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A report on

SMART ATTENDANCE SYSTEM

(Using Face Recognition)

By:
Vishwa Gajjar – 20BCP171
Sahaj Bhadja – 20BCP151
Dhruv Patel – 20BCP152

Under the guidance of:
Dr. Chintan Bhatt
Computer Science, SOT
Pandit Deendayal Energy university

I. Executive Su

This report covers the implementation of face detection and recognition technology for attendance systems. The goal is to eliminate the manual systems for attendance, which are time consuming. The idea is inspired by the fact that manual attendance records lead to a wastage of papers. The vision is to save papers and time. This is being achieved by implementing digitalized systems, where no records in paperback format are required and the time required by humans is also saved. The attendance is recorded on the basis of face detection and recognition by the software itself, reducing the time required and is stored in the form of database or xml files, which eliminates the need of paper. The technologies used in the software setup and the enhancements required are discussed in detail throughout the report.

In the time where everything is being digitalized, the manual system of attendance marking seem to be time consuming and obsolete. The proposed system focuses on optimizing the attendance systems by reducing time as well as paper consumption. The piles of papers stored as a record for attendance can be eliminated using the digital systems. Also, the human errors caused in attendance marking or the intentional frauds / proxy systems can be eliminated using digitalized systems.

II. INTRODUCTION

1.1. Introduction:

The report explains the purpose and making of our project – smart attendance system using face recognition technology. Facial detection and face recognition are being used in this project. Facial detection is used in to determine the location of the facial area, and face recognition is required in order to identify the person and record his / her attendance. When the face of an individual student corresponds with one of the faces already saved in the database, then the attendance of that student is recorded. The database is kept with all the student details that are currently enrolled in the class, and information is fetched from the database for the image recognition process.

Here an attendance marking system is implemented that does not interfere with regular teaching procedures. This technology avoids traditional student identification methods such as calling the student's name or verifying their individual identity cards. Also, it can be used for identity verification purpose along with attendance at places like exam centres. Furthermore, the automatic student attendance system based on facial recognition can overcome the issue of fraudulent approaches, and lecturers are not required to count the number of students numerous times to confirm the students' presence.

1.2. Aims and objectives:

The objective of this project is to develop face recognition-based attendance system that will reduce the time required for manual marking of attendance and will eliminate the need of an authorized person for marking attendance. The expected outcomes of the project are as below:

Detecting the facial region in a video frame.

To extract relevant characteristics / features from the detected face.

To categorise the features in order to identify the detected face.

To record the identified student's attendance.

1.3. The problem statement:

Every college, university, and institution need the attendance record of their employees or student in order to track their work. The conventional way for collecting attendance in a classroom involves calling out the names of the students or their roll numbers, for recording the attendance. The amount of time that is spent on this task is a considerable cause for worry. Assume that the length of time spent on one topic is around sixty or seventy minutes, and that it takes five to ten minutes to register attendance. This will need a significant amount of time from each instructor. Also, the number of papers used to keep a record of the attendance leads to the wastage of piles of pages. So, an environment friendly solution is to digitalize these records in the form of databases and save papers.

In order to prevent these kinds of losses, the project makes use of an automated procedure that is centred on image processing.

1.4. Background:

There are various automated systems for taking attendance that are now being used by a lot of different establishments. The biometric technology and the RFID system are two examples of such systems. Even though it is automated and a step forward over the traditional process, it is not fast enough to fulfil the need. The student must wait in queue for their attendance, which is again a time- consuming process.

A person's identity may be conveyed via the unique characteristics of their face. And so, in this project, an individual's face is used in order to automatically make attendance records. Face recognition is described as a biometric approach for identifying an individual by comparing real-time captured photos with recorded photographs in that person's database.

Face detection is a kind of computer vision technology that can recognise people's faces in digital photographs. Humans find this simple, but computers need exact instructions. Buildings, automobiles, animals, and other items that are not human faces may appear in the photos. It is a challenging task to create an automated system that can identify faces as a human does.
A face recognition system maps facial characteristics from an image or video using biometrics. To identify a match, it compares the information to a database of known faces. Facial recognition employs computer-generated filters to convert facial photos into numerical expressions that can then be compared to detect similarity. Facial analysis attempts to learn about the individuals based on their facial features, such as their age, gender, or the mood they are showing.

A feature is a set of data in a picture that is useful in addressing a particular problem. It might be as basic as a single pixel value, or it could be more sophisticated, such as edges, corners, and forms. You may combine many basic features to create a complicated feature. When certain processes are applied to a picture, information that may be termed features is produced. Computer vision and image processing offer a huge number of relevant characteristics and techniques for extracting features. In general, any inherent or derived property of an image can be used as a feature to solve problems.

A pixel, often known as a picture element, is the smallest constituent in an image. It is essentially a dot in the image. A picture is made up of pixels organized in rows and columns. However, a computer does not recognize pixels as colored dots. It simply comprehends numbers. The computer uses multiple color models to translate colors to numbers. Pixels in color pictures are often represented using the RGB color model. RGB is an abbreviation for Red Green Blue. Each pixel is made up of a combination of the RGB is
excellent at representing all of the colors that people see by mixing different quantities of red, green, and blue. The RGB pixels are converted to Gray Scale for image processing. Each pixel in a grayscale (black and white) picture is a single integer
that represents the quantity of light, or intensity, that it contains. In many applications, the intensity range is 0 (black)

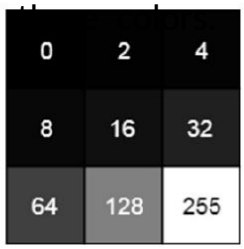


Figure 1 - Grayscale matrix example

to 255. (white). Everything in the range of 0 to 255 is a different shade of grey.

A picture is nothing more than a matrix (or table) of integers if each grayscale pixel is a number.

Technologies and libraries used in this project includes pandas, numpy, matplotlib, seaborn, sklearn, and OpenCV along with Haar Cascade Classifier.

1.5. Related work:

Face recognition systems are popular because of their ease of use and high performance. Face recognition is used in criminal investigations by airport security systems and the FBI, for example, to trace suspects, missing children, and drug trafficking. In addition, Facebook, a famous social networking website, uses facial recognition to enable users to tag their friends in photos for amusement reasons. Furthermore, Intel Company enables consumers to access their online accounts using facial recognition. Apple enables consumers to unlock their iPhone X by utilising facial recognition. Face detections are used in Proctored Online Exams.
Example. PEXA

Traditional digital systems used for attendance systems include: RFID, iris recognition system, and Fingerprint systems.

System Type	Advantage	Disadvantage
RFID card system	Simple	Fraudulent usage
Fingerprint System	Accurate	Time – consuming
Voice Recognition system	-	Less accurate
Iris recognition system	Accurate	Privacy invasion

But, as identified by Arun Katara(2017), RFID (Radio Frequency Identification) card systems, fingerprint systems, and iris recognition systems were all having drawbacks. Because of its simplicity, the RFID card system is used. However, if they have user has some other's identity card, the user will assist their pals in checking in. The fingerprint method is effective, but not efficient, since the verification procedure takes time, therefore the user must line up and do the verification one by one. A more detailed iris recognition system may intrude on

the user's privacy. Although voice recognition is accessible, it is less accurate than other approaches. As a result, it is advised that a face recognition technology be installed in the student attendance system.

However, when it comes to face identification, the human face is constantly visible and contains less information than the iris.

1.6. Flowchart:

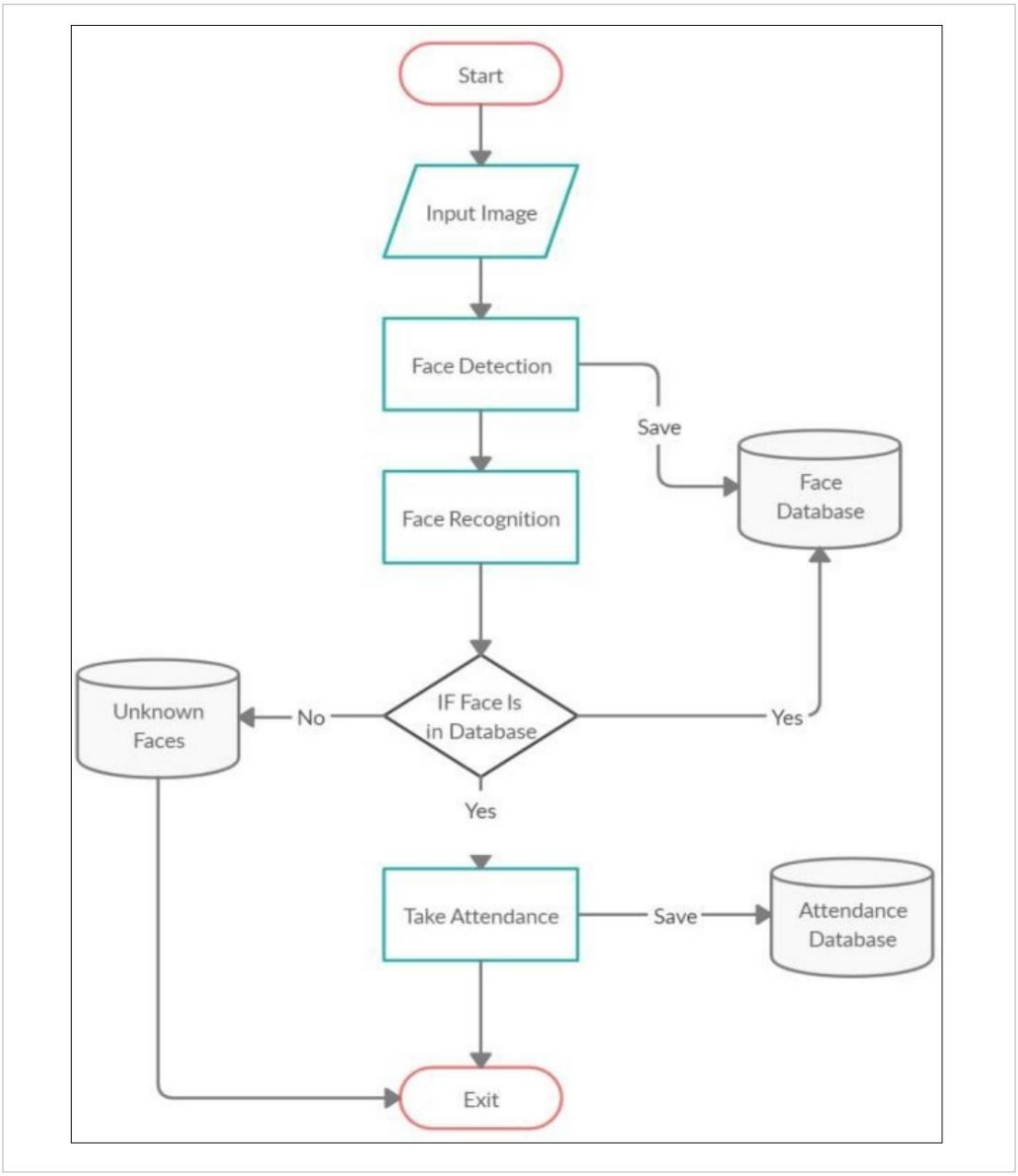


Figure 2 – Flowchart depicting the process flow of the system

1.7. Scope of the project:

In the time where everything is being digitalized, the manual system of attendance marking seem to be time consuming and obsolete. The proposed system focuses on optimizing the attendance systems by reducing time as well as paper consumption. The piles of papers stored as a record for attendance can be eliminated using the digital systems. Also, the human errors caused in attendance marking or the proxy systems can be eliminated using digitalized systems. The system can be utilised at various places like educational institutions, companies and also can be utilised at exam centres for marking attendance as well as verification of the candidate.

III. Literature

3.1. Face recognition technology

The below figure shows the evolution of face recognition technology over time:

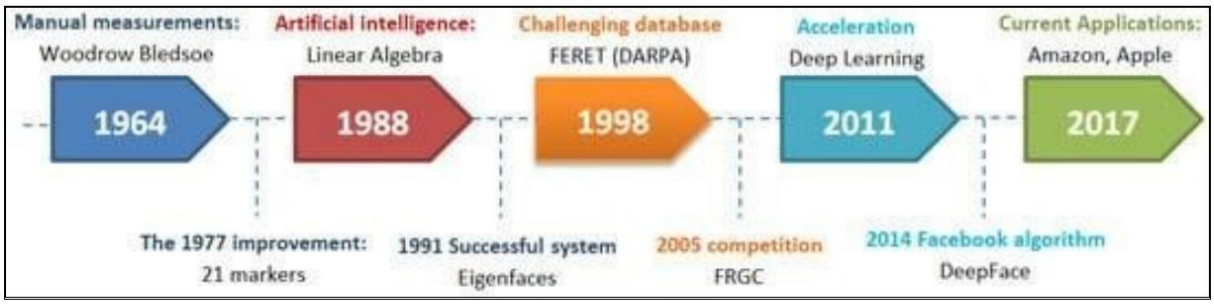


Figure 3 - Evolution of Face Recognition (*Reference: Adjabi, I.; Ouahabi, A.; Benzaoui, A.; Taleb-Ahmed, A. Past, Present, and Future of Face Recognition: A Review. Electronics 2020, 9, 1188)*

In 1ff60s, mathematician and computer scientist Woodrow Wilson Bledsoe first developed a system of measurements that could be used to put photos of faces in different classifications. Because of this work, Bledsoe is known as the unofficial father of facial recognition technology. Woody Bledsoe, and Charles Bisson created a system in which the operator had to identify eyes, ears, nose, and mouth from photos. The calculated and compared distances and ratios in between recognised features and the shared reference points.

Goldstein, Harmon, and Lesk expanded on the research in 1ff70 by incorporating additional variables such as hair colour and lip thickness to automate the identification. Kirby and Sirovich proposed principle component analysis (PCA) to tackle the face recognition issue for the first time in 1ff88.

The problems of face recognition were described in the study provided by Zhao, W et al. (2003). One of the challenges of face recognition is distinguishing between known and unfamiliar photos.

Other works done in the field of face detection and recognition can be understood as shown in the below table:

Table 1 – Literature Review for Face recognition systems

Sr. No.	Authors	Title	Proposed method and techniques	Publication year
1	Bledsoe W.W.	The Model Method in Facial Recognition	Facial recognition computer programming	1ff64
2	Alex Pentland Matthew Turk	Eigenfaces for recognition	Eigenfaces, statistical Principal component analysis (PCA) method.	1ffff1
3	Phillips, P.J. Flynn, P.J.	Overview of the face recognition grand challenge	Was a review of the Face Recognition Grand Challenge (FRGC) competition	2005
4	Guo G. Zhang, N	A survey on deep learning based face recognition	Computer vision image understanding	201ff
5	Taigman, Y. Yang M. Ranzato M.	Deepface: Closing the gap to human-level performance in face verification.	Computer Vision and Pattern Recognition	2014

The various algorithms developed over time for face recognition can be summarised as below:

- Eigenfaces (1ffff1)
- Local Binary Patterns Histograms (LBPH) (1ffff6)
- Fisherfaces (1ffff7)
- Scale Invariant Feature Transform (SIFT) (1ffffff)
- Speed Up Robust Features (SURF) (2006)

Each technique takes a unique approach to extracting picture information and matching it with the input image. However, the Eigenfaces and Fisherfaces

techniques, as well as the SIFT and SURF approaches, use a similar approach. Local Binary Patterns Histograms is one of the oldest and most used face recognition techniques (LBPH).

IV. Methodology

4.1. Technologies used

Build With - Python 3.11.0

Module Used - OpenCV, NumPy, Pandas, Matplotlib, Seaborn, Sklearn

Face Recognition Algorithms - HAAR Cascade, KNN Classifier

Software Used - VS CODE, Git, GitHub

OpenCV:

OpenCV is a library that works across multiple platforms that we can use to create real-time computer vision applications. Image processing, video capture, and analysis are its primary areas of concentration, and it includes features such as face detection and object detection.

OpenCV does a search for faces included inside an image by using machine learning methods. Because faces are so intricate, there is no one test that can definitively tell you whether or not it has discovered a face in an image. Instead, there are literally hundreds upon thousands of different patterns and attributes that need to be matched. The challenge of recognizing the face is broken down into thousands of smaller, more manageable tasks by the algorithms, each of which is quite straightforward to resolve. These responsibilities are also known as classifiers.

Example of some supported functions are given bellow:

- Derivation: Gradient / laplacian computing, contours delimitation
- Hough transforms: lines, segments, circles, and geometrical shapes detection
- Histograms: computing, equalization, and object localization with back projection algorithm

- Segmentation: thresholding, distance transform, foreground/ background detection, watershed segmentation
- Filtering: linear and nonlinear filters, morphological operations
- Cascade detectors: detection of face, eye, car plates
- Interest points: detection and matching
- Video processing: optical flow, background subtraction, camshaft (object tracking)
- Photography: panoramas realization, high-definition imaging (HDR), image inpainting

Features of OpenCV Library: Using OpenCV library, you can –

- Read and write images
- Capture and save videos
- Process images (filter, transform)
- Perform feature detection
- Detect specific objects such as faces, eyes, cars, in the videos or images.
- Analyze the video, i.e., estimate the motion in it, subtract the background, and track objects in it.

- HAAR Cascade:

The Haar Cascade algorithm is one of the most powerful algorithms for the detection of objects, specifically face detection in OpenCV, proposed by Michael Jones and Paul Viola in their research paper titled "Rapid Object Detection Using a Boosted Cascade of Simple Features" in 2001. This algorithm uses a function called cascade function for the detection of objects in the image and a lot of negative and positive images are used to train it.

Working of haar cascade algorithm in OpenCV

To extract features from a given image, the haar cascade algorithm employs a type of filter. These filters only inspect a portion of the image at a time. The intensity of the pixels in the white and black portions is then added. The feature extracted value is the result of subtracting these two sums.

The haar cascade algorithm extracts three types of haar-like features: edge features, line features, and center-surround features. The inclusion of the haar traits indicated in figure-4 was the initial contribution to the study. These picture qualities make it simple to identify the image's borders or lines, as well as locations where the brightness of the pixels vary abruptly. the haar feature would traverse pixel by pixel in the image. Also, all possible sizes of the haar features will be applied.

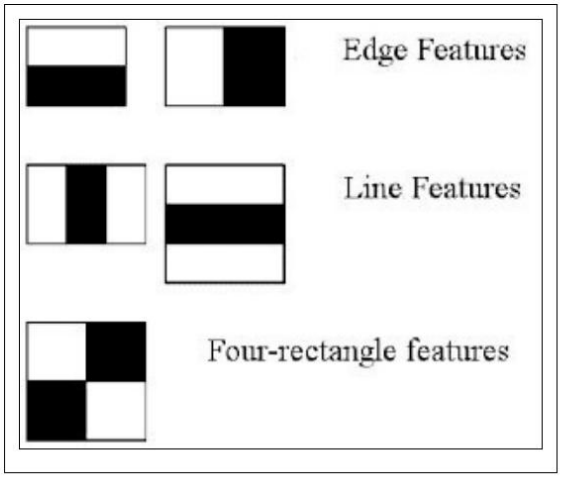


Figure 4 - five different types of Haar-like features extracted from an image

We load the pre-trained XML classifier file to detect the faces in the image. “haarcascade_frontalface_default.xml” detects faces in the frame.

In OpenCV, the syntax for defining the function is as follows:

```
cv2.CascadeClassifier.detectMultiScale(gray_image,scale_factor,min_neighbours)
```

where gray image is the grayscale version of the input image that will be used to identify faces, scale factor indicates the scale at which the image's size must be decreased, and the number of rectangles each rectangle should have been specified by min neighbors.

- KNN Classification algorithm:

One of the most fundamental yet crucial categorization methods in machine learning is K - Nearest Neighbors. It falls under the category of supervised learning and has numerous applications in data mining, intrusion detection, and pattern recognition.

The algorithm works as below:

- Let us say that the number of training data samples is denoted by m. Let "p" denote an undetermined point.

- Save the training samples in an array of data points denoted by the notation [arr]. This indicates that each element of this array represents a tuple that consists of x and y values.
- Create a set S of the K distances that are the shortest that were obtained. Every one of these distances corresponds to a data point that has previously been categorized.
- Return the majority label among S.
- K may be preserved as an odd number in order for us to be able to compute a clear majority in situations in which there are only two potential groups (for example, red and blue). When K is increased, the borders between the various categories become less abrupt and more well delineated. Additionally, the accuracy of the aforementioned classifier improves when the amount of data points included inside the training set is expanded.

4.2. Operating Environment

An IDE supporting .pynb files like VS code with jupyter notebook extension installed can be used to run the program. Also, Anaconda Jupyter Notebook can also be used for the same purpose.

Hardware platform:
- A device like mobile phone / laptop / pc with minimum 8 GB ram for smooth functioning.
- Embedded Web Camera in the device / External Web Cam. (The project requires a qualitative web cam, for which 1080p is a standard resolution, but if you really want to up your picture quality, you will need a 4K webcam)

4.3. Dataset Description

The dataset consists of the identified facial images of people.

We are converting the image to the NumPy N-D array file and store it in a database for the further detection in the form of .npy file.

In a recognizer we fetch the NumPy file from the databases and match it with the current face pixels and return the name.

The images are well-balanced in terms of the distance to the camera, the various sensors, the frontal and non-frontal views, and the various locations.

4.4. Model Implementation

The model is implemented into two parts:

1) Capturing the face and storing it in the dataset
2) Recognizing and classifying the face

It can be understood as shown in the figure below:

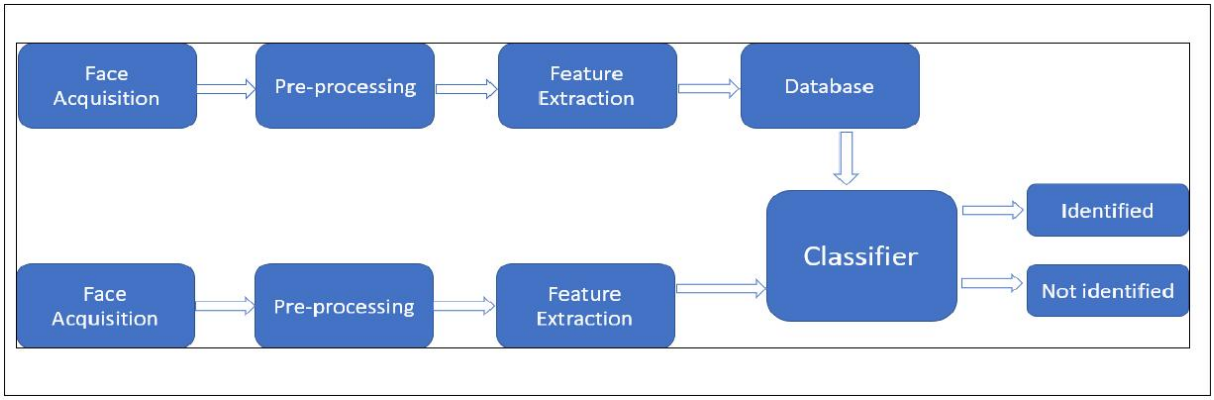
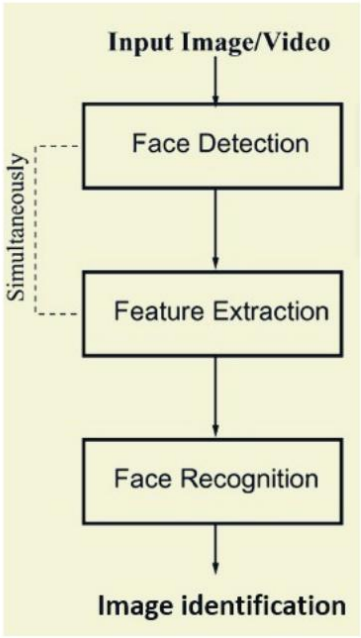


Figure 5 - Work flow of the model

How the Face Detection Works

First, the picture is taken whenever a facial feature is recognised within the frame of the photo. After that, the image is converted from RGB to grayscale because faces are more easily discerned in the grayscale version of the image. After that, image manipulation is applied, which may involve resizing, cropping, blurring, or sharpening of the images, depending on whether or not they require such adjustments. The following step is image segmentation, which is used for

contour detection or segments the multiple objects in a single image so that the classifier can quickly detect the objects and faces in the picture. Image segmentation is the next step in the process. Image segmentation is the next step in the process.



The application of the algorithm is the next stage. An algorithm that is used to pinpoint the locations of human faces inside a given picture or frame. Some characteristics of the human face are universal, such as the fact that the area around the eyes is darker than the pixels in the surrounding area, and the area around the nose is brighter than the area around the eyes.

With the assistance of edge detection, line detection, and centre detection, the haar-like algorithm can also be used for feature selection or feature extraction for an object in an image. This can be done in order to determine where in the picture the eyes, nose, mouth, and other facial features are located. It is used to pick out the most important aspects of an image and then extract those aspects for use in face recognition.

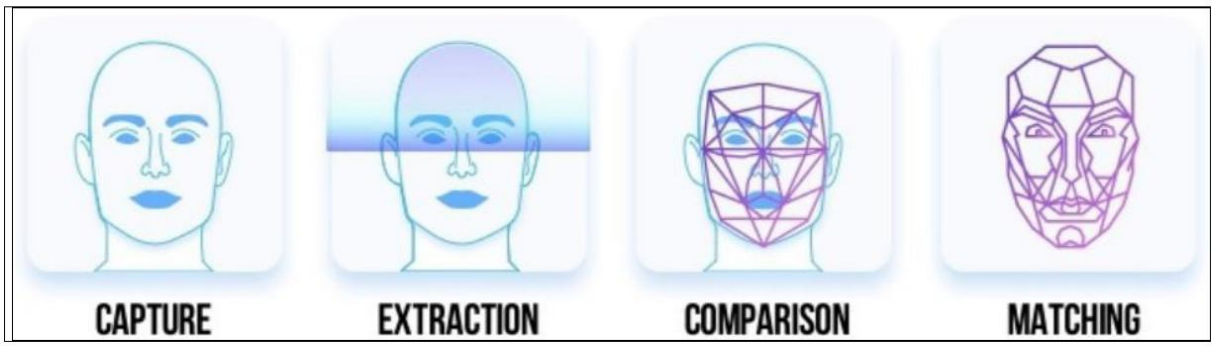


Figure 6 - Stages of face recognition

The next thing that needs to be done is to provide the coordinates of x, y, w, and h, which will make a rectangle box in the picture to show where the face is

located, or we can say that to show the region of interest in the image. After this is complete, it will be able to create a rectangular box in the region of interest where it finds the face. There are also a great number of other detection methods that are utilised concurrently in the detection process. Some of these methods include the detection of smiles, eyes, and blinks

Steps for the model set up:

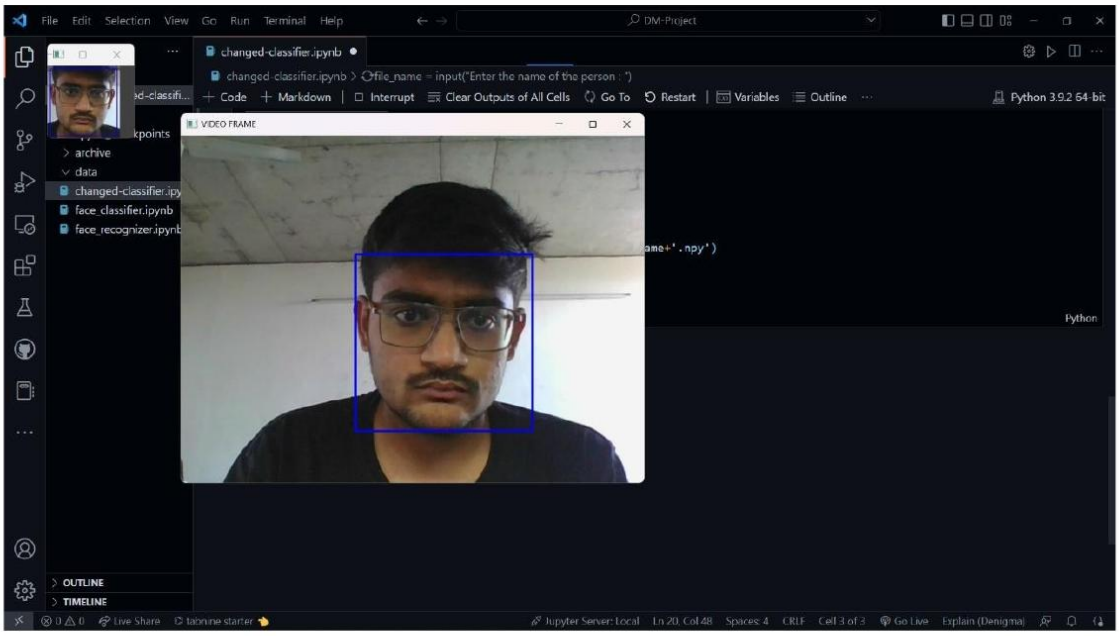
1) Install Python in the system.

2) Install the following libraries using pip install:
   pip install numpy
   pip install pandas
   pip install matplotlib
   pip install seaborn
   pip install Sklearn

3) Install OpenCV:
   First open the command prompt as an admin
   To install OpenCV in windows we need to use this command:
   Python –m pip install opencv-python

4) Run the program for face detection: face_classifier.pynb

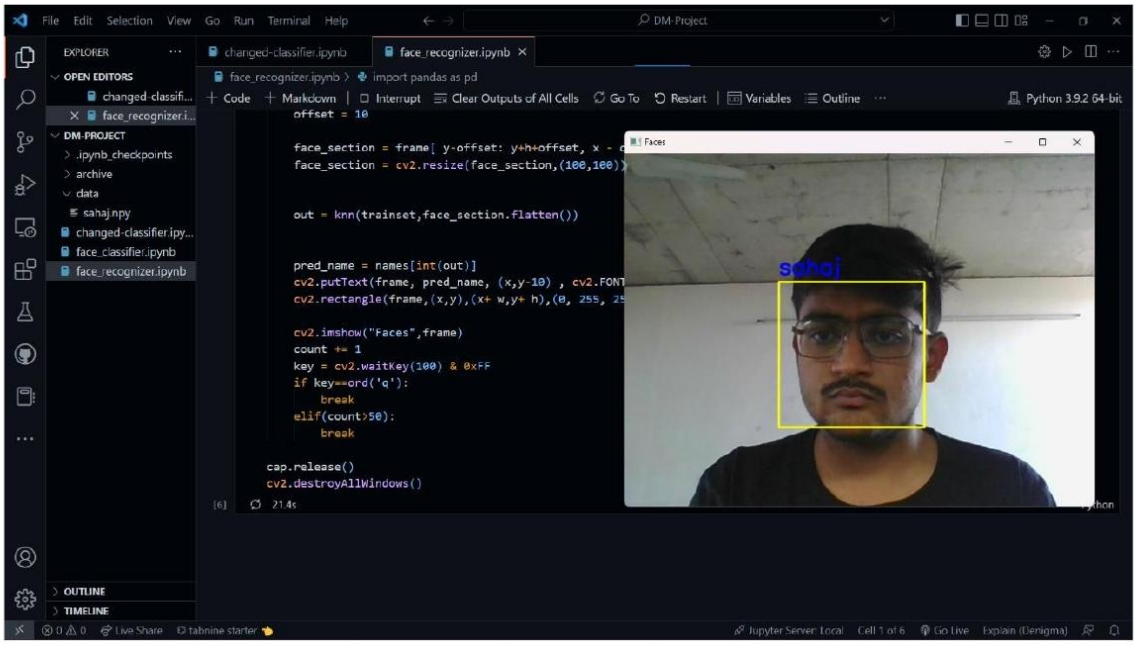
The program will detect the face present in the frame as shown below:



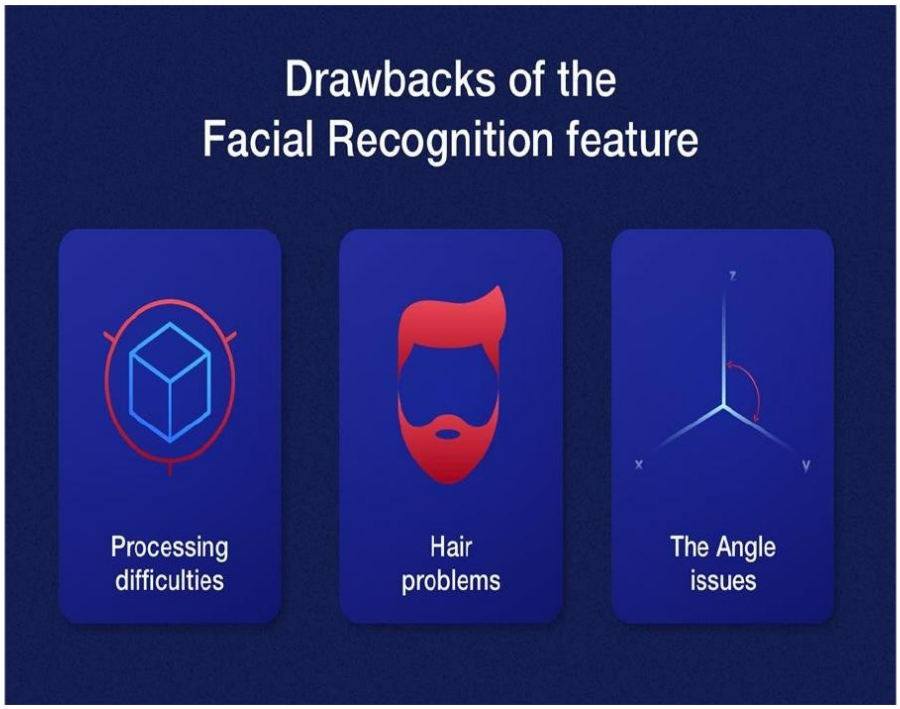
It will ask for the face identity of the person, and once entered, it will be stored in the dataset .npy file.

5) Run the program for face recognition: face_recognizer.pynb

On running the recognizer program, it will match the face present in the frame with the dataset, and if relevant, it will identify the face as shown below:



V. Challenges



Challenges faced:

The challenges faced during face recognition can be listed down as follow:

- Misalignment
- Pose variation
- Illumination variation
- Expression variation
- Intensity of light

VI. Findings and Conclusion

Multiple photos either in group or individual are loaded into system to verify the accuracy. A person should had appeared in those photos for 20 times. When the photos are all tested with the proposed face recognition system, the data is computed in confusion matrix to calculate the accuracy of the system.

Table 2 - Confusion matrix for image recognition

Number of face recognitions			Result
Person 1	Person 2	Person 3	
17	1	2	**Person 1**
1	18	1	**Person 2**
0	0	20	**Person 3**

From the testing results, the overall accuracy of the system for face recognition from images obtained: **91.7%**

VII. Recommendations

Because there is a requirement to design a student attendance system that operates in real time, the process of identifying students will need to be completed within certain time limitations to eliminate the possibility of omission. When there is a change in the backdrop, lighting, stance, or emotion of the students, the facial traits that have been derived from their photos and used to represent their identities need to remain constant. The performance will be judged based on such criteria as high accuracy and a short amount of time spent computing.

The scope of the project can be expanded by face-recognition systems which can identify multiple faces at a time, which will save a lot a time. Also, the accuracy of identifying faces in dimmed light exposure, different facial orientations, with different expressions can be improved.