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Energy – Saving, Face Recognition Authentication System

Pathem Lavanya, Assistant Professor,

G Narayanamma Institute of Technology and Science, Hyderabad, India

ABSTRACT: An Energy-Saving Face Recognition Authentication System combines biometric security features with energy-efficient technologies. The idea is to create a facial recognition-based system by machine learning technique, that not only ensures secure authentication but also minimizes power consumption. Here's a breakdown of how such a system could work. The primary function is to authenticate users by analyzing their facial features. Face recognition is a reliable and user-friendly authentication method because it is difficult to forge, unlike passwords or PINs.

Keywords: Face Recognition System, Rasberry Pi, Deep Neural Network, Machine Learning

1.Introduction

Facial recognition technologies are an application of artificial intelligence and machine learning. It is the problem of identifying and verifying people in a photograph by their face. It is a task that is trivially performed by humans, even under varying light and when faces are changed by age or obstructed with accessories and facial hair. Nevertheless, it is remained a challenging computer vision problem for decades until recently. Face recognition is a process comprised of detection, alignment, feature extraction, and a recognition task.The face recognition is a technique to identify or verify the face from the digital images or video frame. A human can quickly identify the faces without much effort. It is an effortless task for us, but it is a difficult task for a computer. There are various complexities, such as low resolution, occlusion, illumination variations, etc. These factors highly affect the accuracy of the computer to recognize the face more effectively. Face recognition is a simple task for humans. Successful face recognition tends to effective recognition of the inner features (eyes, nose, mouth) or outer features (head, face, hairline). In our project, we used basic techniques of machine learning for the sake of Face recognition. Basically, the whole project comprises of three steps, where these steps make the process to run in a simple and smooth manner. The Algorithm used here is a simple approach, summarizes the local structure in an image by comparing each pixel with its neighbours. The system is bult in such way that it consumes less power also.

1.1 Objectives

The main intention behind building this project is to make the whole face recognition system very simple to use. The methods used and the technologies used are trending now-a-days. Our project proposes a simple, intuitive and efficient solution to conserve the processor from being clocked to its maximum throughput without compromising on the high level of security that the face recognition algorithm offers. Before we have started our project implementation, we have formulated these objectives, which helped while performing the project.

The listed objectives were first formulated so as to maintain the execution of the project in a smother manner and to ensure that there should be no such divergence occur due to any issues regarding algorithm etc.,

- The main objective determines, the low power consumption of the whole process, whenever the faces are captured then only the whole process of Facial recognition starts.

- The algorithm used for the facial capturing, training of the faces stored and the recognition part is designed in a simple approach.

2. Methodology

A basic structural framework for a system can be established under the methodology. The main component which drives the whole project i.e., the face recognition process is Raspberry Pi 4 Model B. In order to capture a real time face, store in the database and then recognize the face to match with face which is stored in the database, a camera need to be connected to Raspberry Pi Camera port. On the raspberry Pi the camera port is present between the audio port and the HDMI port. The camera needs to be installed in the slot with the help of the cable.

The power supply to the raspberry comes form the Type C USB present in the Raspberry Pi. The Raspberry Pi comes with a set of open-source technologies, i.e., communication and multimedia web technologies. The Raspberry Pi Model Bis a Broadcom BCM2835 SOC (system on chip board).

The block diagram of the Energy – Saving, Face Recognition Authentication System is shown in the given below figure Fig. 2.1.

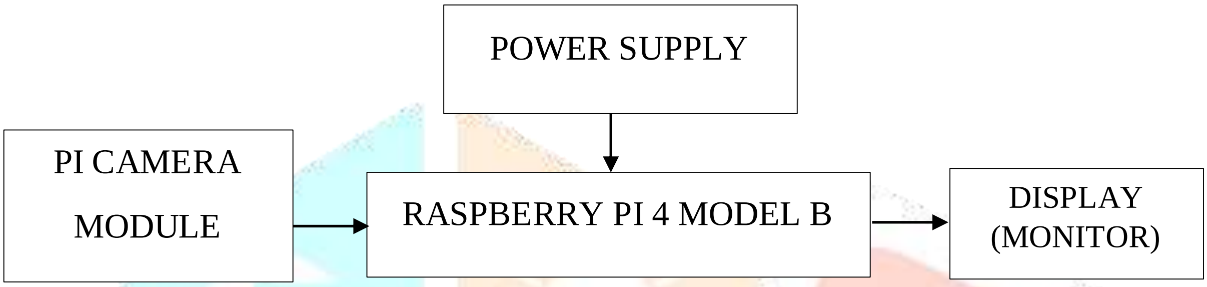


Fig. 2.1 Face Recognition Authentication System.

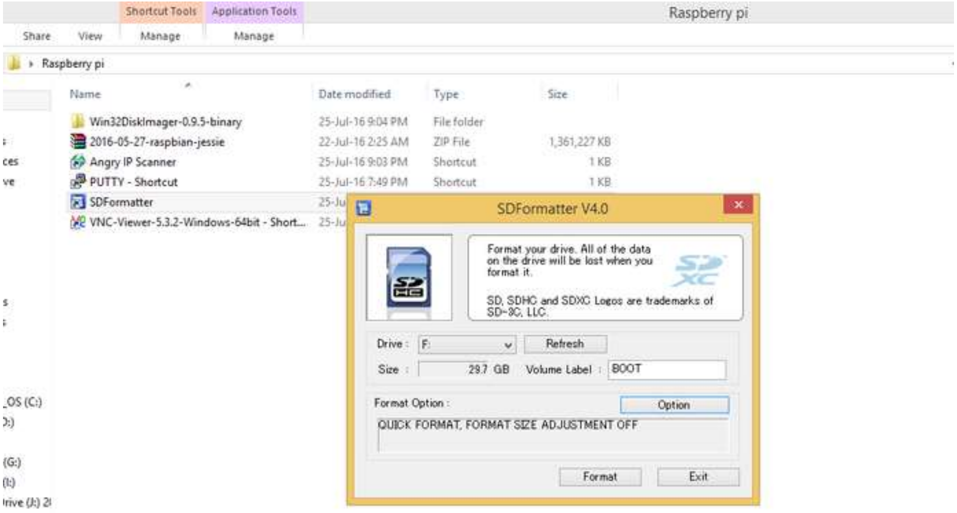
The main hardware component used is Raspberry Pi and to capture the images and recognize those faces is Pi Camera Module. For managing the output and to configure anything we can use external display or the monitor.

In order to program the Raspberry Pi, Raspbian (OS) is downloaded and installed into the SD card and booted in the Raspberry Pi. The Open CV is then installed in the Raspberry Pi using the commands. The Python language is used to write codes for the training the faces and recognition.

3. PROJECT IMPLEMENTATION

As we have completed all the installation processes of the raspberry pi, now here is the picture that shows the Desktop of the Raspberry Pi in the following figure Fig. 3.1.

The following figure Fig. 3.2 shows the Terminal window of the Raspberry Pi



Name	Date modified	Type	Size
Win32DiskImager-0.9.5-binary	25-Jul-16 9:04 PM	File folder	
2016-05-27-raspbian-jessie	22-Jul-16 2:25 AM	ZIP File	1,361,227 KB
Angry IP Scanner	25-Jul-16 9:03 PM	Shortcut	1 KB
PUTTY - Shortcut	25-Jul-16 7:49 PM	Shortcut	1 KB
SDFormatter	25-Ju		
VNC-Viewer-5.3.2-Windows-64bit - Short...	25-Ju		

SDFormatter V4.0

Format your drive. All of the data on the drive will be lost when you format it.

SD, SDHC and SDXC Logos are trademarks of SD-3C, LLC.

Drive : F:

Size : 29.7 GB

Volume Label : BOOT

Format Option :

QUICK FORMAT, FORMAT SIZE ADJUSTMENT OFF

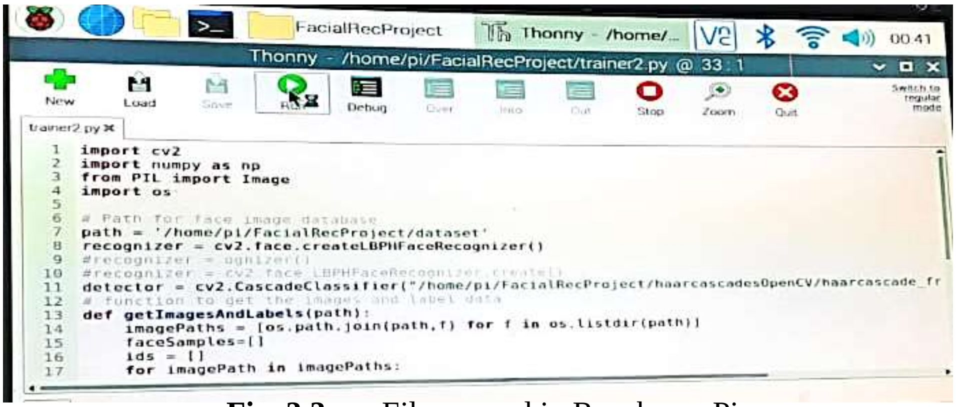
Fig. 3.1 SD card Formatter window

```
pi@raspberrypi:~ $
```

Fig. 5.2 Linux Terminal window of Raspberry Pi

The Energy – Saving Face Recognition Authentication System runs mainly in the three subsequent processes. All the necessary libraries for the compilation of Python Language are being installed and the step-by-step approach is being discussed in the previous chapters.

The below figure Fig. 3.3 shows the window of the .py file, opened in the Raspberry Pi.



```
import cv2
import numpy as np
from PIL import Image
import os

# Path for face image database
path = '/home/pi/FacialRecProject/dataset'
recognizer = cv2.face.createLBPHFaceRecognizer()
#recognizer = ognizer()
#recognizer = cv2.face.LBPHFaceRecognizer.create()
detector = cv2.CascadeClassifier("/home/pi/FacialRecProject/haarcascadesOpenCV/haarcascade_fr
# function to get the images and label data
def getImagesAndLabels(path):
    imagePaths = [os.path.join(path,f) for f in os.listdir(path)]
    faceSamples=[]
    ids = []
    for imagePath in imagePaths:
```

Fig. 3.3 .py File opened in Raspberry Pi

The below figure Fig. 3.4 shows the physically connected Pi Camera Module with the raspberry Pi

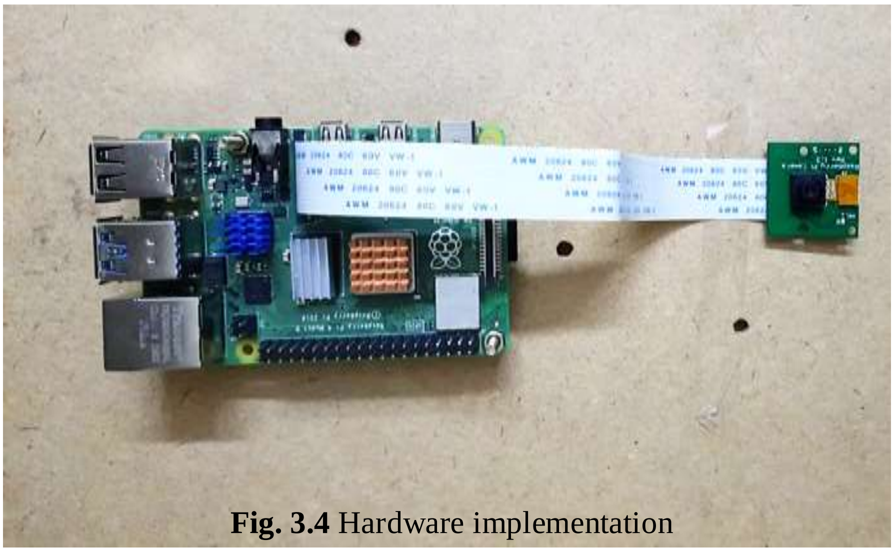


Fig. 3.4 Hardware implementation

The first process of the face recognition authentication system starts with capturing almost 100 samples of each face by entering the ID i.e., equal to 1,2,3 and so on till the no. of faces we are going to save it in the database. We have written a piece of code in which the captured images are converted to the gray scale image, along with dimensions of the image.

The image is cut i.e., cropped to certain level where only till the face's dimension is cropped so as to locate the coordinates of the face. The below steps indicate the workflow of Single input image that is available in dataset.

- Detect faces with a pre-trained model from dlib or OpenCV.
- Transform the face for the neural network. This repository uses dlib's real-time pose estimation with OpenCV's affine transformation to try to make the eyes and bottom lip appear in the same location on each image.
- Use a deep neural network to represent (or embed) the face on a 128-dimensional unit hypersphere. The embedding is a generic representation for anybody's face.
- Unlike other face representations, this embedding has the nice property that a larger distance between two face embeddings means that the faces are likely not of the same person. This property makes clustering, similarity detection, and classification tasks easier than other face recognition techniques where the Euclidean distance between features is not meaningful. The following figure Fig. 3.5 shows the image transformation and steps for it.

Here is the figure Fig. 3.6 which shows the database created for ID equal to 1, which is in the format 1.XY, where the XY indicates the XYth sample in the dataset.

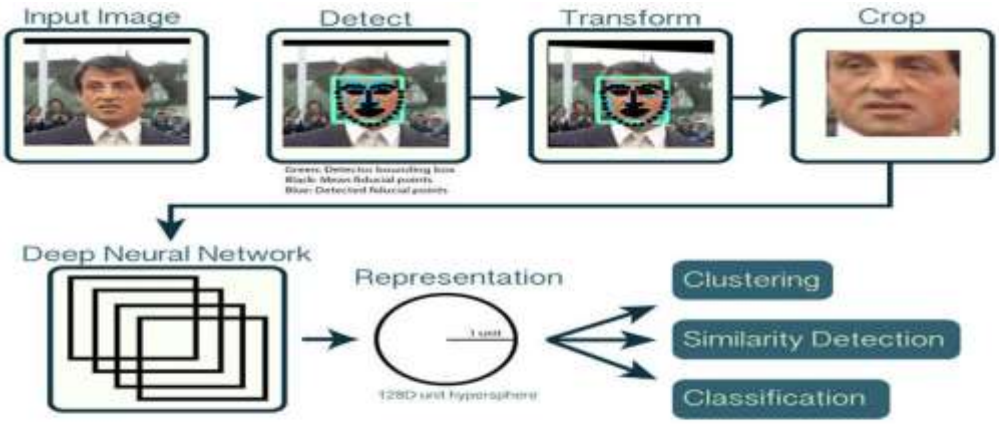


Fig. 3.5 Steps involved in image transformation

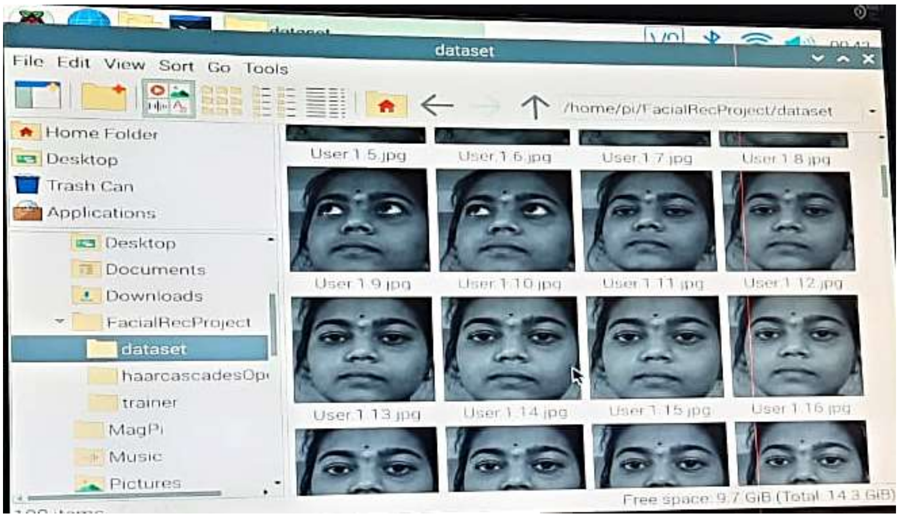


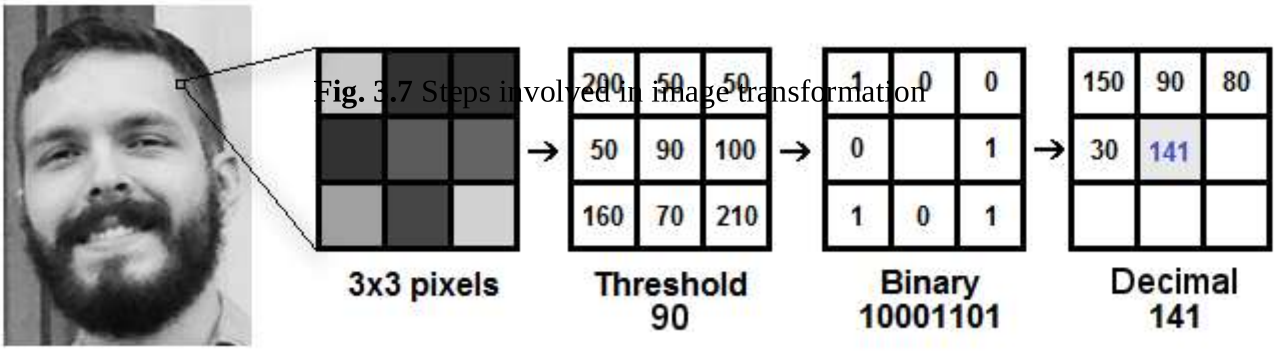
Fig. 3.6 Dataset of the faces

After creating the dataset of the faces, the samples are stored in the dataset. The 2nd piece of code represents the training of faces to the particular ID.

The training of the faces is being performed by using LPBH algorithm. Local Binary Pattern (LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. Using the LBP combined with histograms we can represent the face images with a simple data vector. As LBP is a visual descriptor it can also be used for face recognition tasks.

The LBPH uses 4 parameters. Those are Radius, Neighbors, Grid X, Grid Y. The radius is used to build the circular local binary pattern and represents the radius around the central pixel. It is usually set to 1. The neighbors are the number of sample points to build the circular local binary pattern. Keep in mind: the more sample points you include, the higher the computational cost. It is usually set to 8. Grid X is the number of cells in the horizontal direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8. Grid Y is the number of cells in the vertical direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8.

First, we need to train the algorithm. To do so, we need to use a dataset with the facial images of the people we want to recognize. We need to also set an ID (it may be a number or the name of the person) for each image, so the algorithm will use this information to recognize an input image and give you an output. Images of the same person must have the same ID. The first computational step of the LBPH is to create an intermediate image that describes the original image in a better way, by highlighting the facial characteristics. To do so, the algorithm uses a concept of a sliding window, based on the parameter's radius and neighbors. The below figure Fig. 3.6 shows the procedure of LPB.



200	50	50
50	90	100
160	70	210

1	0	0
0		1
1	0	1

150	90	80
30	141	

Fig. 3.7 Steps involved in image transformation

The step-by-step approach of the above gray scale is listed down.

- Suppose we have a facial image in grayscale.
- We can get part of this image as a window of 3x3 pixels.
- It can also be represented as a 3x3 matrix containing the intensity of each pixel (0~255).
- Then, we need to take the central value of the matrix to be used as the threshold.
- This value will be used to define the new values from the 8 neighbors.
- For each neighbor of the central value (threshold), we set a new binary value. We set 1 for values equal or higher than the threshold and 0 for values lower than the threshold.
- Now, the matrix will contain only binary values (ignoring the central value). We need to concatenate each binary value from each position from the matrix line by line into a new binary value (e.g., 10001101). Note: some authors use other approaches to concatenate the binary values (e.g., clockwise direction), but the final result will be the same.
- Then, we convert this binary value to a decimal value and set it to the central value of the matrix, which is actually a pixel from the original image.
- At the end of this procedure (LBP procedure), we have a new image which represents better the characteristics of the original image.

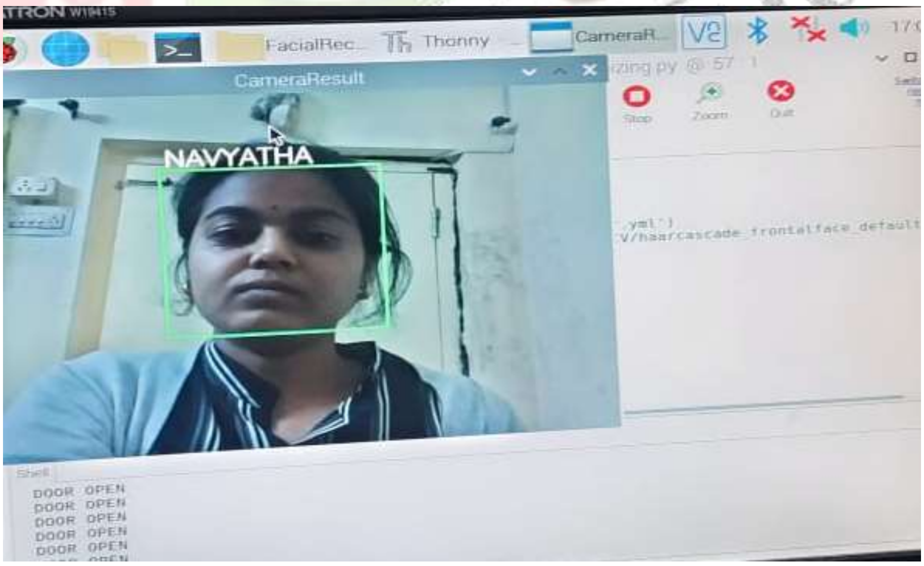
The LBP procedure was expanded to use a different number of radius and neighbors, it is called Circular LBP. Now extracting the Histograms, using the image generated in the last step, we can use the Grid X and Grid Y parameters to divide the image into multiple grids.

Now, after training of faces, we have to implement the recognizing part of the faces. This is the last part i.e.; 3rd part of the procedure. We use the confidence level. We are checking the confidence level. If the confidence level is greater than 50 and less than 100, then we print an output saying, ‘DOOR OPEN’. The remaining part such as results and the impressions are discussed in the coming chapters.

4. RESULTS AND DISCUSSIONS

In the previous section, we discussed about the process of detecting, recognizing faces etc., In this chapter we will be going to discuss the outcome of the procedures, processes we have performed in our project.

In the 3rd step we have used the confidence level and matched the face, now if this face and ID associated with it match with the detected face then we get an output as a statement displaying Door Open in the console window. The face is getting labelled as shown in the given below figure. In the same figure Fig. 4.1 we can see the output in Shell window.



```
yml')
V/haarcascade_frontalface_default
```

```
DOOR  OPEN
DOOR  OPEN
DOOR  OPEN
DOOR  OPEN
DOOR  OPEN
```

Fig. 4.1 Face recognition Result

5. ADVANTAGES, LIMITATIONS AND APPLICATIONS: The implementation and all the procedures were discussed in the previous chapters. After studying the project and analyzing it, we have framed the advantages, disadvantages and also the limitations and they are discussed in this chapter.

5.1 Advantages

- The project consumes less power throughout the process.
- As we have used the confidence level in our project, it gives the level of accuracy in recognizing each face.
- Due to the accuracy levels given by the system, the system could give better security

5.2 Limitations

- The project is little bit expensive due to the use of Raspberry Pi.
- The data which is identical i.e., in the case of both twins it is been deluded.
- There are difficulties with big data processing.

5.3 Applications

- This system is best used places like Apartments, Individual houses etc.,
- Even the proposed system is used where the consumption of energy is least.
- This system is used where high security is needed.

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The face recognition system built, is robust, simple in the structure and the techniques used were understandable and can be incorporated further. This project approaches the problem of efficiency in computationally oppressive facial recognition systems by proposing an elegant solution of using the recognition system in conjunction with a low-power sensor system. By doing so we are making the face recognition system more efficient by letting it breathe when there is no human in the vicinity of the camera view. This allows for more considerable savings and also affords lower electricity consumption, which in turn affords greater efficiency in terms of power.

6.2 Future Scope

The face recognition system would further be increased in complexity and would further be built by introducing very complex algorithms in order to map the coordinates of the face, with very less step size.

The system would be implemented in a good hardware environment to experience good graphics and greater accuracy in the face and this can be done by installing a good mega pixel camera. As the figure Fig. 6.1 shows a different way of implementing the face recognition technique by using vector patterns.

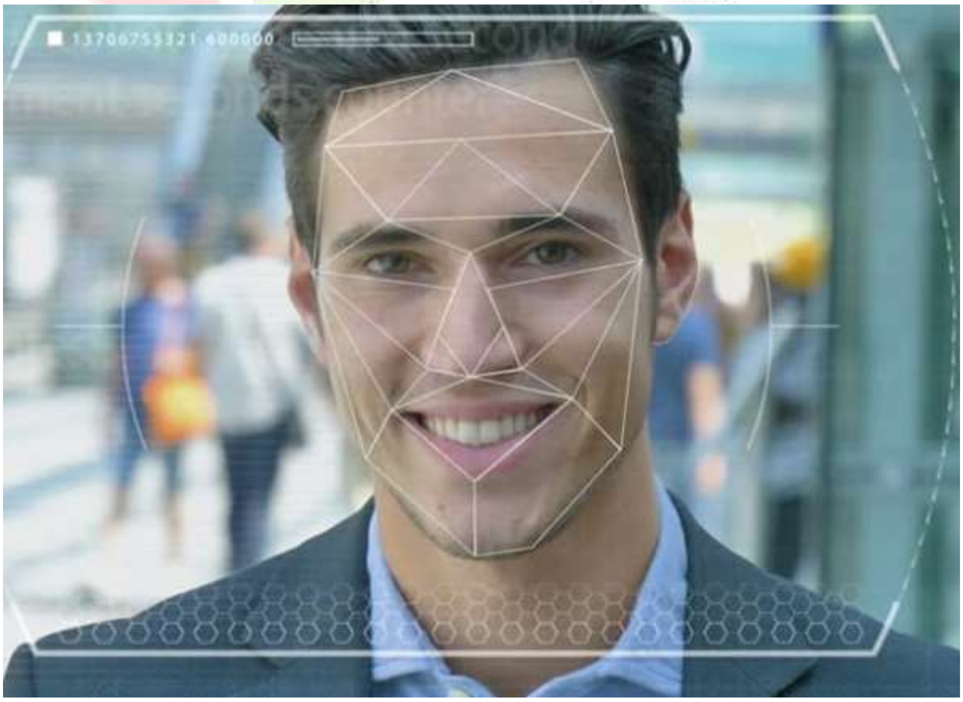


Fig. 6.1 Biometric Face recognition vectors

Today, one of the fields that uses facial recognition the most is security. Facial recognition is a very effective tool that can help law enforcers recognize criminals and software companies are leveraging the technology to help users access their technology. This technology can be further developed to be used in other avenues such as ATMs, accessing confidential files, or other sensitive materials. This can make other security measures such as passwords and keys obsolete.

Another way that innovators are looking to implement facial recognition is within subways and other transportation outlets. They are looking to leverage this technology to use faces as credit cards to pay for your transportation fee. Instead of having to go to a booth to buy a ticket for a fare, the face recognition would take your face, run it through a system, and charge the account that you've previously created. This could potentially streamline the process and optimize the flow of traffic drastically.

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