UNIVERSITY OF CALCUTTA

PROJECT TOPIC ON
HUMAN FACE DETECTION SYSTEM

Submitted By:

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INTRODUCTION

The face is one of the easiest ways to distinguish the individual identity of each other. Face recognition is a personal identification system that uses personal characteristics of a person to identify the person's identity. Human face recognition procedure basically consists of two phases, namely face detection, where this process takes place very rapidly in humans, except under conditions where the object is located at a short distance away, the next is the introduction, which recognize a face as individuals. Stage is then replicated and developed as a model for facial image recognition (face recognition) is one of the much-studied biometrics technologies and developed by experts.

AIM OF THIS PROJECT

The main aim of our project is to develop a Human Face Detection System that can clearly and accurately distinguish between Human Face and Non (Human) Face objects, i.e. it can detect a human face in a given image.

The system loads the image and then reduces the variability in the faces; the images are processed before they are fed into the network. All positive examples that is the face images are obtained by cropping images with frontal faces to include only the front view. All the cropped images are then corrected for lighting through standard algorithms.

LITERATURE REVIEW

There are mentions about the disadvantages of RFID (Radio Frequency Identification) card system, fingerprint system and iris recognition system. RFID card system is implemented due to its simplicity. The fingerprint system is indeed effective but not efficient because it takes time for the verification process so the user has to line up and perform the verification one by one. However for face recognition, the human face is always exposed and contains less information compared to iris. Iris recognition system which contains more detail might invade the privacy of the user. Voice recognition is available, but it is less accurate compared to other methods.

Advantages & Disadvantages of Different Biometric System

SYSTEM TYPE	***ADVANTAGES***	***DISADVANTAGES***
RFID card system	Simple	Fraudulent usage
Fingerprint system	Accurate	Time-consuming
Voice recognition system	-	Less accurate compared to others
Iris recognition system	Accurate	Privacy Invasion

Face Detection

Difference between face detection and face recognition are often misunderstood. Face detection is to determine only the face segment or face region from image, whereas face recognition is to identify the owner of the facial image. A few factors which cause face detection and face recognition to encounter difficulties consist of background, illumination, pose expression, occlusion, rotation, scaling and translation. The definition of each factor is tabulated below.

Factors Causing Face Detection Difficulties

Background	Variation of background and environment around people in the image which affect the efficiency of face recognition.
Illumination	Illumination is the variation caused by various lighting environments which degrade the facial feature detection.
Pose	Pose variation means different angle of the acquired the facial image which cause distortion to recognition process, especially for Eigen face and Fisher face recognition method.
Expression	Different facial expressions are used to express feelings and emotions. The expression variation causes spatial relation change and the facial-feature shape change.
Occlusion	Occlusion means part of the human face is unobserved. This will diminish the performance of face recognition algorithms due to deficiency information.
Rotation, scaling and translation	Transformation of images which might cause distortion of the original information about the images.

Most of the face detection methods used frontal upright facial images which consist of only one face. The face region is fully exposed without obstacles and free from the spectacles. Viola-Jones algorithm

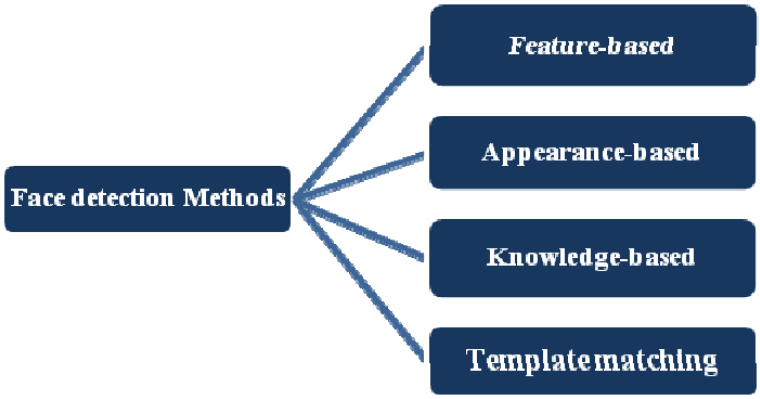
is not only fast and robust, but gives high detection rate and performs better in different lighting condition. This algorithm is able to eliminate the issues of illumination as well as scaling and rotation. Viola-Jones algorithm is the most efficient among all algorithms for instance the AdaBoost algorithm, the FloatBoost algorithm, Neural Networks, the S-AdaBoost algorithm, Support Vector Machines (SVM) and the Bayes classifier.

Advantages & Disadvantages of Face Detection Methods

FACE DETECTION METHOD	***ADVANTAGES***	***DISADVANTAGES***
Viola jones algorithm	1. High detection speed 2. High accuracy.	1. Long training time. 2. Limited head pose. 3. Not able to detect dark faces.
Local Binary pattern	1. Simple computation. 2. High tolerance against the monotonic illumination changes.	1. Only used for binary and grey images. 2. Overall performance is inaccurate compared to Viola-Jones algorithm.
AdaBoost algorithm (part of Viola jones algorithm)	Need not to have any prior knowledge about face structure.	The result highly depends on the training data and affected by weak classifiers.
SMQT Features and SNOW Classifier Method	1. Capable to deal with lighting problem in object detection. 2. Efficient in computation.	The region contain very similar to grey value regions will be misidentified as face.
Neural-Network	High accuracy only if large size of image were trained.	1. Detection process is slow and computation is complex. 2. Overall performance is weaker than Viola-Jones algorithm.

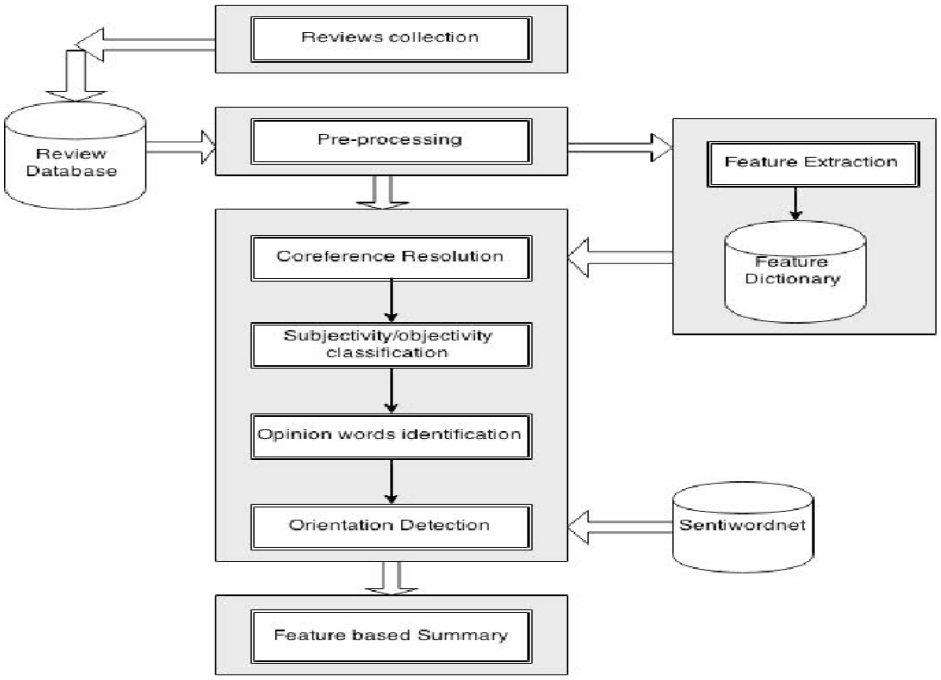
The face is one of the easiest ways to distinguish the individual identity of each other. Face detection is a personal identification system that uses personal characteristics of a person to identify the person's identity. Human face recognition procedure basically consists of two phases, namely face detection, where this process takes place very rapidly in humans, except under conditions where the object is located at a short distance away, the next is the introduction, which recognize a face as individuals. Stage is then replicated and developed as a model for facial image recognition (face recognition) is one of the much-studied biometrics technologies and developed by experts. There are two kinds of methods that are currently popular in developed face detection and recognition pattern namely, **Viola Jones Algorithm** for **face detection** and Eigenface method using **Principal Component Analysis (PCA)** for **face recognition**.

The Viola-Jones algorithm is a widely used mechanism for object detection. The main property of this algorithm is that training is slow, but detection is fast. This algorithm uses Haar basis feature filters, so it does not use multiplications.



Feature Based

The feature-based method is to locate faces by extracting structural features of the face. It is first trained as a classifier and then used to differentiate between facial and non-facial regions. The idea is to overcome the limits of our instinctive knowledge of faces. This approach divided into several steps and even photos with many faces they report a success rate of 94%.



Active Shape ModelActive shape models focus on complex non-rigid features like actual physical and higher level appearance of features Means that Active Shape Models (ASMs) are aimed at automatically locating landmark points that define the shape of any statistically modelled Department of ECE Page 5 object in an image.

Appearance Based

The appearance-based method depends on a set of delegate training face images to find out face models. The appearance-based approach is better than other ways of performance. In general appearance-based method rely on techniques from statistical analysis and machine learning to find the

relevant characteristics of face images. This method also used in feature extraction for face recognition.

Knowledge Based

The knowledge-based method depends on the set of rules, and it is based on human knowledge to detect the faces. Ex- A face must have a nose, eyes, and mouth within certain distances and positions with each other. The big problem with these methods is the difficulty in building an appropriate set of rules. There could be many false positive if the rules were too general or too detailed. This approach alone is insufficient and unable to find many faces in multiple images.

Template Matching

Template matching method uses predefined or parameterised face templates to locate or detect the faces by the correlation between the templates and input images. Ex- a human face can be divided into eyes, face contour, nose, and mouth. Also, a face model can be built by edges just by using edge detection method. This approach is simple to implement, but it is inadequate for face detection. However, deformable templates have been proposed to deal with these problems.

Other Face detection Methods

- **Eigenface-Based:-** Eigenface based algorithm used for Face Recognition, and it is a method for efficiently representing faces using Principal Component Analysis (PCA).
- **Distribution-Based:-** The algorithms like PCA and Fisher's Discriminant can be used to define the subspace representing facial patterns. There is a trained classifier, which correctly identifies instances of the target pattern class from the background image patterns.
- **Neural-Networks:-** Many detection problems like object detection, face detection, emotion detection, and face recognition, etc. have been faced successfully by Neural Networks.

Image Feature Analysis

These algorithms aimto find structural features that exist even when thepose, viewpoint, or lighting conditions vary, andthen use these to locate faces. These methods aredesigned mainly for face localization

Feature Searching

Viola Jones Algorithm: Paul Viola and Michael Jones presented an approach for object detection which minimizes computation time while achieving high detection accuracy. Paul Viola and Michael Jones [39] proposed a fast and robust method for face detection which is 15 times quicker than any technique at the time of release with 95% accuracy at around 17 fps.The technique relies on the use of simple Haar-like features that are evaluated quickly through the use of a new image representation. Based on the concept of an ―Integral Image‖ it generates a large set of features and uses the boosting algorithm AdaBoost to reduce the overcomplete set and the introduction of a degenerative tree of the boosted classifiers provides for robust and fast interferences. The detector is applied in a scanning fashion and used on gray-scale images, the scanned window that is applied can also be scaled, as well as the features evaluated.

There are 2 stages in the Viola-Jones Algorithm:

I. Training

II. Detection

Steps for training:

I. Training the classifiers with facial and non-facial images and

II. Adaboost

Steps for detection:

I. Detecting the Haar-like features and

II. Creating the integral image

Cascading By Haar Cascade classifier

Haar Features:

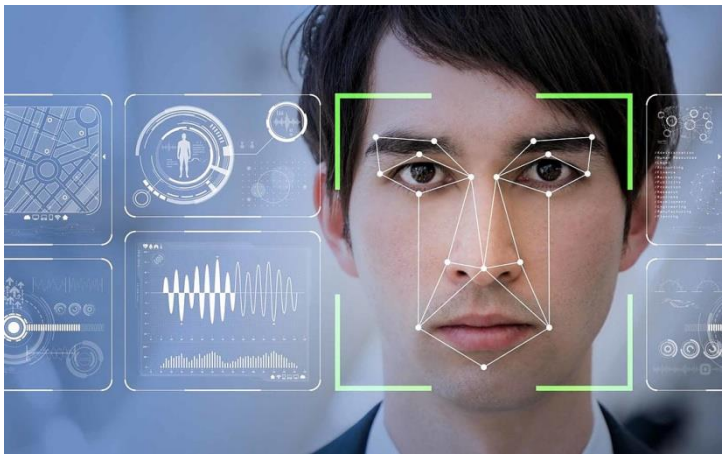
Each feature is a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle.

WHAT IS FACE DETECTION?

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images.
Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene.

WHAT IS HUMAN FACE DETECTION?

Human face detection means that a system is able to identify that there is a human **face** present **in an** image or video.



OUR PROPOSED METHOD

- Considering an coloured image and converting it into grey scale image.
- Searching for the facial features in the grey scale image.
- Applying a "**T**" structure to enclose the 4 distinct features of a face i.e. left eye, right eye, nose and lips which are already been detected in the grey scale image.
- Searching for the "**WBW**" pattern in the eyes so as to confirm that the face detected is a human face.

ALGORITHMS USED

- Viola Jones Algorithm
- Haar Cascade Classifiers (to extract face features)
- T Pattern
- WBW Pattern

VIOLA JONES ALGORITHM

Developed in 2001 by Paul Viola and Michael Jones. Viola-Jones algorithm is an object-recognition framework that allows the detection of image features in real-time.
There are 2 stages in the Viola-Jones Algorithm:

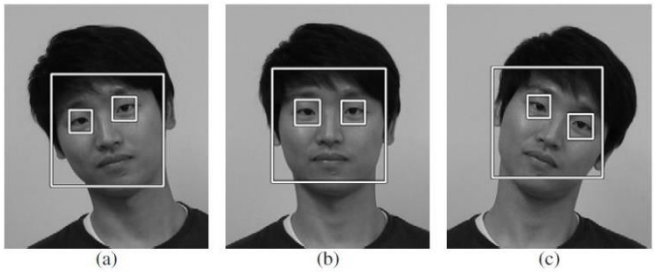
I. Training
II. Detection

Steps for training:

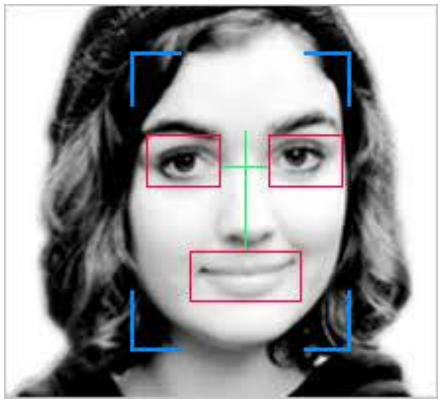
I. Training the classifiers with facial and non-facial images and
II. Adaboost

Steps for detection:

I. Detecting the Haar-like features and
II. Creating the integral image



Detection of eyes in frontal face image

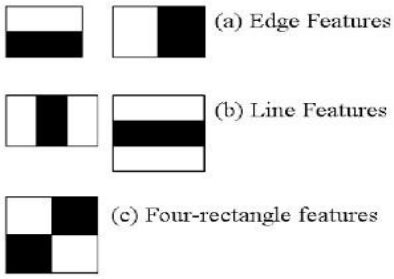


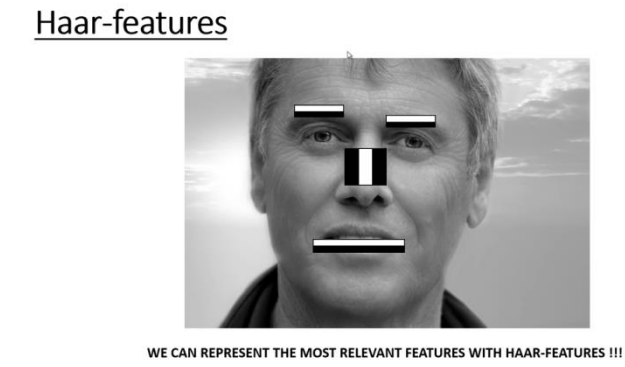
Detection of eyes, nose and lips in frontal face image

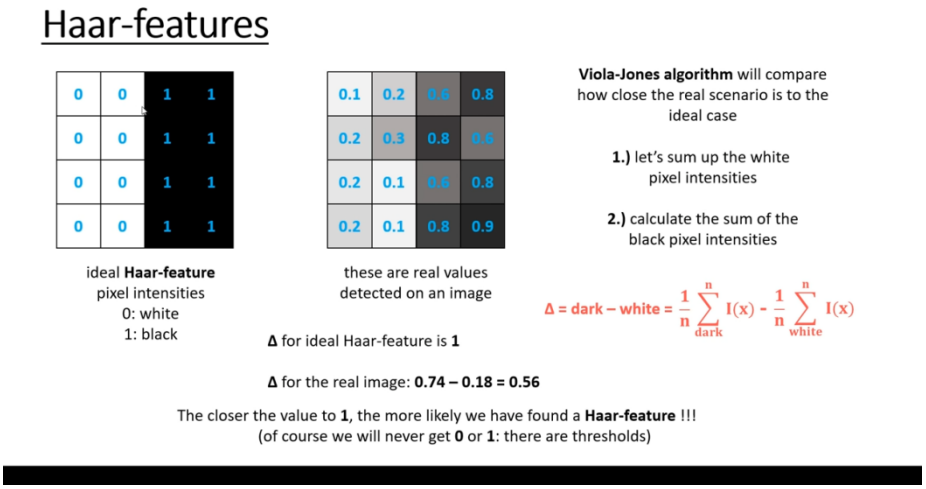
HAAR CASCADE CLASSIFIER

Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, “Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001.
It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

Haar Features:
Each feature is a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle.

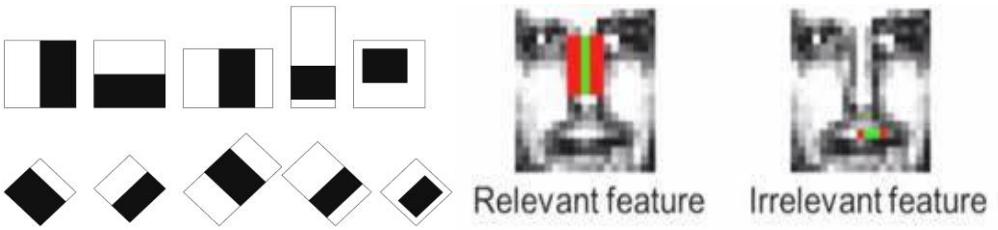






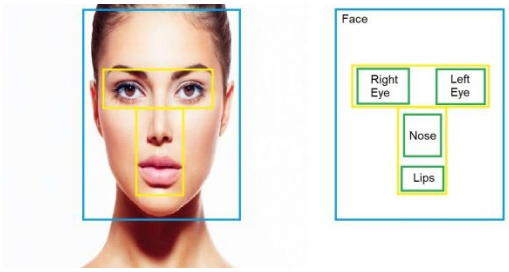
ADABOOST

As stated previously there can be approximately 160,000+ feature values within a detector at 24x24 base resolution which need to be calculated. But it is to be understood that only few set of features will be useful among all these features to identify a face.

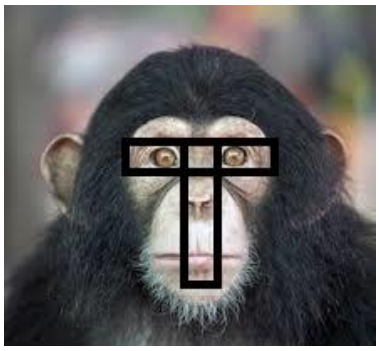


T PATTERN

- Consider the 4 features extracted (i.e. left eye, right eye, nose and lips) using Viola-Jones algorithm in the cropped grey scale image.
- Take the T pattern of same dimension as the extracted face features image.
- Superimpose the T pattern image on the face features image.
- Compare the 4 face features with the T pattern and confirm for the human face.

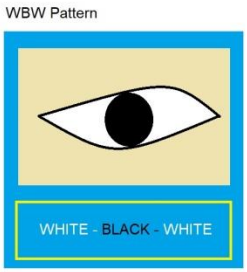


T pattern enclosing the 4 facial features



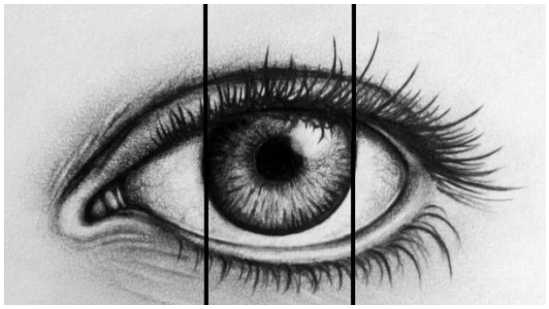
T pattern is valid for the ape species.

WBW PATTERN



WBW pattern of the human eyes

- First we will look for **WBW** pattern in frontal face image(WBW pattern means white part of eyes then black pupil then again white part of eyes)
- After getting such pattern we will try to find out another one which should be **almost** parallel to the previous pattern with respect to area of that previous WBW pattern.



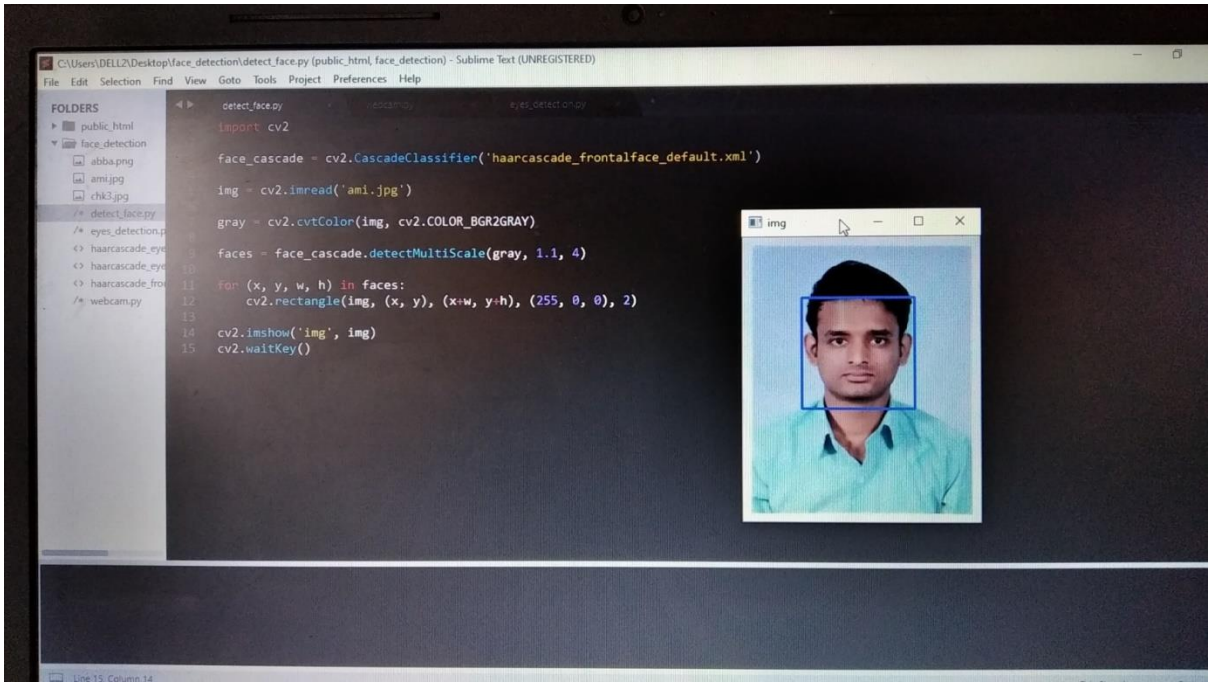
WBW pattern is valid for the human eyes

Firstly no animal has both eyes in front face (exceptions are there, e.g.: ape). But in the case of ape two things might happen:

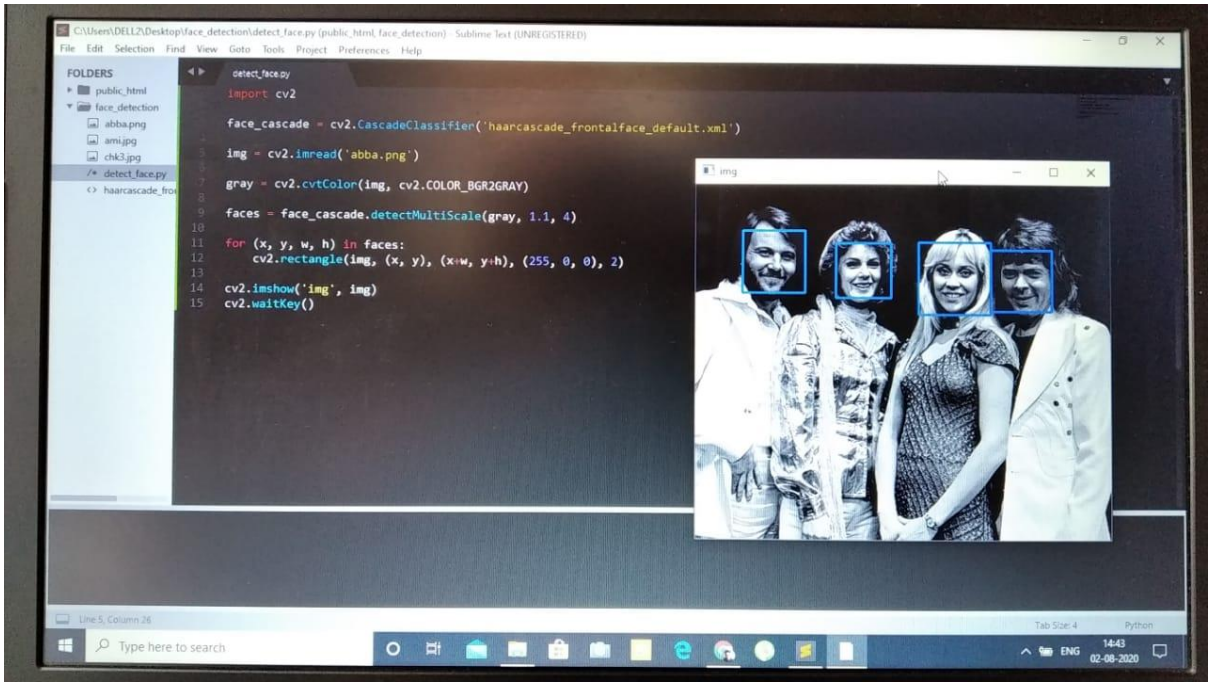
I. We would not find WBW pattern because most of them has fully black eyes.
II. For the ape species which don't have fully black eyes the have yellow parts surrounding the black pupils.

WBW pattern is not valid for the ape species

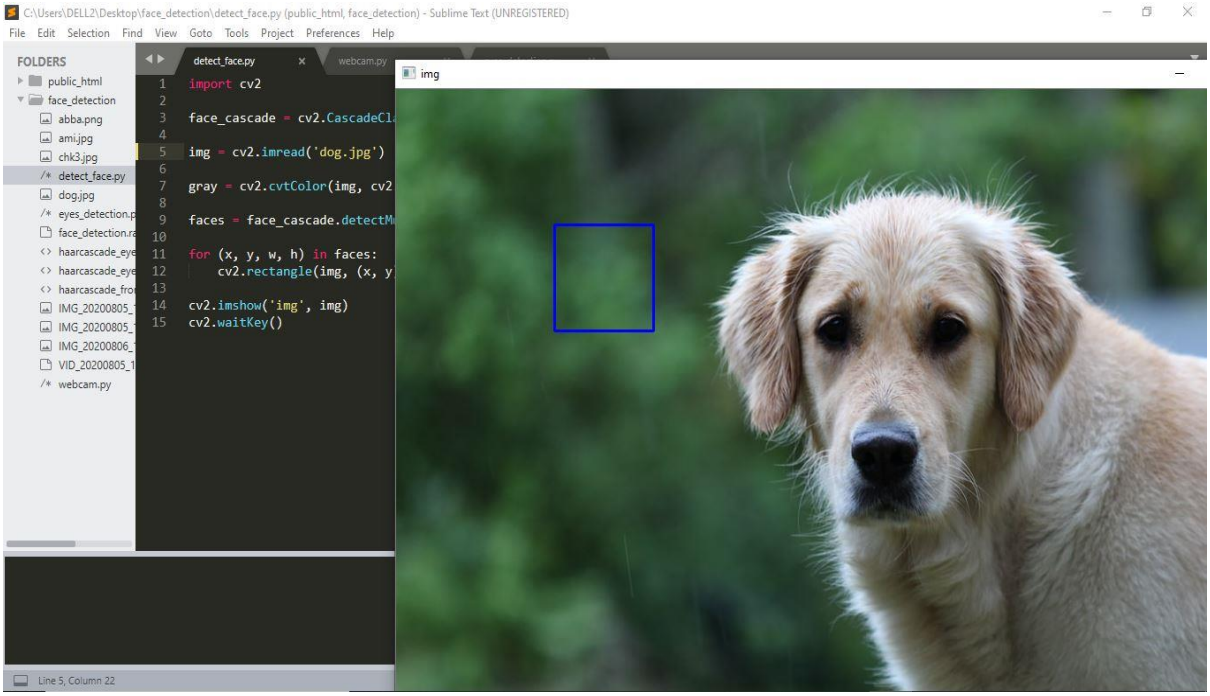
FINAL OUTPUT



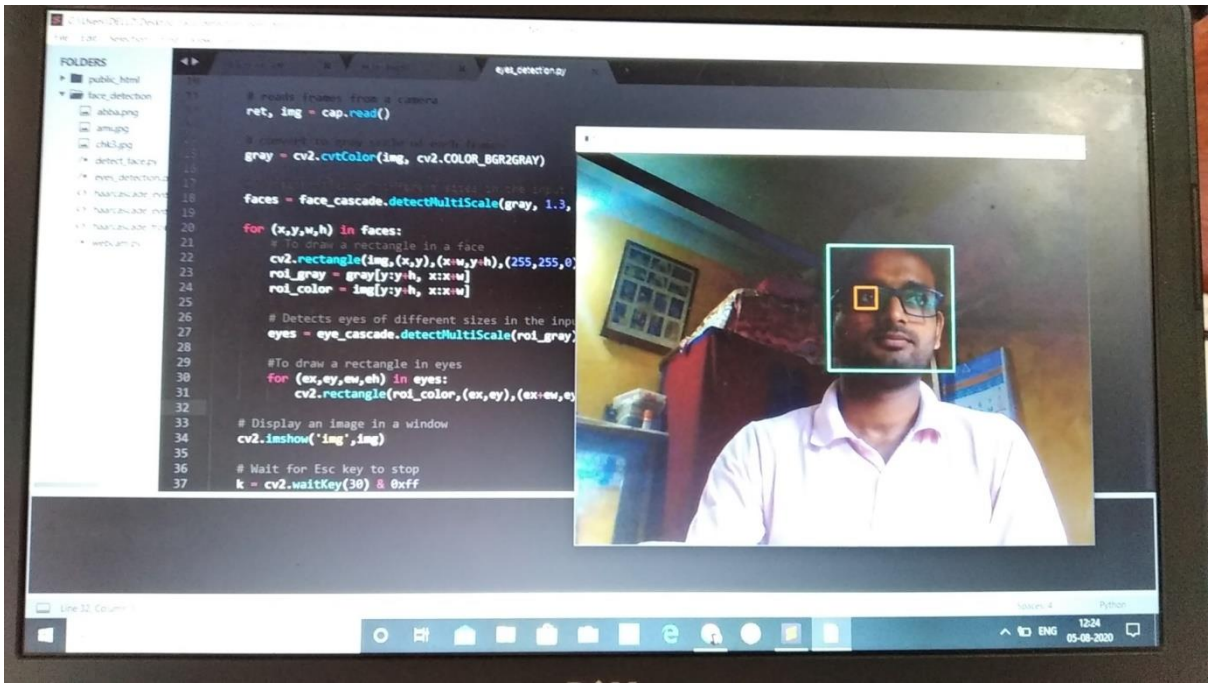
Detection of the face in an image



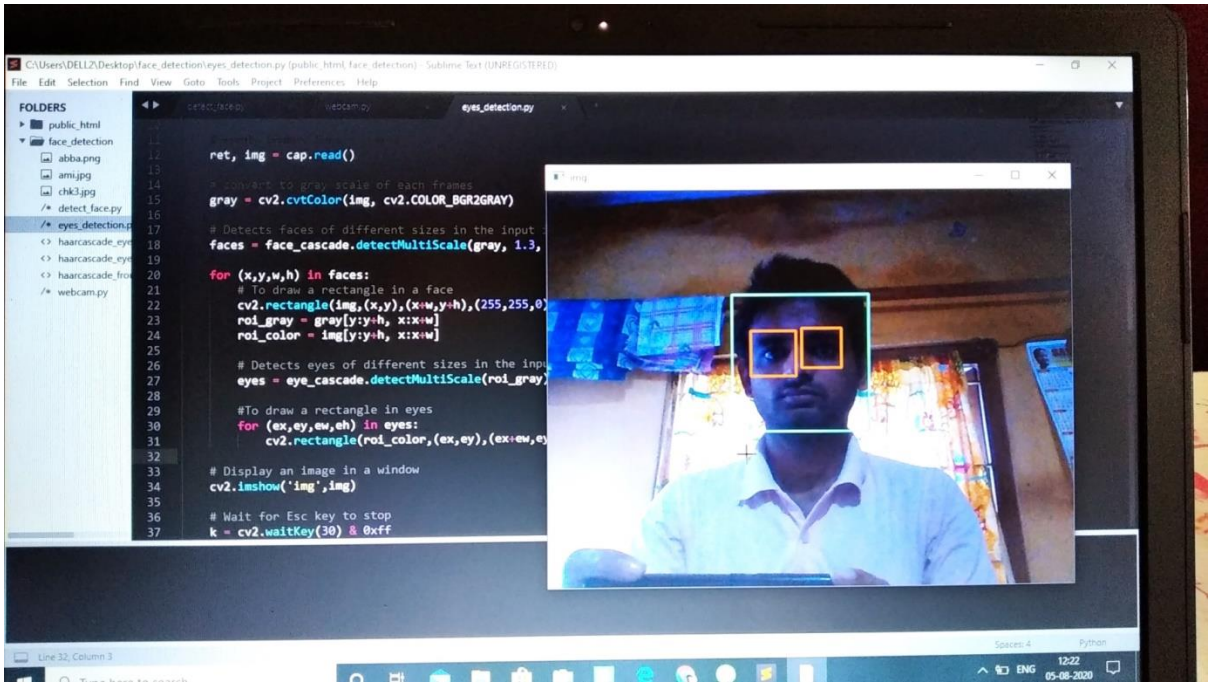
Detection of multiple faces in an image



No face is detected other than that of a human



Detection of the eye within a face image



Detection of the left and right eyes within a face image

SOURCE CODE

Code for Detection of Face Image

```
import cv2

face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')

img = cv2.imread('ami.jpg')

gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

faces = face_cascade.detectMultiScale(gray, 1.1, 4)

for (x, y, w, h) in faces:
        cv2.rectangle(img, (x, y), (x+w, y+h), (255, 0, 0), 2)

cv2.imshow('img', img)
cv2.waitKey()
```

Code for Detection of the Facial Features

```
import cv2
face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')
eye_cascade = cv2.CascadeClassifier('haarcascade_eye.xml')

# capture frames from a camera
cap = cv2.VideoCapture(0)

# loop runs if capturing has been initialized.
while 1:

   # reads frames from a camera
   ret, img = cap.read()

   # convert to gray scale of each frames
   gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

   # Detects faces of different sizes in the input image
   faces = face_cascade.detectMultiScale(gray, 1.3, 5)

   for (x,y,w,h) in faces:
      # To draw a rectangle in a face
      cv2.rectangle(img,(x,y),(x+w,y+h),(255,255,0),2)
      roi_gray = gray[y:y+h, x:x+w]
      roi_color = img[y:y+h, x:x+w]
```

```
        # Detects eyes of different sizes in the input image
        eyes = eye_cascade.detectMultiScale(roi_gray)

        #To draw a rectangle in eyes
        for (ex,ey,ew,eh) in eyes:
            cv2.rectangle(roi_color,(ex,ey),(ex+ew,ey+eh),(0,127,255),2)

    # Display an image in a window
    cv2.imshow('img',img)

    # Wait for Esc key to stop
    k = cv2.waitKey(30) & 0xff
    if k == 27:
        break

# Close the window
cap.release()

# De-allocate any associated memory usage
cv2.destroyAllWindows()
```

Code for Detection of Face Image by Webcam

```
import cv2

face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')

cap = cv2.VideoCapture(0)

while True:
        _, img = cap.read()

        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

        faces = face_cascade.detectMultiScale(gray, 1.1, 4)

        for (x, y, w, h) in faces:
                cv2.rectangle(img, (x, y), (x+w, y+h), (255, 0, 0), 2)

        cv2.imshow('img', img)
        k = cv2.waitKey(30) & 0xff
        if k==27:
                break

cap.release()
```

APPLICATIONS

- Facial motion capture
- Facial recognition
- Photography
- Marketing
- Emotional Inference
- Lip Reading

ADVANTAGES

- Independent of Skin Textures
- Independent of Light Effects
- Independent of Facial Marks
- Platform Independent

DISADVANTAGES

- Frontal face image is must
- All four face features are required

FUTURE SCOPES

- Time complexity reduction
- Overcome mandatory requirement of all 4 face features

CONCLUSION

- The computer based facial recognition industry has made much useful advancement in the past decade; however, the need for higher accuracy remains. Through the determination and commitment of industry, government evolutions and organised standard bodies, growth and progress will continue, raising the bar for face detection and recognition technology.
- Still working on algorithms to detect face from different angles.

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