A

Project-II Report On

# "Real-Time Object Detection And Handwritten Equation Solver "

Submitted In Partial Fulfillment of the Requirement

For The Award of Degree of Bachelor of Engineering

In Computer Science & Engineering of

Kavayitri Bahinabai ChaudhariNorth Maharashtra University, Jalgaon

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**2019-2020**

**Shri Sant Gadge Baba**

**College of Engineering and Technology,**

**Bhusawal 425203**

# *Certificate*

This is to certify that Mr. Sarfaraz Khan, Mr. Pawan Baviskar, Miss Manasi Patil, Miss. Taru Ojha, Miss. Priyanka Wankhede has partially completed their project workon "Real-Time Detection and Handwritten Equation Solver" for the partial fulfillment of the Bachelor's Degree in the Computer Science & Engineering as prescribed by the Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon during academic year 2019-2020.

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**[Guide]** **[External Examiner]**

**Prof. D. D. Patil** **Dr. R.P.Singh**

**(H.O.D.)** **Principal**

## DECLARATION

We hereby declare that the Project-II Report entitled, **"Real-Time Detection and Handwritten Equation Solver"** is written and studied by us under the guidance of Prof. A. P. Ingale, Asst Prof. Department of Computer Science and Engineering, Shri Sant Gadge Baba College of Engineering and Technology, Bhusawal. This report is written by studding various articles, books, papers, journals and other resources available on internet out of which some of them are listed in the end of report.

**Place: Bhusawal** **Signature of Student**

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Mr. Sarfaraz Khan.

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# ABSTRACT

An object detection system recognises and searches the objects of the real world out of a digital image or a video, where the object can belong to any class or category, for example humans, cars, vehicles and so on. Authors have used OpenCV packages, Caffe model, Python and numpy in order to complete this task of detecting an object in an image or a video. This review paper discusses how deep learning technique is used to detect a live object, localise an object, categorise an object, extract features, appearance information, and many more, in images and videos using OpenCV and how caffee model is used to implement and also why authors have chosen caffe model over other frameworks. To build our deep learning-based real-time object detector with OpenCV we need to access webcam in an efficient manner and to apply object detection to each frame.

Recognition of handwritten mathematical expressions is helpful in writing technical documents as well as useful in converting handwritten documents with mathematical equations into electronic format. Symbol recognition in mathematical expressions is a complex task due to large character set and writer variability in size and style of symbols. In this project an assistance system is developed that analyses the handwritten mathematical equations. In this work, mathematical expression recognition task is carried out in different phases which include data collection, preprocessing, segmentation, feature extraction, symbol classification as well as mathematical expression. The system will be able to recognize images of handwritten equations and output the result of the equation. Being able to recognize handwritten equations, it has applications for consumers and academics.. Furthermore, whereas handwritten equations are human readable, the “code” of typesetting languages are often highly nested and difficult to edit. These problems of typesetting present an opportunity for improving the workflow of writing math equations digitally. Handwritten character or symbol recognition is one of the application in pattern classification. It is generally easy for anyone to recognize handwritten or characters and symbols but it is difficult for a computer to recognize them. This difficulty can be overcome by adopting machine learning approach by designing a system that recognizes the patterns.

**Keywords:-** Handwritten mathematical expressions, segmentation, feature extraction, symbol classification, machine learning, typesetting, Object Detection, OpenCV, Images, Videos, Caffe model.

# I N D E X

# LIST OF FIGURES

# CHAPTER NO 01
# INTRODUCTION

## 1.1 Introduction of Real-time Object Detection :

Object Detection is the process of finding and recognizing real-world object instances such as car, bike, TV, flowers, and humans out of an images or videos. An object detection technique lets you understand the details of an image or a video as it allows for the recognition, localization, and detection of multiple objects within an image [16].

It is usually utilized in applications like image retrieval, security, surveillance, and advanced driver assistance systems (ADAS).Object Detection is done through many ways:

• Feature Based Object Detection

• Viola Jones Object Detection

• SVM Classifications with HOG Features

• Deep Learning Object Detection

Object detection from a video in video surveillance applications is the major task these days. Object detection technique is used to identify required objects in video sequences and to cluster pixels of these objects .

Deep learning has gained a tremendous influence on how the world is adapting to Artificial Intelligence since past few years. Some of the popular object detection algorithms are Region-based Convolutional Neural Networks (RCNN), Faster- RCNN, Single Shot Detector (SSD) and You Only Look Once (YOLO). Amongst these, Faster-RCNN and SSD have better accuracy, while YOLO performs better when speed is given preference over accuracy.

Deep learning combines SSD and Mobile Nets to perform efficient implementation of detection and tracking. This algorithm performs efficient object detection while not compromising on the performance.

The detection of an object in video sequence plays a major role in several applications specifically as video surveillance applications.

Object detection in a video stream can be done by processes like pre-processing, segmentation, foreground and background extraction, feature extraction.

## 1.2 Introduction Handwritten Equation Solver:

With the advancement in technology, machine learning and deep learning are playing a crucial role in present times. Now, machine learning and deep learning techniques are being employed in handwriting recognition, robotics, artificial intelligence, and many more fields. Developing such system requires training our machines with data, making it capable to learn and make required prediction. This article presents a Handwritten Equation Solver trained by handwritten digits and mathematical symbol using Convolutional Neural Network with some image processing techniques to achieve a decent accuracy of 98.46%.

# CHAPTER NO 02
# PROBLEM STATEMENT

## 2.1. Problem Statement for Real-time Object Detection.

Many problems in computer vision were saturating on their accuracy before a decade. However, with the rise of deep learning techniques, the accuracy of these problems drastically improved. One of the major problems was that of image classification, which is defined as Predicting the class of the image. In this case, the input to the system will be an image, and the output will be a bounding box corresponding to all the objects in the image, along with the class of object in each box. An overview of all these problems is depicted in Fig.2.1.

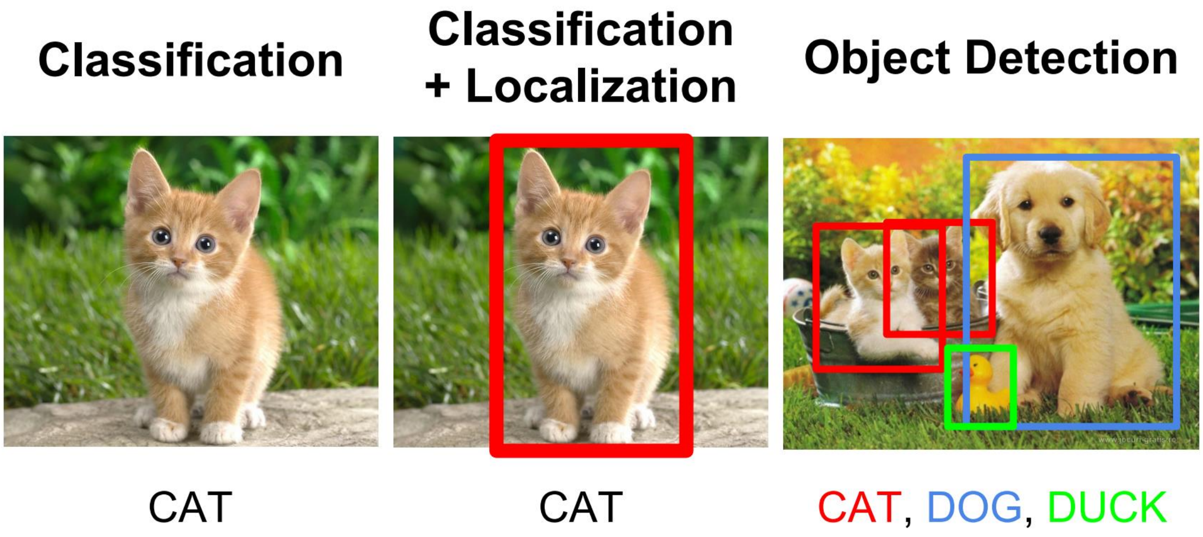


**FIG 2.1:- Computer Vision Task.**

## 2.1. Problem Statement for Real-time Object Detection.

This application is useful for recognizing mathematical expression given as an input image once input image is given to propose system then it will calculate result of given expression in the image.Recoginition and classification are done by neural network.

# CHAPTER NO 03
# LITERATURE SURVEY

## 3.1 Real-time Object Detection.

### 3.1.1. Earlier System.

In the late 1960s, computer vision began at universities which were pioneering artificial intelligence. It was meant to mimic the human visual system, as a stepping stone to endowing robots with intelligent behavior. In 1966, it was believed that this could be achieved through a summer project, by attaching a camera to a computer and having it "describe what it saw”. What distinguished computer vision from the prevalent field of digital image processing at that time was a desire to extract three-dimensional structure from images with the goal of achieving full scene understanding. Studies in the 1970s formed the early foundations for many of the computer vision algorithms that exist today, including extraction of edges from images, labelling of lines, non-polyhedral and polyhedral modelling, representation of objects as interconnections of smaller structures, optical flow, and motion estimation.

### 3.1.2. Problem associated with earlier system.

Before the emergence of machine learning and deep learning, computer vision was just an assumption in that era. There were many problems that lack computer vision to exist, which are as follows:-

a) Lack of hardware support.
b) Lack of hardware power.
c) Absence of deep learning models and algorithms.
d) Languages support.
e) Lack of mathematical and statistical tools.

### 3.1.3. Proposed System.

Earlier system comes up with many flaws, lack of resources and lack of software and hardware support, to overcome with this obstacles we proposed a real time detection models which have advanced deep learning model, statistical tools, languages support (python in our case), advanced GPU to render images sharply, Webcam to fetch live frames (images) for live Detection and a beautiful computer vision library like OpenCV.

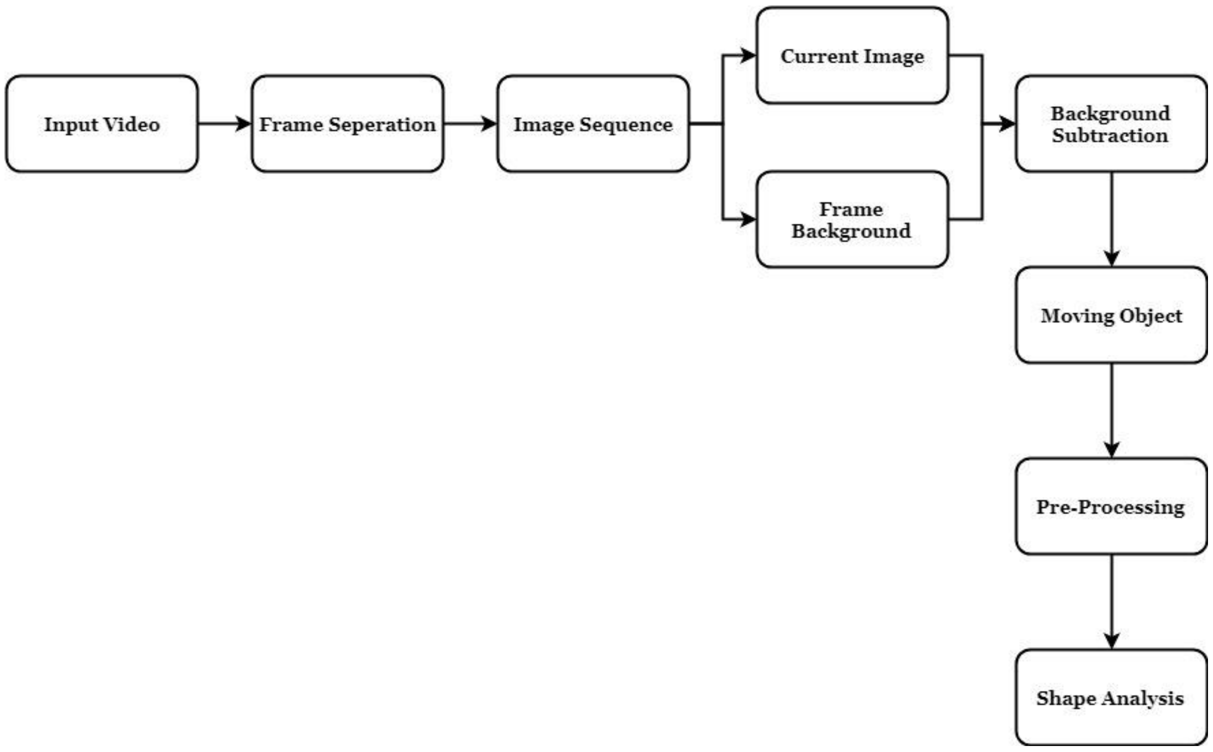


**Fig3.1:-Block diagram of Real-time Object Detection.**

## 3.2 Handwritten Equation Solver.

Handwriting Recognition has an active community of academics studying it. The biggest conferences for handwriting recognition are the International Conference on Frontiers in Handwriting Recognition (ICFHR), held in even-numbered years, and the International Conference on Document Analysis and Recognition (ICDAR), held in odd-numbered years. Both of these conferences are endorsed by the IEEE and IAPR.

Active areas of research include:

- Online Recognition
- Offline Recognition
- Signature Verification
- Postal-Address Interpretation
- Bank-Check Processing
- Writer Recognition

**RESULTS SINCE 2009**

Since 2009, the recurrent neural networks and deep feed forward neural networks developed in the research group of Jürgen Schmidhuber at the Swiss AI Lab IDSIA have won several international handwriting competitions. In particular, the bi-directional and multi-dimensional Long short-term memory (LSTM) of Alex Graves et al. won three competitions in connected handwriting recognition at the 2009 International Conference on Document Analysis and Recognition (ICDAR), without any prior knowledge about the three different languages (French, Arabic, Persian) to be learned. Recent GPU-based deep learning methods for feed forward networks by Dan Ciresan and colleagues at IDSIA won the ICDAR 2011 offline Chinese handwriting recognition contest; their neural networks also were the first artificial pattern recognizers to achieve human-competitive performance on the famous MNIST handwritten digits problem of Yann LeCun and colleagues at NYU.

# CHAPTER NO 04

# ANALYSIS

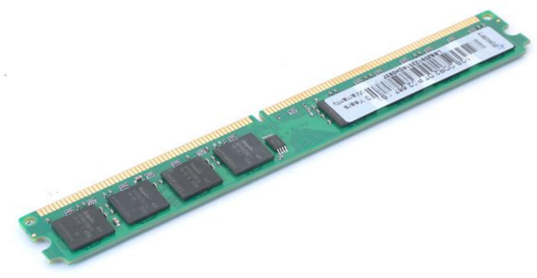
**REQUIREMENT ANALYSIS**

## 4.1. Real-time Object Detection

### Hardware Requirement

- ❑ Webcam.

- ❑ 4 GB ram or more (Recommended).



- ❑ Graphics Card (Minimum 2GB Recommended).

## Software Requirement

- ❑ Python 3 (version 3.7 recommended).
- ❑ MobilenetSSD (Deep learning neural network).
- ❑ Better IDE like Jupiter notebook, PyCharm.

### 4.1. Handwritten Equation Solver.

Requirement analysis results in the specification of software's operational characteristics indicates software's interface with other system elements and establish constraints that software must meets. Requirement analysis allows the software engineer to elaborate on basis requirements during earlier requirement engineering task and build models that depict user scenarios, functional activities, problem classes and their relationships, system and class behavior and the flow of data as it is transformed.

The requirements analysis task is a process of discovery, refinement, modeling and specification. The scope, initially established by us and refined during project planning, is refined in details. Model of the required data, information and control flow and operations behavior are created.

## REQUIREMENT SPECIFICATION

### a) FUNCTIONAL REQUIREMENTS

The functional requirements for a system describe what system do.

1. The developed system should recognize handwritten mathematical expression present in the image.
2. System must provide the quality of service to user.
3. System must provide accuracy for character recognition.

### NORMAL REQUIREMENTS

These are the requirements clearly stated by the customer hence requirement must be present for customer satisfaction.

- **N1:** Application should have graphical user interface.
- **N2:** Input of characters with various font size and styles should recognize.
- **N3:** Application should be able for matching the stored patterns on input handwritten character

### VALIDATION OF REQUIREMENTS

The project "HES using Neural Network" will be recognized as successful implementation if it provide all the required images on the basis of suitable input with minimum time. The requirement specification define should be validated such a that the successful implementation of product can be recognized. Hence validation specifies classes of tests to be performed to validate function, performance and the constraints. With respect to the system under consideration the following issues are to be validated to ensure consistency of system.

- **V1:** The Neural Network are known to be capable of providing good recognition rate at the present as compare to other methods.
- **V2:** Handwritten Mathematical Expression Recognition system give much better result in terms of performance and accuracy in comparison with existing usual approach due to the application of artificial way character recognition and Neural Network in detection of characters.

- **V3:** Handwritten Mathematical Expression Recognition technology provides image definition, image preprocessing and image segmentation and recognition capabilities and still maintains high level of accuracy.

## SYSTEM REQUIREMENTS

### Hardware Requirements

• Intel i3 Processer

• 128 MB RAM

• 10 GB Hard Disk.

### Software Requirements

• Windows 7/8/8.1

• Language: Python(including keras, numpy, pandas, pickle).

• Eclipse

# CHAPTER NO 05

# DESIGN METHODOLOGY

## 5.1. Real-Time Object Detection.

There has been a lot of work in object detection using traditional computer vision techniques (sliding windows, deformable part models). However, they lack the accuracy of deep learning based techniques. Among the deep learning based techniques, two broad class of methods are prevalent: two stage detection (RCNN [1], Fast RCNN [2], Faster RCNN [3]) and unified Detection (Yolo [4], SSD [5]). The major concepts involved in these techniques have been Explained below.

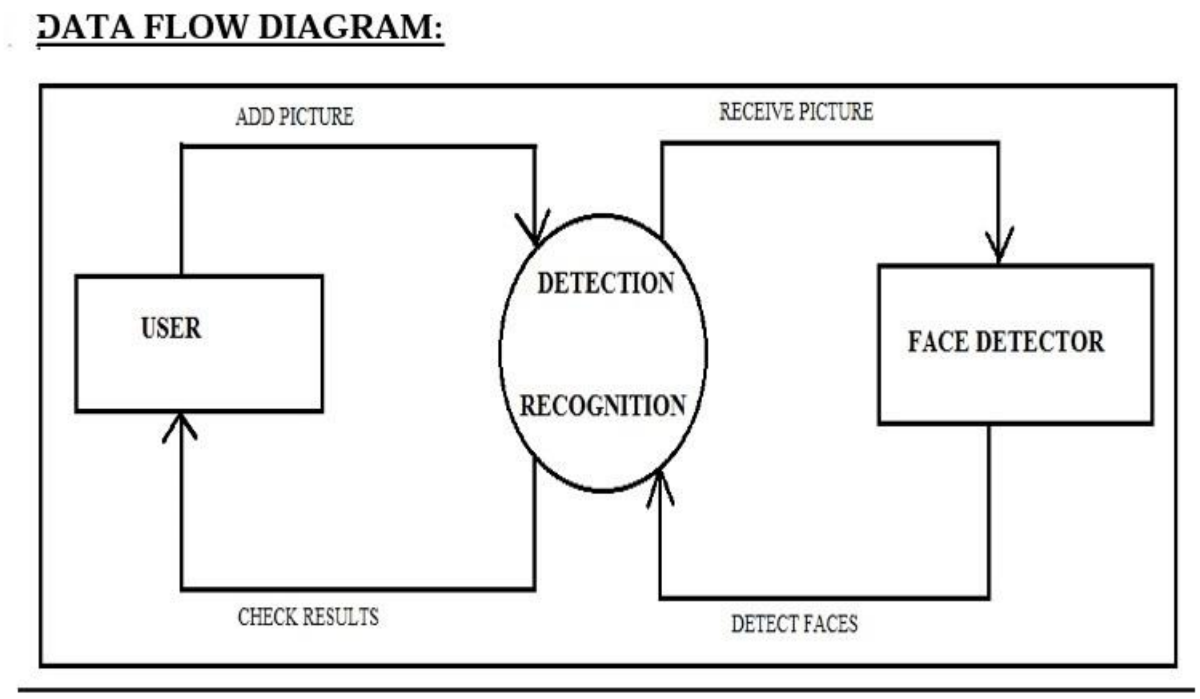


**Fig 5.1:-Data Flow Diagram for Real-Time Object Detection.**

In the above data flow diagram, we have shown the the two entities that are linked with specific process. The arrows are the dependency associated either with entities to process or process to entities.

Entities are user and face detector, which is linked with the process of detection recognition by a means of note or an dependency arrow.

Types of link associated are Add picture, Receive Picture, Detect faces, Check result.

The major concepts involved in these techniques have been explained below.

**a) Bounding Box.**

The bounding box is a rectangle drawn on the image which tightly _ts the object in the image. A bounding box exists for every instance of every object in the image. For the box, 4 numbers (center x, center y, width, height) are predicted. This can be trained using a distance measure between predicted and ground truth bounding box. The distance measure is a jaccard distance which computes intersection over union between the predicted and ground truth boxes as shown in Fig. 5.2.

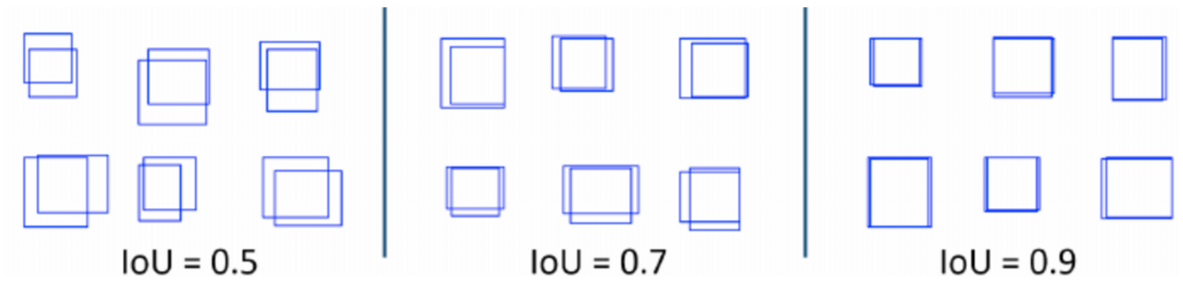


**Fig 5.2:- Jaccard distance**

**b) Classification + Regression.**

The bounding box is predicted using regression and the class within the bounding box is predicted using classification. The overview of the architecture is shown in Fig. 4

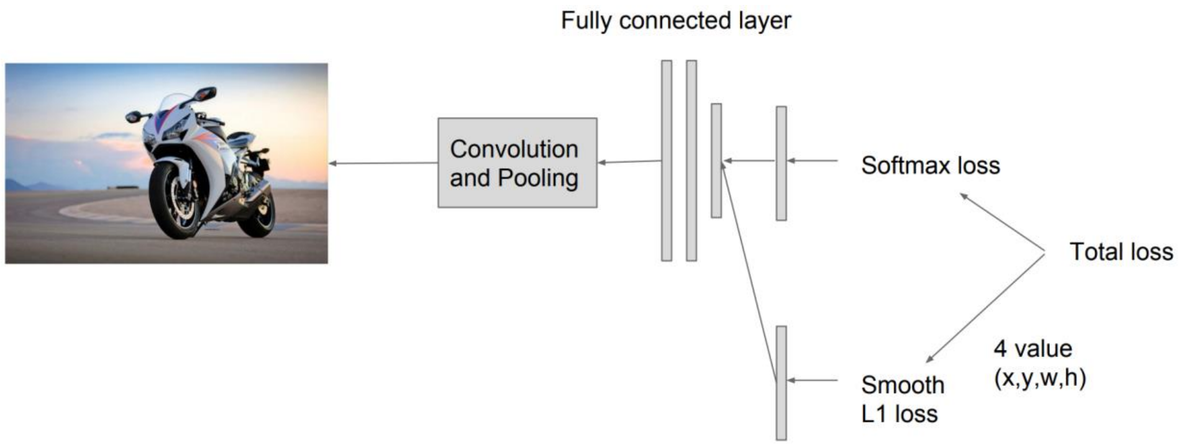
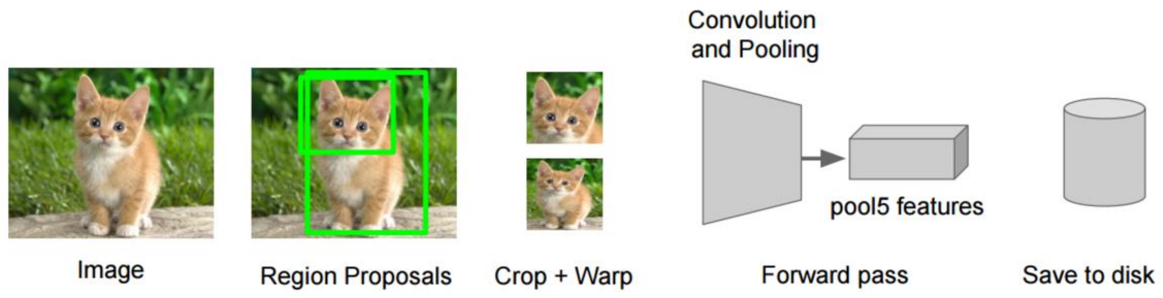


**Fig 5.3:- Architecture overview**

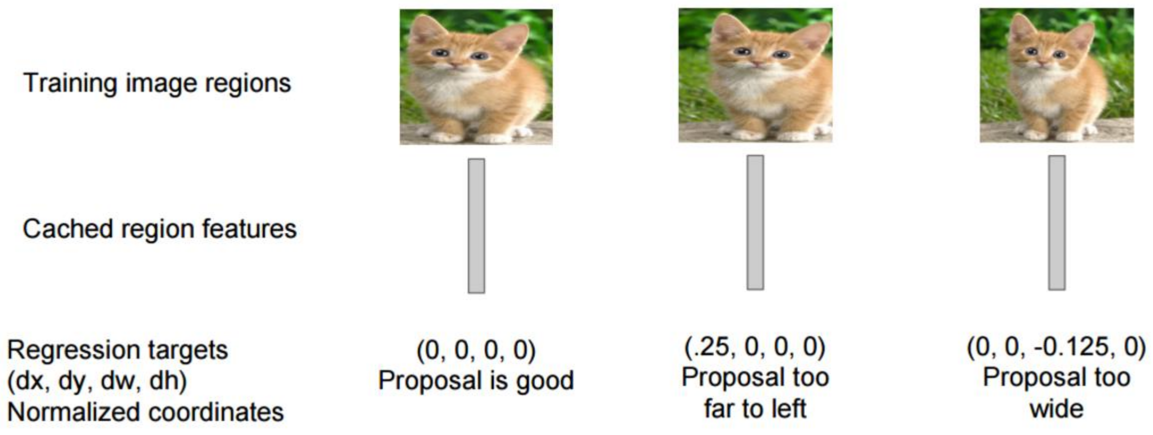
**c) Two-stage Method.**

In this case, the proposals are extracted using some other computer vision technique and then resized to fixed input for the classification network, which acts as a feature extractor. Then an SVM is trained to classify between object and background (one SVM for each class). Also a bounding box regressor is trained that outputs some some correction (o_sets) for proposal boxes. The overall idea is shown in Fig. 5 These methods are very accurate but

are computationally intensive (low fps).



**(a) Stage one.**


Training image regions
Cached region features
Regression targets (dx, dy, dw, dh) Normalized coordinates
(0, 0, 0, 0) Proposal is good
(.25, 0, 0, 0) Proposal too far to left
(0, 0, -0.125, 0) Proposal too wide

**(b) Stage two.**

**Fig 5.4:-Two Stage method.**

**d) Unified Method.**

The difference here is that instead of producing proposals, pre-de_ne a set of boxes to look for objects. Using convolutional feature maps from later layers of the network, run another network over these feature maps to predict class scores and bounding box o_sets. The broad idea is depicted in Fig. 6. The steps are mentioned below:

1. Train a CNN with regression and classi_cation objective.
2. Gather activation from later layers to infer classi_cation and location with a fully connected or convolutional layers.
3. During training, use jaccard distance to relate predictions with the ground truth.
4. During inference, use non-maxima suppression to _lter multiple boxes around the same object.

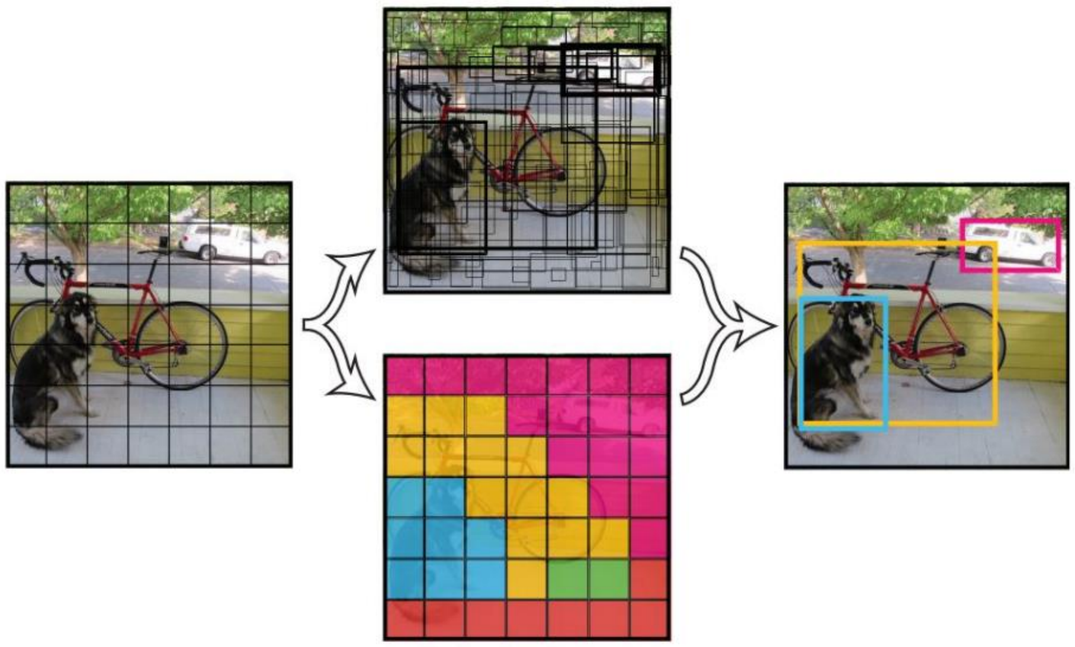


**Fig 5.5:- Unified Method.**

The major techniques that follow this strategy are: SSD (uses di_erent activation maps (multiple-scales) for prediction of classes and bounding boxes) and Yolo (uses a single activation map for prediction of classes and bounding boxes). Using multiple scales helps to achieve a higher mAP(mean average precision) by being able to detect objects with different sizes on the image better. Thus the technique used in this project is SSD.

**ENTITY RELATIONSHIP DIAGRAM:**

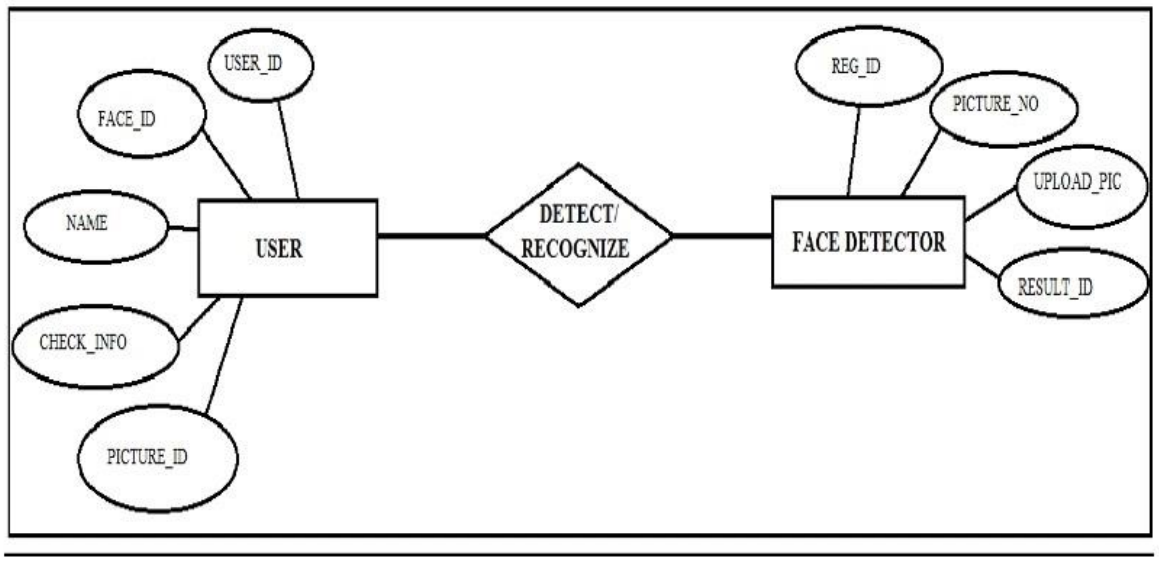


**Fig 5.6:-E-R Diagram of Real-time objects detection.**

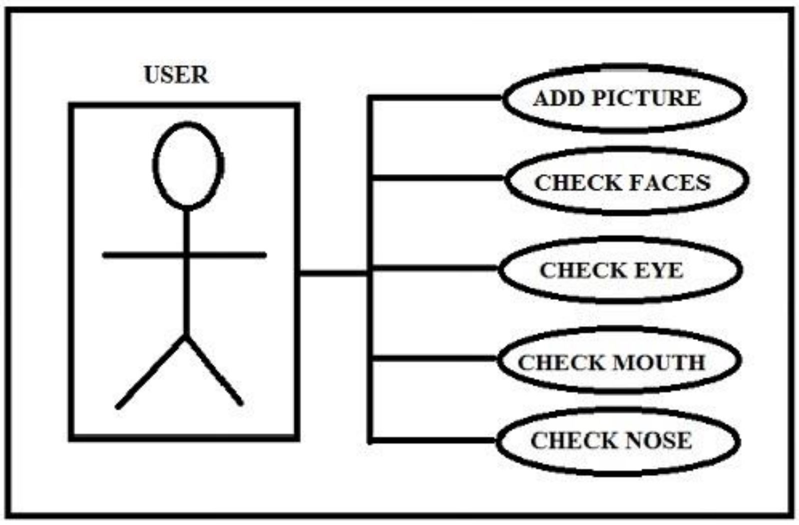
Entity relationship diagram displays the relationships of entity set stored in a database. In other words, we can say that ER diagrams help you to explain the logical structure of databases. In the above case, there are two strong Entities:-

a) USER.
b) FACE DETECTOR.

There is also one process present in between two entities which is Detect/Recognize.
Also there is many to one relationship between attributes with entities, attributes are as follows:-USER_ID, FACE_ID, REG_ID, PICTURE_ID etc.

## USE CASE DIAGRAM:

### User Module:



### Software Module:

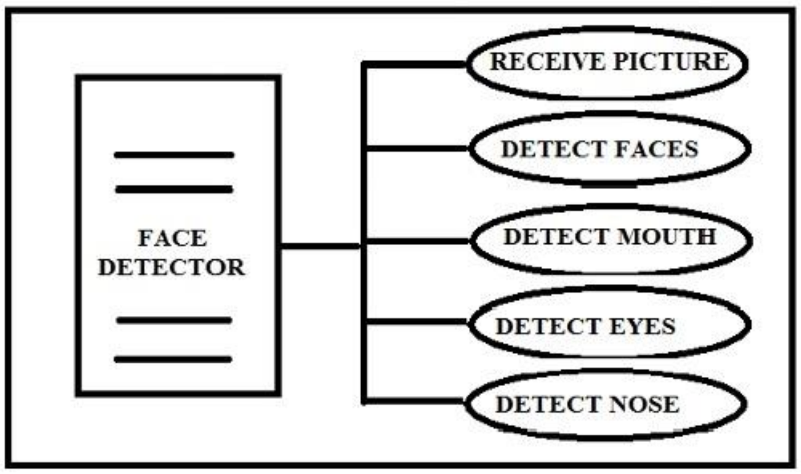


**Fig 5.7:-Use case Diagram of Real-time object detection.**

A UML use case diagram is the primary form of system/software requirements for a new software program underdeveloped. Use cases specify the expected behavior (what), and not the exact method of making it happen (how). Use cases once specified can be denoted both textual and visual representation (i.e. use case diagram.).

In above case there are two actors that are shown in above diagrams, they are:-

A) User and Face detectors.
B) There are two boundary of system is present which are User module and Software Module.
C) Link is associated from actor to use cases act as a relationship.

Use cases are:- add picture, receive picture, detect noise etc.

## 5.1.1. Algorithm.

### 5.1.1.1. Single shot detector.

The network used in this project is based on Single shot detection (SSD) [5]. The architecture
is shown in Fig. 5.7.

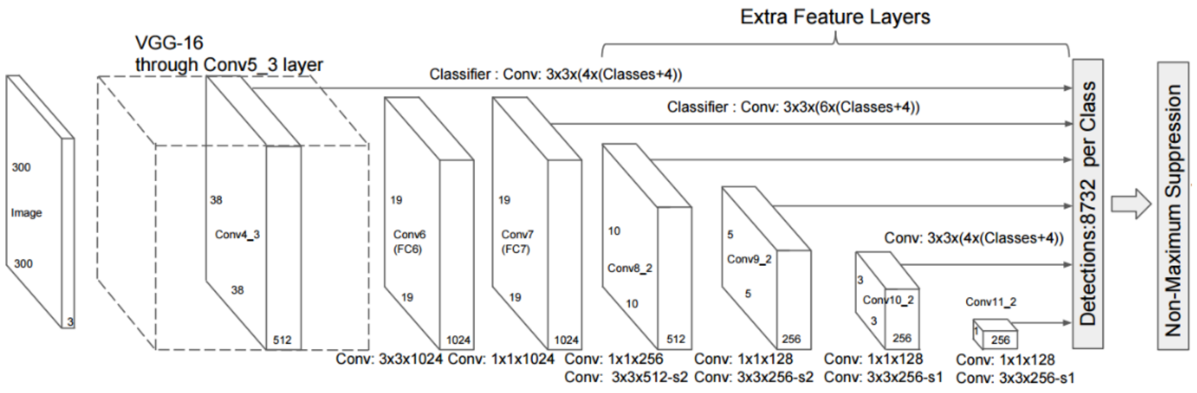


**Fig 5.8: SSD Architecture**

The SSD normally starts with a VGG [6] model, which is converted to a fully convolutional network. Then we attach some extra convolutional layers, which help to handle bigger objects. The output at the VGG network is a 38x38 feature map (conv4 3). The added Layers produce 19x19, 10x10, 5x5, 3x3, 1x1 feature maps. All these feature maps are used for predicting bounding boxes at various scales (later layers responsible for larger objects). Thus the overall idea of SSD is shown in Fig. 5.8. Some of the activations are passed to the sub-network that acts as a classifier and a localizer.

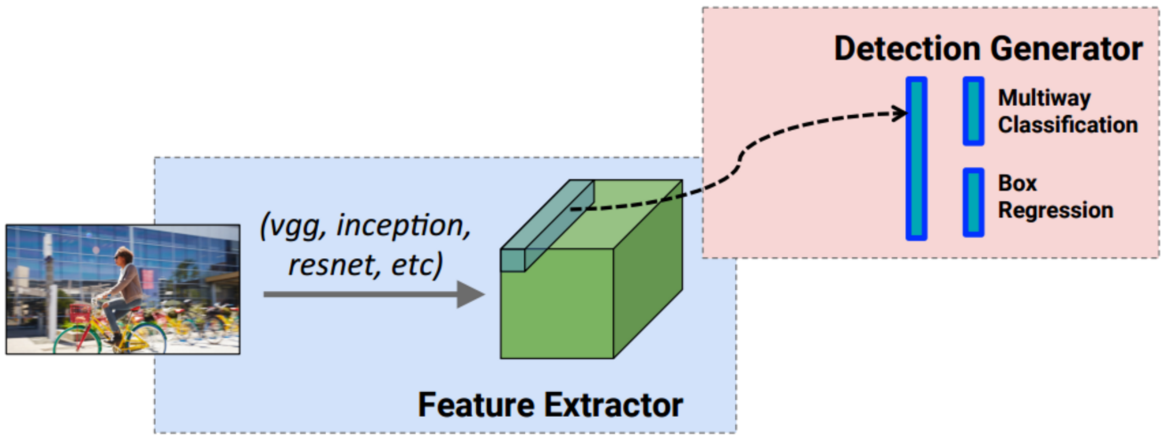


**Fig 5.9:- SSD Overall Idea.**

Anchors (collection of boxes overlaid on image at di_erent spatial locations, scales and aspect ratios) act as reference points on ground truth images as shown in Fig. 5.8.
A model is trained to make two predictions for each anchor:_ A discrete class, A continuous o_set by which the anchor needs to be shifted to _t the ground-truth bounding box.

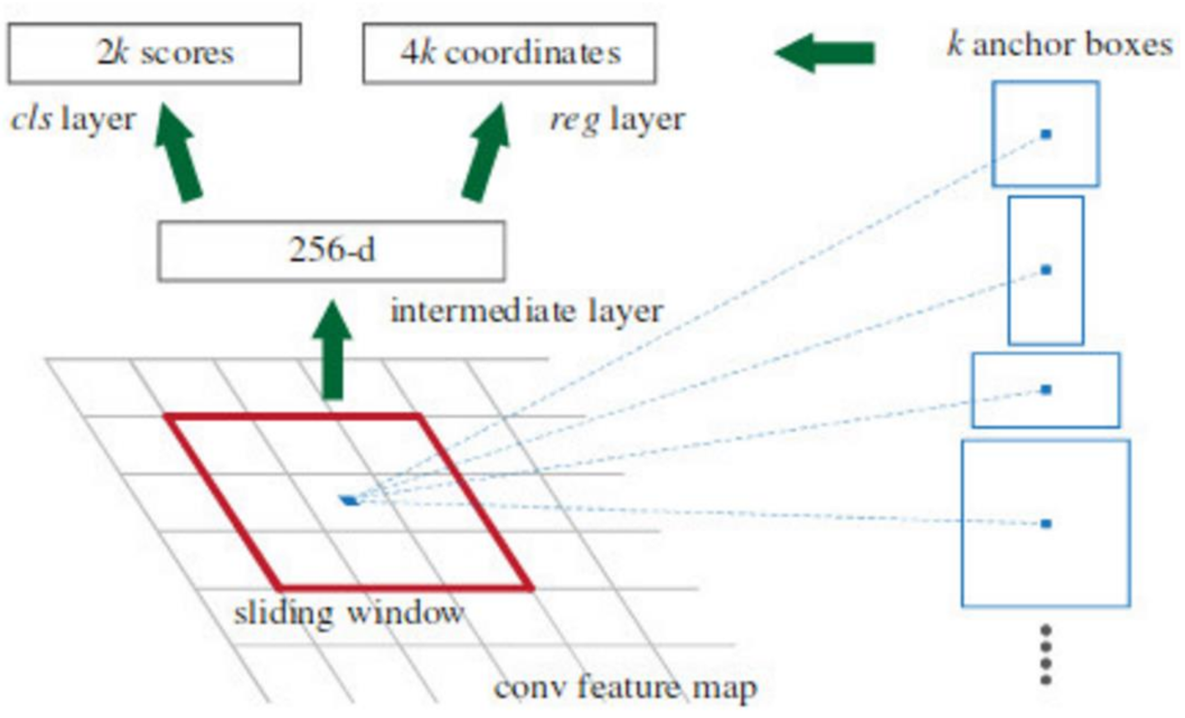


**Fig 5.10:- Anchors**

During training SSD matches ground truth annotations with anchors. Each element of the feature map (cell) has a number of anchors associated with it. Any anchor with an IoU jaccard distance) greater than 0.5 is considered a match. Consider the case as shown in Fig. 5.10, where the cat has two anchors matched and the dog has one anchor matched. Note that both have been matched on di_erent feature maps.

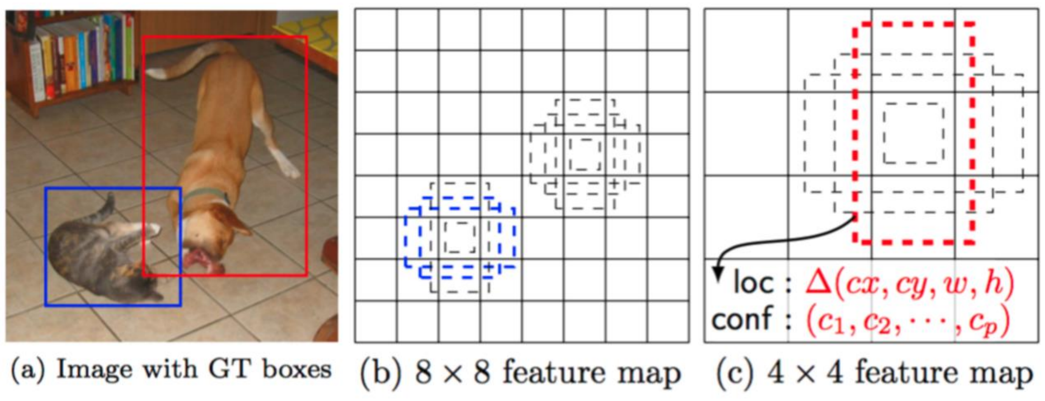


**Fig 5.11:-Matches.**

### 5.1.1.2. MobileNet.

MobileNets algorithm MobileNets uses depthwise separable convolutions that helps in building deep neural networks. The MobileNets model is more appropriate for portable and embedded vision based applications where there is absence of process control. The main objective of MobileNets is to optimize the latency while building small neural nets at the same time. It concentrates just on size without much focus on speed.

MobileNets are constructed from depthwise separable convolutions. In the normal convolution, the input feature map is fragmented into multiple feature maps after the convolution

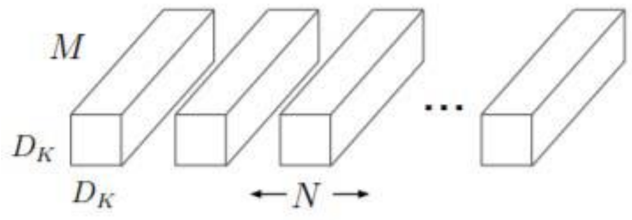


**Fig 5.12:- Normal Convolution**

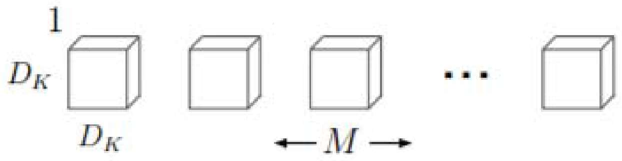


**Fig. 5.13:- Depth wise Convolution Filter**

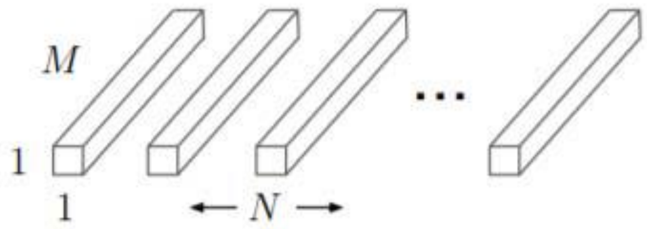


**Fig. 5.14:- 1×1 Convolutional Filters**

## 5.1.2. Techniques used.

### 5.1.2.1 Deep learning

The field of artificial intelligence is essential when machines can do tasks that typically require human intelligence. It comes under the layer of machine learning, where machines can acquire skills and learn from past experience without any involvement of human. Deep learning comes under machine learning where artificial neural networks, algorithms inspired by the human brain, learn from large amounts of data. The concept of deep learning is based on humans’ experiences; the deep learning algorithm would perform a task continuously so that it can improve the outcome. Neural networks have various (deep) layers that enable learning. Any drawback that needs “thought” to work out could be a drawback deep learning can learn to unravel.

### 5.1.2.2 OpenCV

OpenCV stands for Open supply pc Vision Library is associate open supply pc vision and machine learning software system library. The purpose of creation of OpenCV was to produce a standard infrastructure for computer vision applications and to accelerate the utilization of machine perception within the business product [6]. It is a rich wholesome libraby as it contains 2500 optimized algorithms, which also includes a comprehensive set of both classic and progressive computer vision and machine learning algorithms. These algorithms is used for various functions such as discover and acknowledging faces. Identify objects classify human actions. In videos, track camera movements, track moving objects.

### 5.1.2.3 Caffe Model

Caffe is a framework of Deep Learning and it was made used for the implementation and to access the following things in an object detection system.

•Expression: Models and optimizations are defined as plaintext schemas in the caffe model unlike others which use codes for this purpose.

•Speed: for research and industry alike speed is crucial for state-of-the-art models and massive data [11].

•Modularity: Flexibility and extension is majorly required for the new tasks and different settings

•Openness: Common code, reference models, and reproducibility are the basic requirements of scientific and applied progress.

## 5.2 Handwritten Equation Solver.

Firstly, we import our saved model.

1. Now, input an image containing a handwritten equation. Convert the image to a binary image and then invert the image(if digits/symbols are in black).
2. Now obtain contours of the image by default, it will obtain contours from left to right.
3. Obtain bounding rectangle for each contour.
4. Sometimes, we may get two or more contours for the same digit/symbol. To avoid that, we can check if the bounding rectangle of those two contours overlaps or not. If they overlap, then discard the smaller rectangle.
5. Now, resize all the remaining bounding rectangle to 28 by 28.
6. Using our model, predict the corresponding digit/symbol for each bounding rectangle and store it in a string.

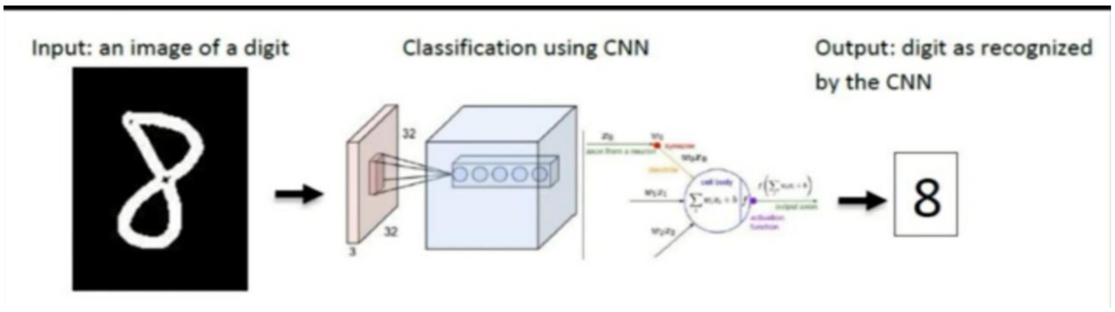

Input: an image of a digit
Classification using CNN
Output: digit as recognized by the CNN
32
32
3
8

**Fig 5.15. CNN**

7. After that use ‘eval’ function on the string to solve the equation.

## ANALYSIS MODEL

### Behavioral Model

Use case Diagram –

The use case view models functionality of the system as perceived by outside uses. A use case is a coherent unit of functionality expressed as a transaction among actors and the system.

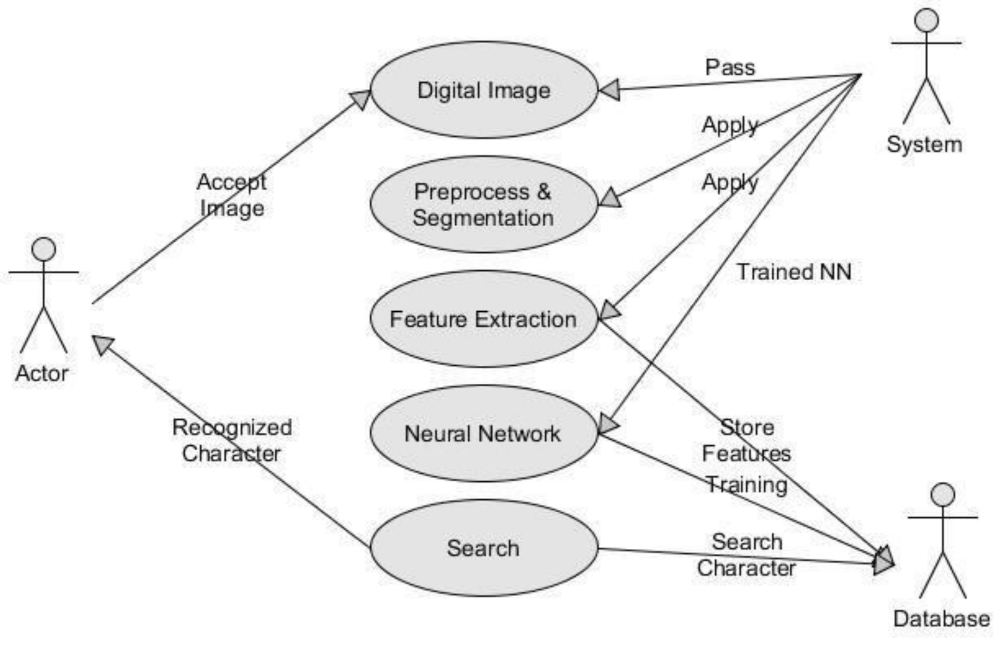


**Fig 5.16: Use Case Diagram**

## SEQUENCE DIAGRAM

A sequence diagram is a graphical view of a scenario that shows object interaction in a time based sequence what happens first, what happens next. Sequence diagram establish the role of objects and helps provide essential information to determine class responsibilities and interfaces. This type of diagram is best used during early analysis phase in design because they are simple and easy to comprehend. Sequence diagram are normally associated with use cases.

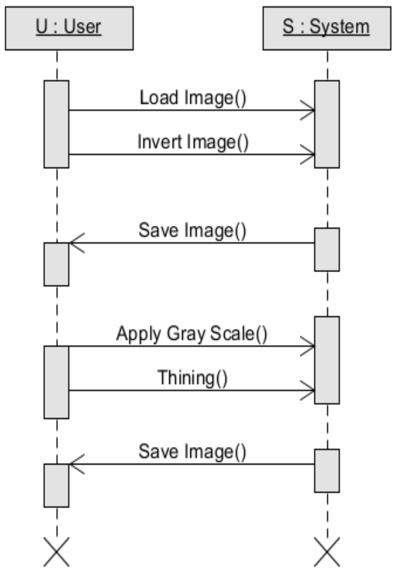


**Fig 5.17: Sequence Diagram of Preprocessing**

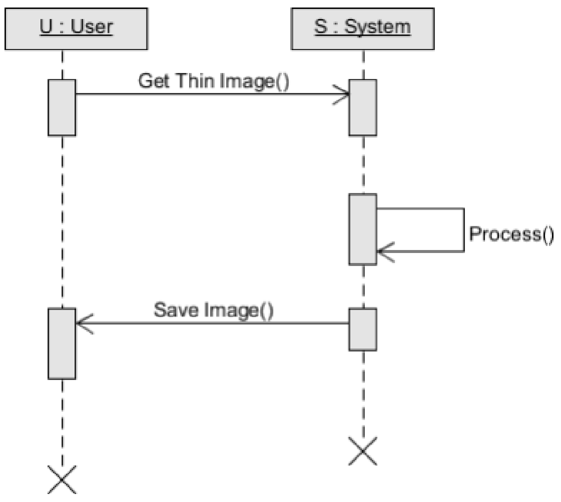


**Fig 5.18: Sequence Diagram of Segmentation**

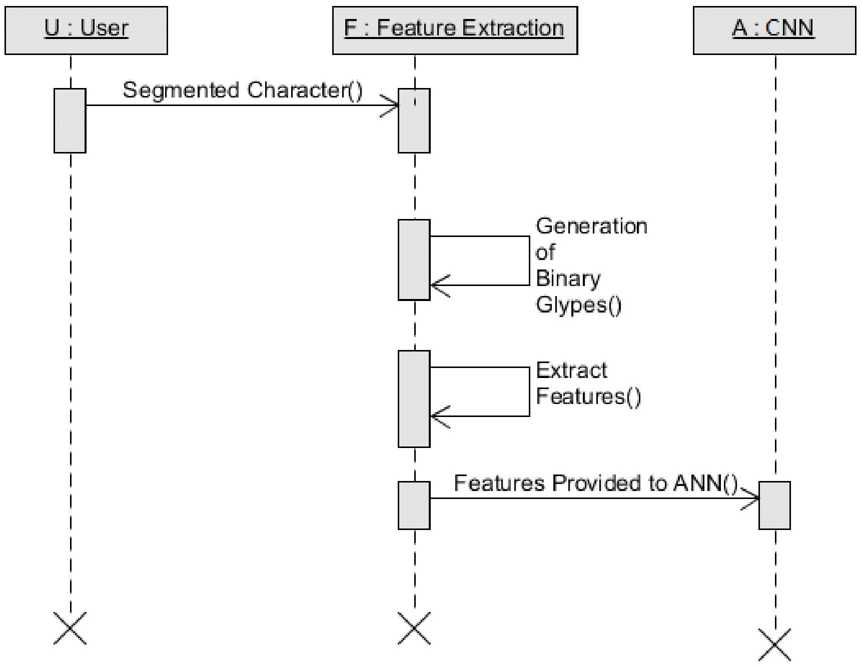


Fig 5.19: Sequence Diagram of Feature Extraction

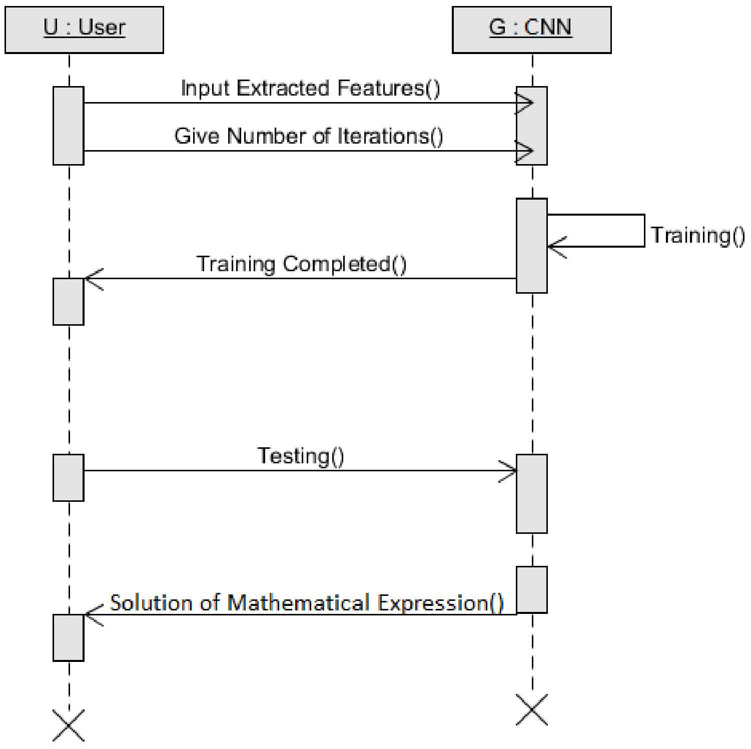

U : User
G : CNN
Input Extracted Features()
Give Number of Iterations()
Training()
Training Completed()
Testing()
Solution of Mathematical Expression()

Fig 5.20: Sequence Diagram of Classification

## FUNCTIONAL MODELLING

### Data Flow Diagram

Data flow diagram (DFD) is also called as Bubble Chart is a graphical technique, which is used to represent information flow, and transformers those are applied when data moves from input to output. DFD represents system requirements clearly and identify transformers those becomes programs in design. DFD may further partitioned into different levels to show detailed information flow e.g. level 0, level 1 etc.

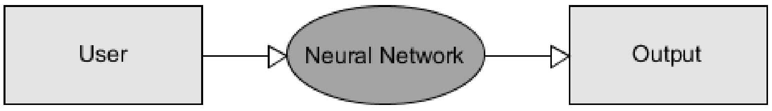


**Fig 5.21: DFD(level 0) for HES System**

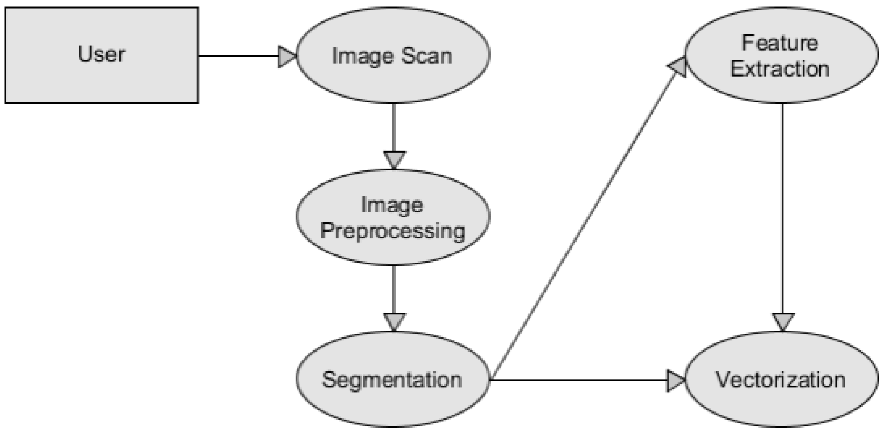


**Fig 5.22: DFD (level 1) for Image Reader**

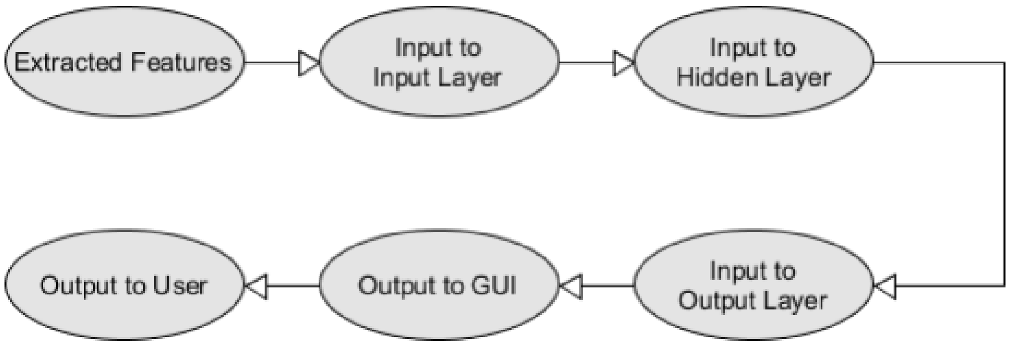


**Fig 5.23: DFD (level 1) for Recognition Unit**

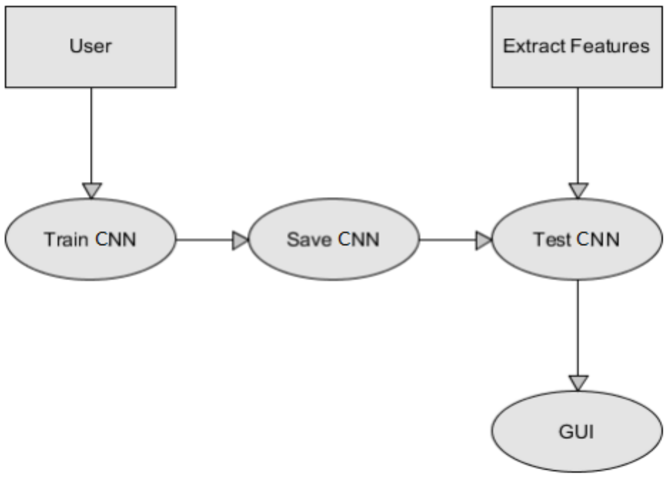


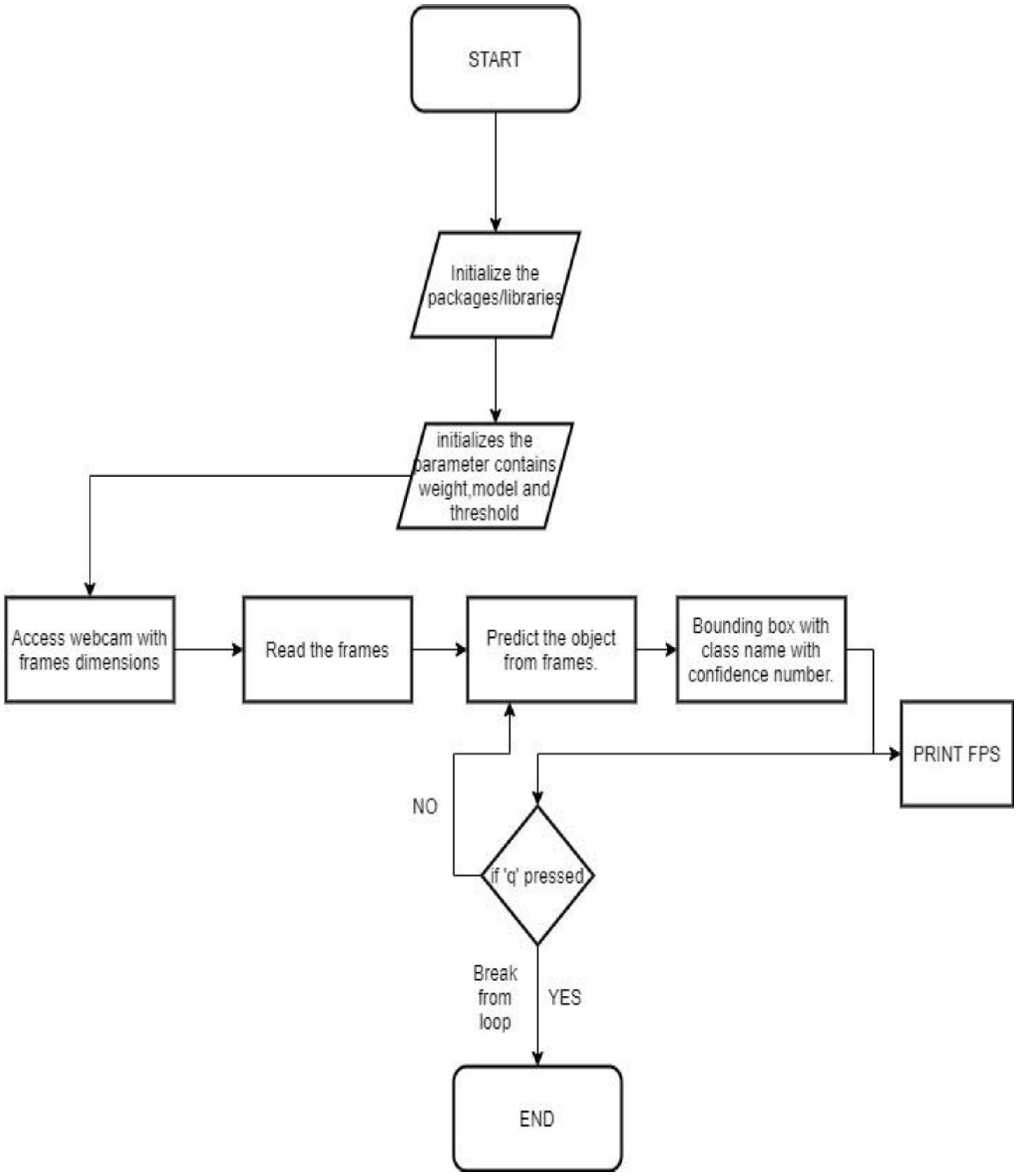
**Fig 5.24: Data Flow Diagram for CNN**

# CHAPTER 06

# FLOW-CHART & CODING

## 6.1 REALTIME OBJECT DETECTION.

**Flowchart**


START
Initialize the packages/libraries
initializes the parameter contains weight,model and threshold
Access webcam with frames dimensions
Read the frames
Predict the object from frames.
Bounding box with class name with confidence number.
PRINT FPS
NO
if 'q' pressed
Break from loop
YES
END

Program Explanation:-

Step1:

```
1.  # import the necessary packages
2.  from imutils.video import VideoStream
3.  from imutils.video import FPS
4.  import numpy as np
5.  import argparse
6.  import imutils
7.  import time
8.  import cv2
```

We begin by importing packages on **Lines 2-8**.It requires imutils and opencv3.3 libraries along with numpy,argparse.

Step2:

```
10.  # construct the argument parse and parse the arguments
11.  ap = argparse.ArgumentParser()
12.  ap.add_argument("-p", "--prototxt", required=True,
13.     help="path to Caffe 'deploy' prototxt file")
14.  ap.add_argument("-m", "--model", required=True,
15.     help="path to Caffe pre-trained model")
16.  ap.add_argument("-c", "--confidence", type=float, default=0.2,
17.     help="minimum probability to filter weak detections")
18.  args = vars(ap.parse_args())
```

Well parse our command line argument.

Step3:

```
20.  # initialize the list of class labels MobileNet SSD was trained to
21.  # detect, then generate a set of bounding box colors for each class
22.  CLASSES = ["background", "aeroplane", "bicycle", "bird", "boat",
23.     "bottle", "bus", "car", "cat", "chair", "cow", "diningtable",
24.     "dog", "horse", "motorbike", "person", "pottedplant", "sheep",
25.     "sofa", "train", "tvmonitor"]
26.  COLORS = np.random.uniform(0, 255, size=(len(CLASSES), 3))
```

On **Lines 22-26** we initialize CLASS labels and corresponding random COLORS.

Step4:

```
28.  # load our serialized model from disk
29.  print("[INFO] loading model...")
30.  net = cv2.dnn.readNetFromCaffe(args["prototxt"], args["model"])
31.
32.  # initialize the video stream, allow the cammera sensor to warmup,
33.  # and initialize the FPS counter
34.  print("[INFO] starting video stream...")
35.  vs = VideoStream(src=0).start()
36.  time.sleep(2.0)
37.  fps = FPS().start()
```

We load our serialized model, providing the references to our prototxt and model files on **Line 30** — notice how easy this is in OpenCV 3.3.Next let's initialize our video stream (this can be from a video file or a camera). First we start the VideoStream (**Line 35**), then we wait for the camera to warm up (**Line 36**), and finally we start the frames per second counter (**Line 37**). The VideoStream an FPS classes are part of my imutils package.

Step5:

```
39.  # loop over the frames from the video stream
40.  while True:
41.      # grab the frame from the threaded video stream and resize it
42.      # to have a maximum width of 400 pixels
43.      frame = vs.read()
44.      frame = imutils.resize(frame, width=400)
45.
46.      # grab the frame dimensions and convert it to a blob
47.      (h, w) = frame.shape[:2]
48.      blob = cv2.dnn.blobFromImage(cv2.resize(frame, (300, 300)),
49.          0.007843, (300, 300), 127.5)
50.
51.      # pass the blob through the network and obtain the detections and
52.      # predictions
53.      net.setInput(blob)
54.      detections = net.forward()
```

First, we read  a frame (**Line 43**) from the stream, followed by resizing it (**Line 44**).Since we will need the width and height later, we grab these no on **Line 47**. This is followed by converting the frame to a blob with the dnn module (**Lines 48 and 49**).Now for the heavy lifting: we set the blob as the input to our neural network (**Line 53**) and feed the input through the net (**Line 54**) which gives us our detections.

Step6:

```
    # loop over the detections
    for i in np.arange(0, detections.shape[2]):
        # extract the confidence (i.e., probability) associated with
        # the prediction
        confidence = detections[0, 0, i, 2]

        # filter out weak detections by ensuring the `confidence` is
        # greater than the minimum confidence
        if confidence > args["confidence"]:
            # extract the index of the class label from the
            # `detections`, then compute the (x, y)-coordinates of
            # the bounding box for the object
            idx = int(detections[0, 0, i, 1])
            box = detections[0, 0, i, 3:7] * np.array([w, h, w, h])
            (startX, startY, endX, endY) = box.astype("int")

            # draw the prediction on the frame
            label = "{}: {:.2f}%".format(CLASSES[idx],
                confidence * 100)
            cv2.rectangle(frame, (startX, startY), (endX, endY),
                COLORS[idx], 2)
            y = startY - 15 if startY - 15 > 15 else startY + 15
            cv2.putText(frame, label, (startX, y),
                cv2.FONT_HERSHEY_SIMPLEX, 0.5, COLORS[idx], 2)
```

We start by looping over our Detection, keeping in mind that multiple objects can be detected in a single image. We also apply a check to the confidence (i.e., probability) associated with each detection. If the confidence is high enough (i.e. above the threshold), then we'll display the prediction in the terminal as well as draw the prediction on the image with text and a colored bounding box.

Step7:

```
80.     # show the output frame
81.     cv2.imshow("Frame", frame)
82.     key = cv2.waitKey(1) & 0xFF
83.
84.     # if the `q` key was pressed, break from the loop
85.     if key == ord("q"):
86.         break
87.
88.     # update the FPS counter
89.     fps.update()
```

The above code block is pretty self-explanatory — first we display the frame (**Line 82**). Then we capture a key press (**Line 83**) while checking if the ‘q’ key (for “quit”) is pressed, at which point we break out of the frame capture loop (**Lines 86 and 87**).Finally we update our fps counter (**Line 90).**

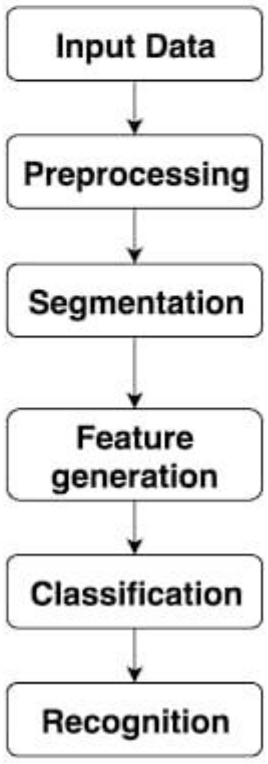
**Step8:**

```
91. # stop the timer and display FPS information
92. fps.stop()
93. print("[INFO] elapsed time: {:.2f}".format(fps.elapsed()))
94. print("[INFO] approx. FPS: {:.2f}".format(fps.fps()))
95.
96. # do a bit of cleanup
97. cv2.destroyAllWindows()
98. vs.stop()
```

When we’ve exited the loop, we stop the fps counter (**Line 93**) and print information about the frames per second to our terminal (**Lines 94 and 95**).We close the open window (**Line 98**) followed by stopping the video stream (**Line 99**).

## 6.2 HANDWRITTEN EQUATION SOLVER

### FLOWCHART



Coding explanation:

model = Sequential()
Our CNN model is built using the Sequential class, which represents a linear stack of layers.
-Add convolution
model.add(Conv2D(30, (5, 5),input_shape=(1 ,28, 28), activation='relu'))
The size of the convolutional matrix, in this case a 5x5 grid.
model.add(MaxPooling2D(pool_size=(2, 2)))
By specifying (2, 2) for the max-pooling, the effect is to reduce the size of the image by a factor of 4.
-Add another convolution
model.add(Conv2D(15, (3, 3),activation='relu'))
The size of the convolutional matrix, in this case a 3x3 grid.-
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.2))
A dropout layer with a 20% chance of setting inputs to zero, so as to avoid overfitting.Overfitting happens when a model learns the detail and noise in the training data to the extent that it negatively impacts the performance of the model on new data.
, activation='relu')) First layer has 128 functions, and it is called relu (or rectified linear unit
-Compile Model
model.compile(loss='categorical_crossentropy', optimizer='adam', met rics=['accuracy'])
Loss function will measure, how good or how bad the results were.
And then with optimiser:- it'll generate new parameter for the functions to see if it can do better.

# CHAPTER NO 07

# TESTING

## 7.1 REALTIME OBJECT DETECTION.

| Test Case Object | Perquisite | Step | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| a).If webcam stop working | System should be working | Disconnect The webcam or change the videostream “src” value other than 0. | Webcam will not be able to work properly. | Webcam Stops. | Pass |
| b).If the image dimension is incorrect. | System should be working | Introduced the incorrect image dimension or resize image function value =null. | System will not output any prediction. | System output the prediction. | Fail |
| c).If the opencv library version is below 3.3. | System should not be working. | Use the version which is below 3.3. | System will not show any detection and generate error. | System is not showing any detection and generating an error. | Pass |
| d).if confidence is below 0.5. | System should be working. | Use the blur poor quality Image. | System will not output detection. | System is showing detection. | Pass |

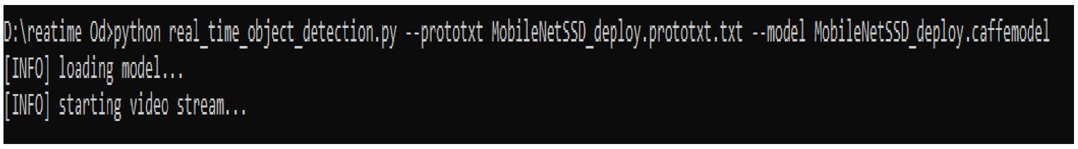
## 7.2 HANDWRITTEN EQUATION SOLVER.

| Test Case Object | Perquisite | Step | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| a).If keras version is different | System should be working | Set keras version 2.0 latest. | System will not predict images, therefore no detection. | Output fails by generating mismatch version of keras. | Pass |
| b).If the image dimension is incorrect. | System should be working | Introduced the incorrect image dimension other than 28x28px. | System will not output any prediction. | System output the prediction. | Fail |
| c).If using sigmoid function instead of softmax. | System should not be working. | Use the sigmoid function. | System will not show any Prediction and generate error. | System is not showing any prediction and generating an error. | Pass |
| d).if confidence is below 0.5. | System should be working. | Use the blur poor quality Image. | System will not output detection. | System is showing detection. | Pass |

# CHAPTER NO 08

# RUNNING SCREENSHOTS OF PROJECT

## 8.1 REALTIME OBJECT DETECTION



```
D:\reatime Od>python real_time_object_detection.py --prototxt MobileNetSSD_deploy.prototxt.txt --model MobileNetSSD_deploy.caffemodel
[INFO] loading model...
[INFO] starting video stream...
```

Fig 8.1.1 Loading model and initializing video stream

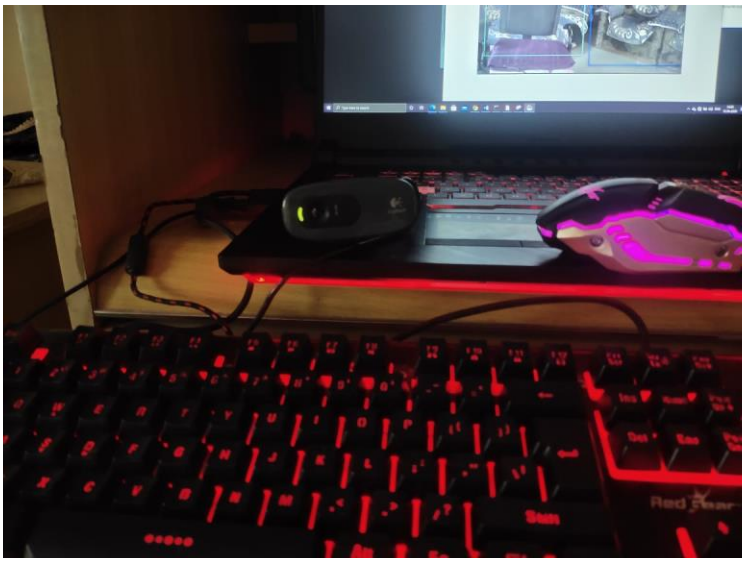


Fig 8.1.2 Initializing Webcam

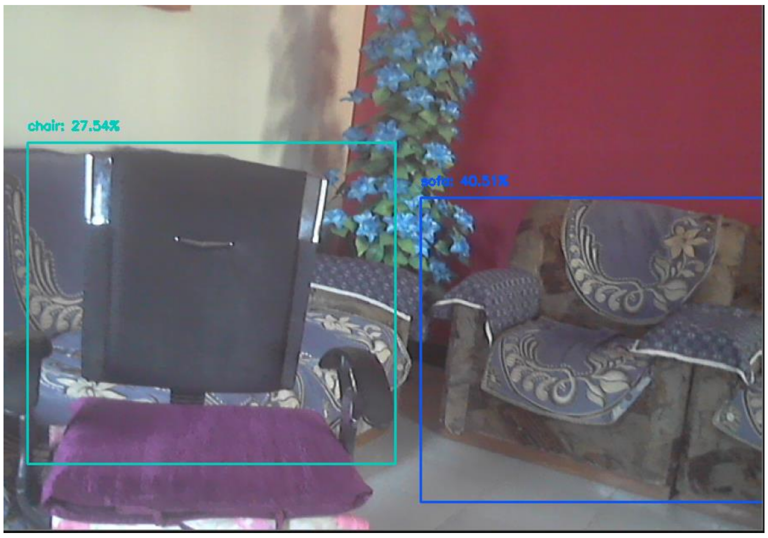
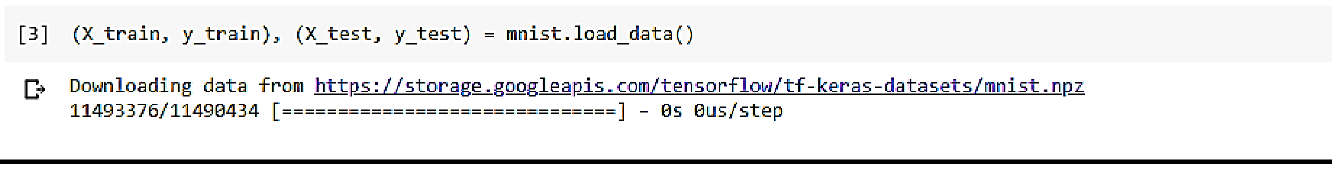


Fig 8.1.3 Real-time object detection result

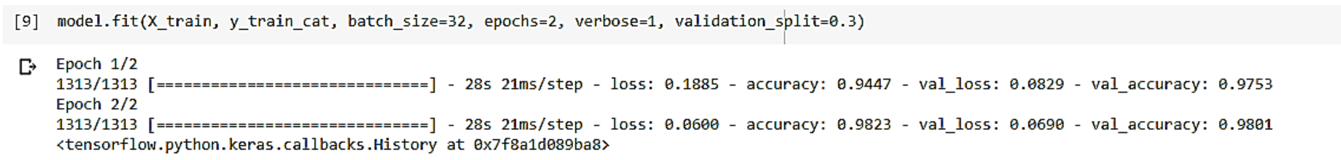
## 8.2 HANDWRITTEN EQUATION SOLVER



```
[3]  (X_train, y_train), (X_test, y_test) = mnist.load_data()

     Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
     11493376/11490434 [==============================] - 0s 0us/step
```

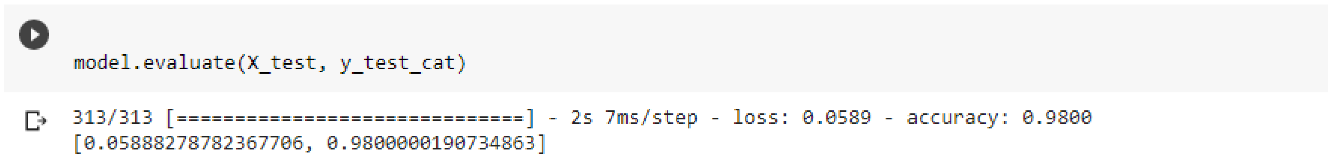
Fig 8.2.1 Downloading Data



```
[9]  model.fit(X_train, y_train_cat, batch_size=32, epochs=2, verbose=1, validation_split=0.3)

     Epoch 1/2
     1313/1313 [==============================] - 28s 21ms/step - loss: 0.1885 - accuracy: 0.9447 - val_loss: 0.0829 - val_accuracy: 0.9753
     Epoch 2/2
     1313/1313 [==============================] - 28s 21ms/step - loss: 0.0600 - accuracy: 0.9823 - val_loss: 0.0690 - val_accuracy: 0.9801
     <tensorflow.python.keras.callbacks.History at 0x7f8a1d089ba8>
```

Fig 8.2.2 Running epoch on Downloaded Data



```
model.evaluate(X_test, y_test_cat)

313/313 [==============================] - 2s 7ms/step - loss: 0.0589 - accuracy: 0.9800
[0.05888278782367706, 0.9800000190734863]
```

Fig 8.2.3 Evaluating the model

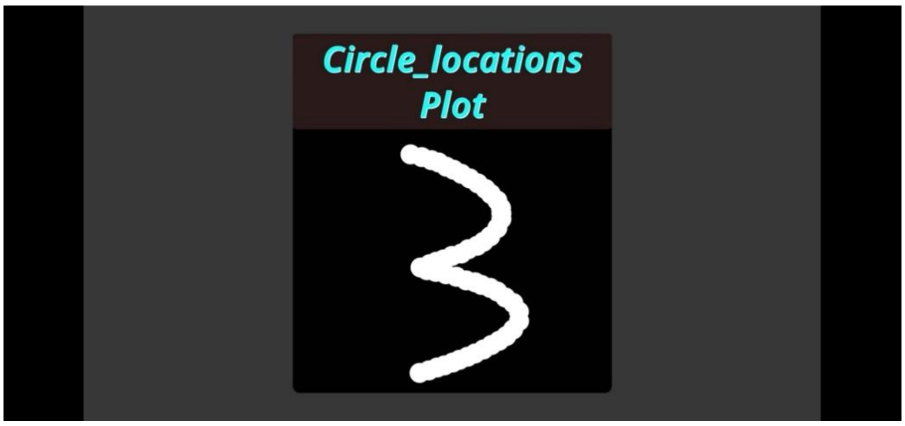


Fig 8.2.4 Inputing first image

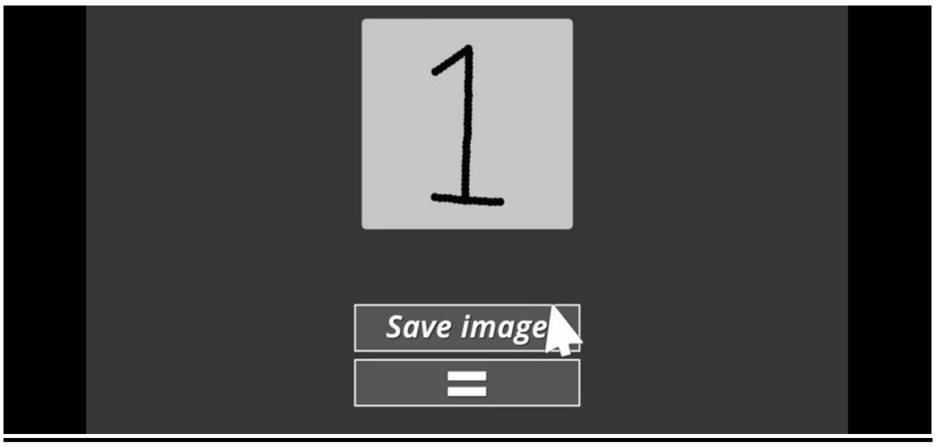


Fig 8.2.5 Inputting second image

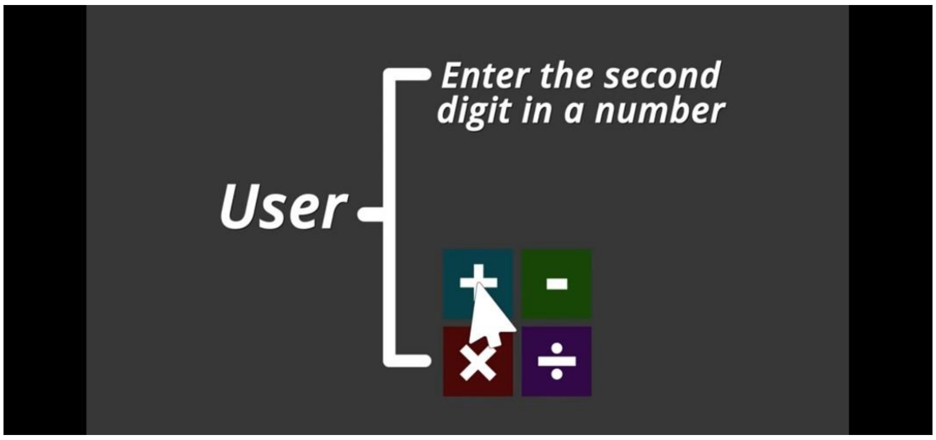


Fig 8.2.6 Selecting operator

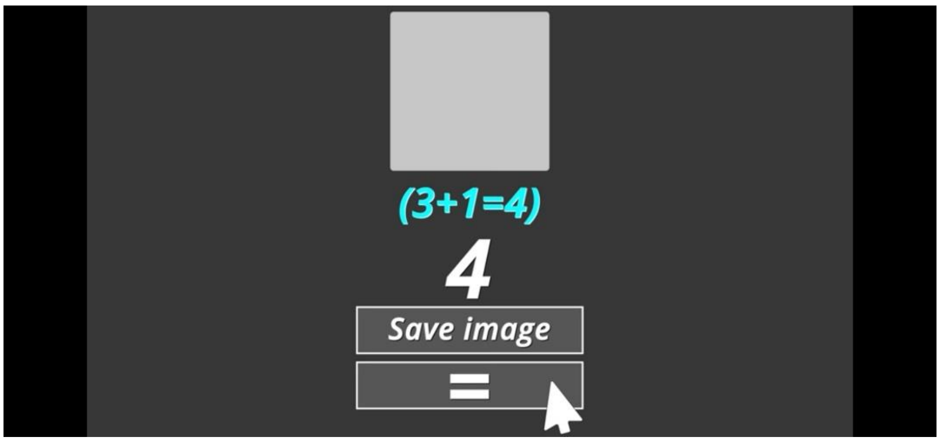


Fig 8.2.7 result of operation

# CHAPTER 09

# APPLICATION

## 9.1. Application of Real-time Object Detection.

The major applications of Object Detection:-

**9.1.1 Facial Recognition.** "Deep Face" is a deep learning facial recognition system developed to identify human faces in a digital image. Designed and developed by a group of researchers in Facebook. Google also has its own facial recognition system in Google Photos, which automatically separates all the photos according to the person in the image. There are various components involved in Facial Recognition or authors could say it focuses on various aspects like the eyes, nose, mouth and the eyebrows for recognizing a faces.

**9.1.2 People Counting**. People counting is also a part of object detection which can be used for various purposes like finding person or a criminal; it is used for analysing store performance or statistics of crowd during festivals. This process is considered a difficult one as people move out of the frame quickly.

**9.1.3 Industrial Quality Check**. Object detection also plays an important role in industrial processes to identify or recognize products. Finding a particular object through visual examination could be a basic task that's involved in multiple industrial processes like sorting, inventory management, machining, quality management, packaging and so on. Inventory management can be terribly tough as things are hard to trace in real time. Automatic object counting and localization permits improving inventory accuracy.

**9.1.4 Self Driving.** Cars Self-driving is the future most promising technology to be used, but the working behind can be very complex as it combines a variety of techniques to perceive their surroundings, including radar, laser light, GPS, odometer, and computer vision. Advanced control systems interpret sensory info to allow navigation methods to work, as well as obstacles and it. This is a big step towards Driverless cars as it happens at very fast speed.

**9.1.5 Security Object Detection**. plays a vital role in the field of Security; it takes part in major fields such as face ID of Apple or the retina scan used in all the sci-fi movies. Government also widely use this application to access the security feed and match it with their existing database to find any criminals or to detecting objects like car number involved in criminal activities. The applications are limitless

## 9.2. Application of Handwritten Equation Solver.

**APPLICATIONS**

### 9.2.1 Banking-

The most frequent use of HWR is to handle cheques: a handwritten cheque is scanned, its contents converted into digital text, the signature verified and the cheque cleared in real time, all with human involvement.

Legal-legal documents, especially the printed ones, can be digitised, stored, databased and made searchable

### 9.2.2 Healthcare-

one's entire medical history on a searchable, digital store means that things like past illnesses and treatments, diagnostic tests, hospital records, insurance payments etc can be made available in one unified place.HWR is also used to convert the image in Audio Form.

### 9.2.3 Searchability-

Once your scanned file has been converted to machine-readable text, you can save it in a format such as .doc, .rtf, .txt (simplest), .pdf etc. These files are internally searchable.

### 9.2.4 Editability-

Once document is digitised with HWR, this is easily done using a word processor, rather than have to type the whole document again.

### 9.2.5 Accessibility-

Once a document is scanned by HWR and made available on a common database, it is available to anyone with access to that database.

### 9.2.6 Storability-

Digitising documents reduces the storage space required for the same information from a few cubic inches to so many bytes on a server.

### 9.2.7 Backups-

Digital back-ups can be done cheaply, and potentially, an infinite number of times; instead of maintaining costly duplicates and triplicates in paper form.

# CHAPTER NO 10

# COST ESTIMATION

**Real-time object detection and handwritten equation solver:-**

| **Component Name** | **Quantity** | **Cost/component** |
|---|---|---|
| laptop | 1 | 70,000 |
| Webcam | 1 | 700 |
| Anaconda enterprise edition | 1 | 500 |

Fig 10.1 Cost estimation.

# CHAPTER NO 11
# EXPECTED RESULT AND CONCLUSION

## 7.1 Real-time Object Detection.

### 7.1.1 Expected Result Of Real-time Object Detection.

After building the whole process, this project gives some desired output. Expected outputs are as follows:-

a) Webcam should be in an operable position to record and gives the real time frames.

b) The image should be displayed in an rounding square box with object labelling on it.

c) The real-time detection should show the percentage accuracy detected in an image's object.

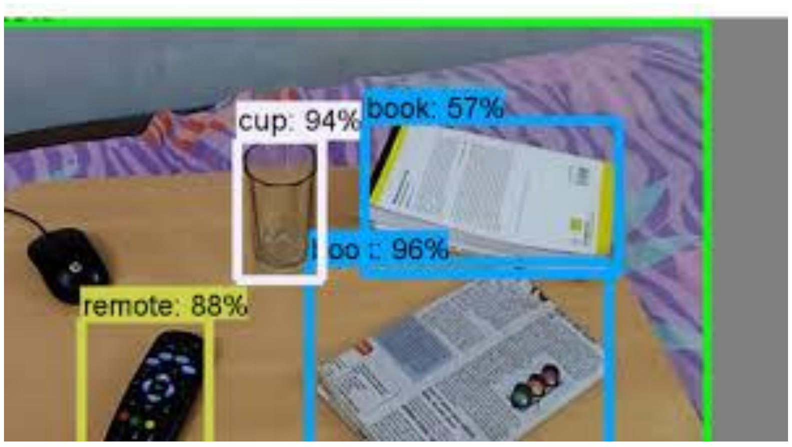


**Fig 7.1:-Expected Result of Real-time Object detection.**

### 7.1.2 Expected Result Of Handwritten Equation Solver.

After building the whole process, this project gives some desired output. Expected outputs are as follows:-

a) Webcam should be in an operable position to record and gives the images for solving equation.

b) The equation solved should give the high accuracy result.

## 7.2 Conclusion of Real-time Object Detection and Handwritten Equation Solver.

Deep learning based object detection has been a research hotspot in recent years. This project starts on generic object detection pipelines which provide base architectures for other related tasks. With the help of this the three other common tasks, namely object detection, face detection and pedestrian detection, can be accomplished[1]. Authors accomplished this by combing two things: Object detection with deep learning and OpenCV and Efficient, threaded video streams with OpenCV. The camera sensor noise and lightening condition can change the result as it can create problem in recognizing the object. The end result is a deep learning based object detector that can process around 20-40 FPS. Handwritten mathematical expression recognition of simple algebraic expression process performed successfully. The work included several phases which include data collection, preprocessing, segmentation, feature extraction, classification and symbol recognition. The accuracy of symbol classification and whole algebraic expression recognition is tested. An user interface to automatic mathematical expression recognition is developed with effective classifier. Hence, it is observed that classifier produces higher accuracy. In future, the work can be extended to recognize on-line mathematical expression recognition.

# A C K N O W L E D G E M E N T

We feel great pleasure in submitting this Project-1 report on “**Real-time object Detection and Handwritten Equation solver** ”.

We would wish to thank my Principal **Dr. R. P. Singh,** Academic Dean, **Dr. R. B. Barjibhe** and H.O.D., **Prof. D. D. Patil** for opening the doors of knowledge towards the realization of this project-I.

We wish to express true sense of gratitude towards our teacher and guide, **Prof. A.P. Ingale** who at every discrete step in project-I, contributed with his valuable guidance and help us to solve every problem that arose.

Most likely We would like to express my sincere gratitude towards our family and friends for always being there when We needed them the most.

With all respect and gratitude, We would like to thank all authors listed and not listed in references whose concepts are studied and used by us whenever required. We owe my all success to them.

Mr. Sarfaraz Khan

Mr. Pawan Baviskar

Miss. Priyanka Wankhede

Miss. Manasi Patil

Miss Taru Ojha

B.E C.S.E, 2019 – 2020, SSGBCOET, BSL

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