input
Kernel
Output
Padding
Feature Map

Stride = 1

1	4	6	4	7	9
2	9	5	9	0	1
6	4	0	6	6	4
9	7	8	2	9	2
7	9	0	1	4	6
6	5	1	4	5	8

Input img (6 * 6)

×

1	0	-1
1	0	-1
1	0	-1

Kernel (3*3)

→

-2	-2	-4	5
4	3	-2	10
14	11	-11	-3
13	14	-9	-9

Feature Map (4*4)

Stride = 2

1	4	6	4	7	9
2	9	5	9	0	1
6	4	0	6	6	4
9	7	8	2	9	2
7	9	0	1	4	6
6	5	1	4	5	8

Input img (6 * 6)

×

1	0	-1
1	0	-1
1	0	-1

Kernel (3*3)

→

-2	-4
14	-11

Feature Map (2*2)

3. Pooling -

i. Used for Dimensionality Reduction.

ii. Reduces the amount of Parameters and Computational power required.

iii. Types of pooling-

a) **Average pooling –**

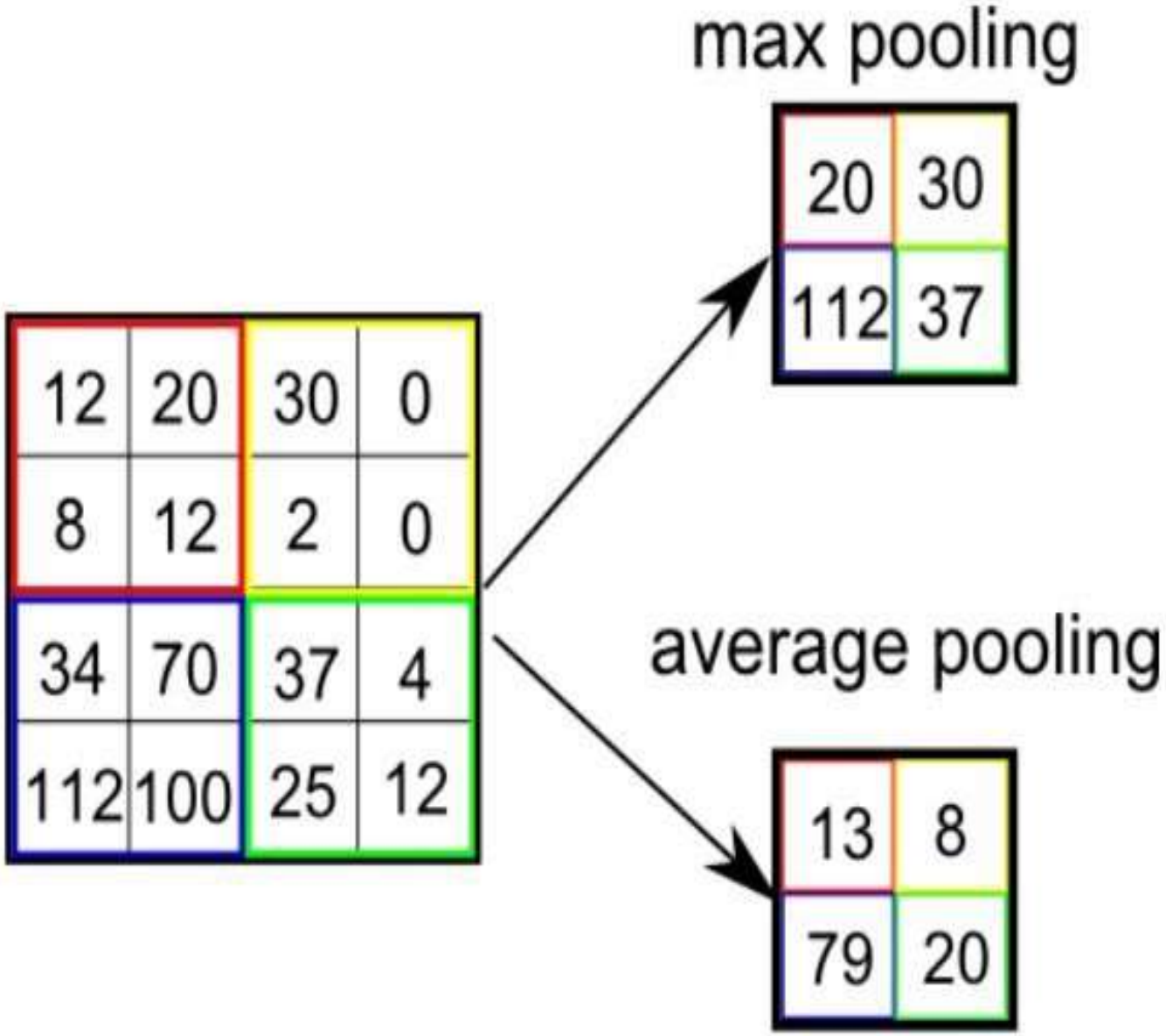
- Returns the **average of all the values** from the portion of the image covered by the Kernel.

b) Max Pooling-

- Find the maximum value of a pixel from a portion of the image covered by the kernel.

.

IV. $\text{Dim(o/p)} = \text{int}\left\{\frac{\text{Size(Feature Map)}}{2}\right\}$


max pooling
12 20 30 0
8 12 2 0
34 70 37 4
112 100 25 12
20 30
112 37
average pooling
13 8
79 20

4. One Hot Encoding –

i. Used to convert the label into binary format (0 or 1).

ii. label Binarizer()

5. Data Augmentation –

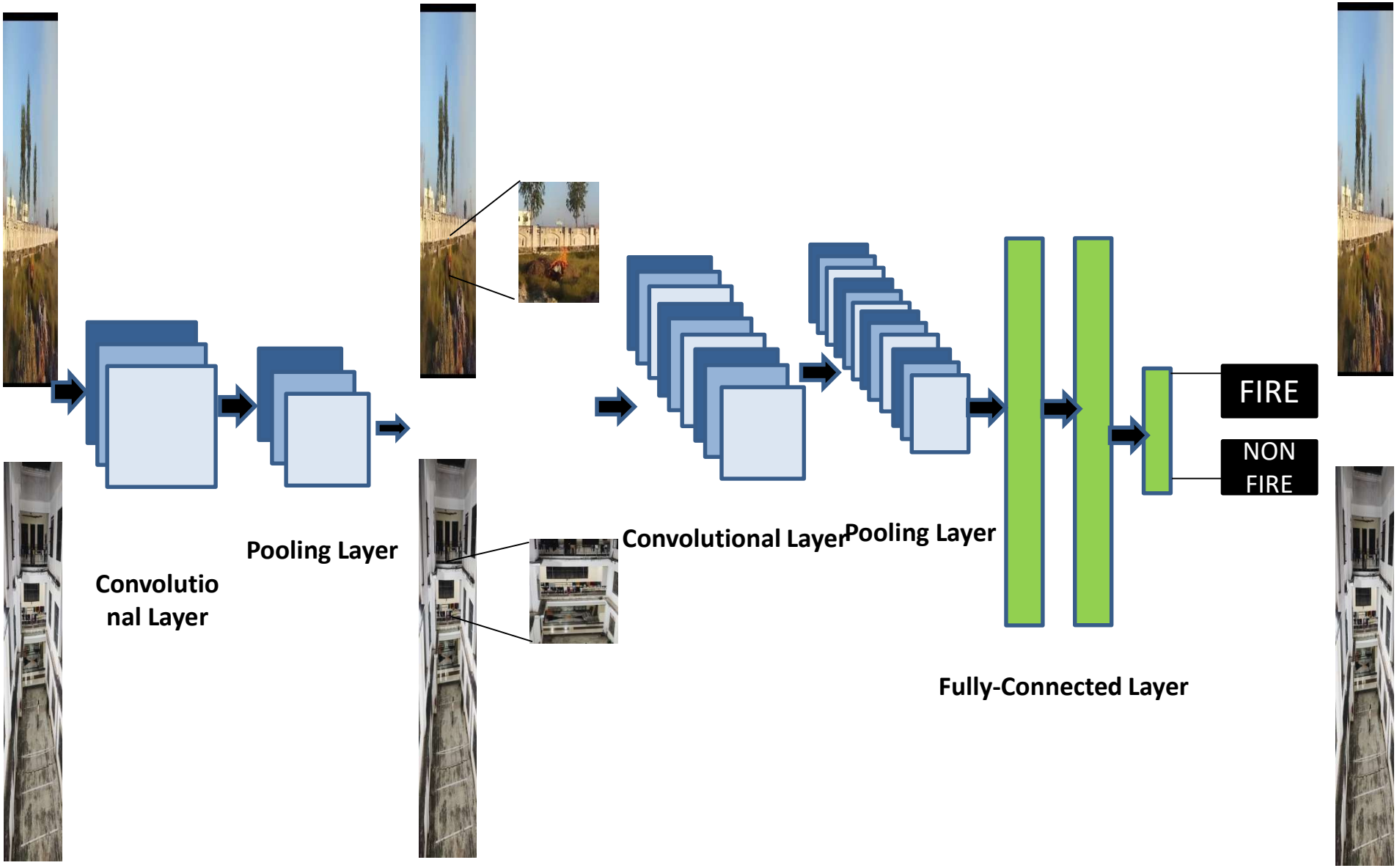
i. Recreating image or data with the help of input data.

ii. Avoid the overfitting problem, we need expand the dataset.

iii. More the data, the better our models would perform.

iv. Image Data Generator()

Convolutional Neural Network

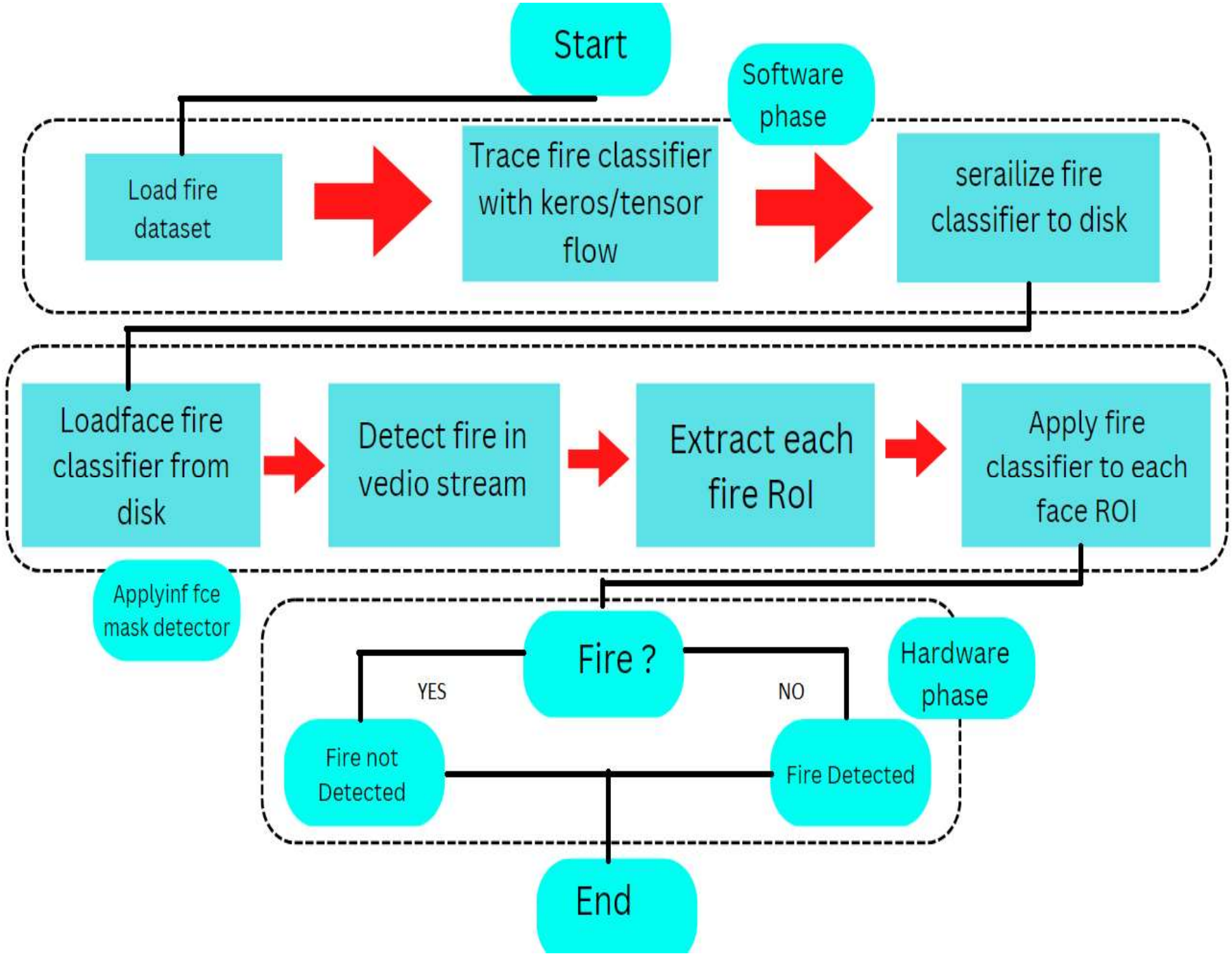


1.INPUT IMAGE

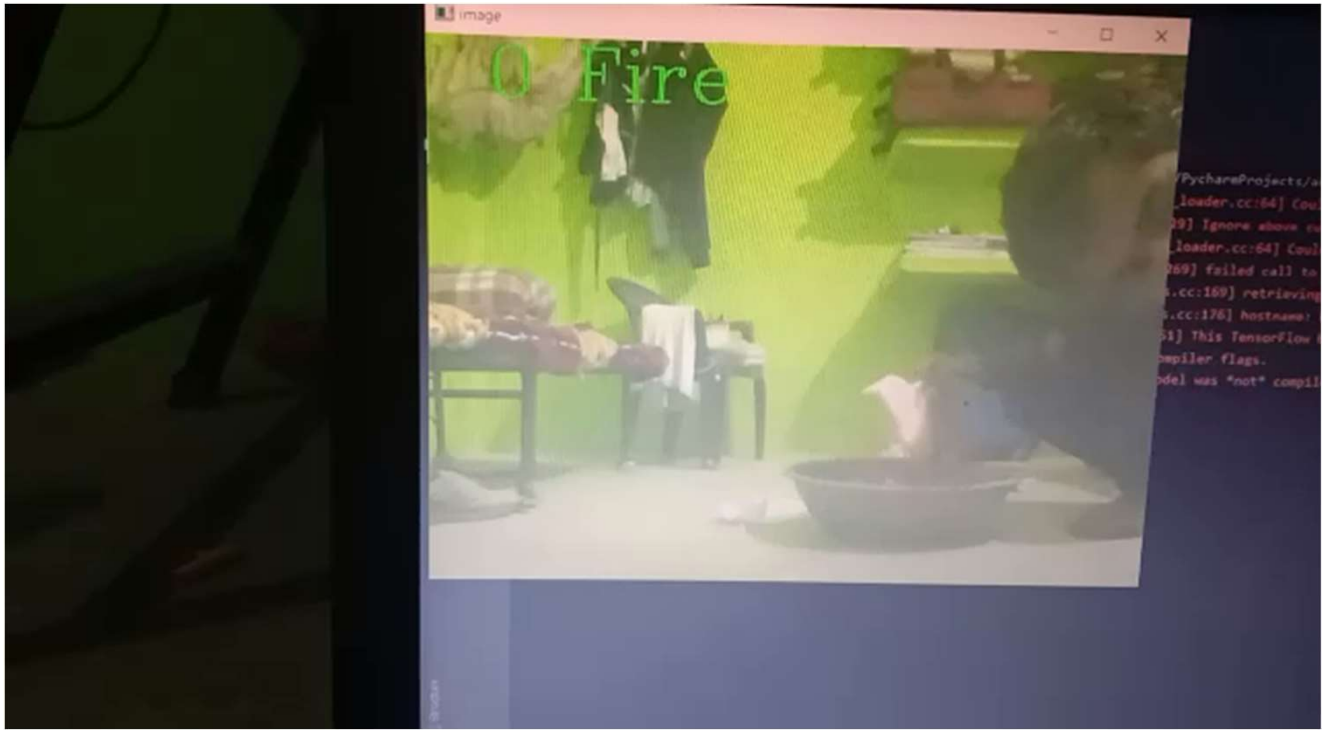
2.REGION PROPOSAL

3.FEATURE EXTRACTION AND CLASSIFICATION

4.OUTPUT DETECTION RESULT


Start
Software phase
Load fire dataset
Trace fire classifier with keros/tensor flow
serailize fire classifier to disk
Loadface fire classifier from disk
Detect fire in vedio stream
Extract each fire RoI
Apply fire classifier to each face ROI
Applyinf fce mask detector
Fire ?
YES
NO
Hardware phase
Fire not Detected
Fire Detected
End

Working of D.L fire Detection -



Testing -

Sr.no	Testing	`Haar-Cascade	HSV based	Deep Learning
1	Total no of samples	100	85	100
2	No of positive samples	50	45	60
3	No of negative samples	50	40	40
4	No of Correct Predictition	72	51	89
5	No of False Predictition	28	34	11
6	Accuracy	72%	60%	89%

Distance – under 1m

Sr.no	Testing	`Haar-Cascade	HSV based	Deep Learning
1	Total no of samples	50	50	50
2	No of positive samples	25	25	25
3	No of negative samples	25	25	25
4	No of Correct Predictition	30	21	40
5	No of False Predictition	20	29	10
6	Accuracy	60%	42%	80%

Distance range – above 1m

Future Scope

I. Extract the location of the fire.
II. Design the Robot to Extinguish the fire.
III. Add the alert.
IV. Separate camera from robot.
V. Add more data to get more accurate result.
VI. Get optimize position of camera.

print(“THANKS EVERYONE ”)