REAL-TIME FACE DETECTION & RECOGNITION

Project Report

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DECLARATION

We hereby declare that this Project Report titled "Real Time Face Recognition & Detection" submitted by us and approved by our project guide, to the College of Computing Sciences and Information Technology (CCSIT), Teerthanker Mahaveer University, Moradabad, is a bonafide work undertaken by us and it is not submitted to any other University or Institution for the award of any degree diploma / certificate or published any time before.

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ABSTRACT

Face recognition has been a very active research area in the past two decades. Many attempts have been made to understand the process of how human beings recognize human faces. It is widely accepted that face recognition may depend on both componential information (such as eyes, mouth and nose) and non-componential/holistic information (the spatial relations between these features), though how these cues should be optimally integrated remains unclear. In the present study, a different observer's approach is proposed using Eigen/fisher features of multi-scaled face components and artificial neural networks. The basic idea of the proposed method is to construct facial feature vector by down-sampling face components such as eyes, nose, mouth and whole face with different resolutions based on significance of face components.

In this report, we use two approaches for detecting a face and track it continuously. Basically video sequences provide more information than a still image. It is always a challenging task to track a target object in a live video. We undergo challenges like illumination; pose variation and occlusion in pre-processing stages. But this is can be overcome by detection of the target object continuously in each and every frame.

Face recognition is a pattern recognition technique and one of the most important biometrics; it is used in a broad spectrum of applications. The accuracy is not a major problem that specifies the performance of automatic face recognition system alone, the time factor is also considered a major factor in real time environments. Recent architecture of the computer system can be employed to solve the time problem, this architecture represented by multi-core CPUs and many core GPUs that provide the possibility to perform various tasks by parallel processing. However, harnessing the current advancements in computer architecture is not without difficulties.

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1. INTRODUCTION

Human-robot interaction receives an increasing attention among the researches in different areas of interest during last years. In the current project we address one of the computer vision tasks, involved in developing of such an interactive system. Namely, we are interested in detecting human user presence and tracking of his attention. Possible applications for this would include receptionist robot, which needs to perform particular actions when human approaches or leaves the system, interactive games, commercials etc.

Object detection has been a great challenge from the past few years. In computer vision human face detection is an important research topic. It is needed for many computer applications like HCI, surveillance, human-robot interaction, etc. In this field facial tracking is finding more growth of use in security and safety applications to detect various situations1. This tracking domain can be used to control or communicate with robots.

Detecting human faces in a video is a great challenging problem. These configurations may be like angle of view, background intensity, and various illuminations. This is due to high variety of configurations that may occur. The complexness of the face results in a particular degree of issue for fast detection and tracking.

For face detection and tracking in a given video sequence different algorithms have been introduced over the past few years. Each algorithm has got its own advantages and disadvantages. But any face tracking algorithm will have some errors which will cause deviation from the required object. The tracker can be accurate if and only if it is able to minimize this deviation. The technique used in this report is one of the effective approaches. It is quicker and simpler and we make use of the Eigen vectors for detecting the faces along with the superficial points of our faces.

Object detection and tracking are important in many computer vision applications including activity recognition, automotive safety, and surveillance.

In this example, you will develop a simple face tracking system by dividing the tracking problem into three parts: 1. Detect a face 2. Facial features to track 3. Track the face

2. TECHNOLOGIES USED

2.1 OpenCV- OpenCV is the huge open-source library for the computer vision, machine learning, and image processing and now it plays a major role in real-time operation which is very important in today's systems. By using it, one can process images and videos to identify objects, faces, or even handwriting of a human. When it integrated with various libraries, such as Numpy, python is capable of processing the OpenCV array structure for analysis. To identify image pattern and its various features we use vector space and perform mathematical operations on these features.

The first OpenCV version was 1.0. OpenCV is released under a BSD license and hence it's free for both **academic** and **commercial** use. It has C++, C, Python and Java interfaces and supports Windows, Linux, Mac OS, iOS and Android. When OpenCV was designed the main focus was real-time applications for computational efficiency. All things are written in optimized C/C++ to take advantage of multi-core processing.

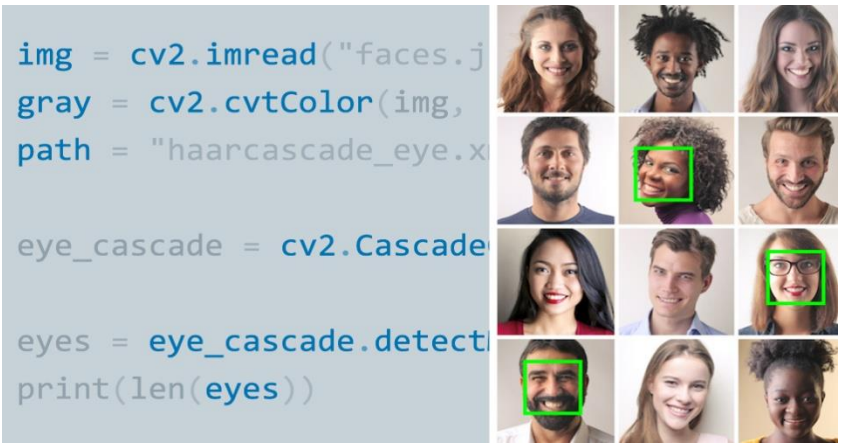

Fig 1. OpenCV Example

Applications of OpenCV: There are lots of applications which are solved using OpenCV, some of them are listed below

- face recognition
- Automated inspection and surveillance
- number of people – count (foot traffic in a mall, etc)

- Vehicle counting on highways along with their speeds
- Interactive art installations
- Anamoly (defect) detection in the manufacturing process (the odd defective products)
- Street view image stitching
- Video/image search and retrieval
- Robot and driver-less car navigation and control
- object recognition
- Medical image analysis
- Movies – 3D structure from motion
- TV Channels advertisement recognition

OpenCV Functionality

- Image/video I/O, processing, display (core, imgproc, highgui)
- Object/feature detection (obj detect, features2d, nonfree)
- Geometry-based monocular or stereo computer vision (calib3d, stitching, video stab)
- Computational photography (photo, video, superres)
- Machine learning & clustering (ml, flann)
- CUDA acceleration (gpu)

2.2 HAAR CASCADE CLASSIFIER-

Haar Cascade classifiers are an effective way for object detection. This method was proposed by Paul Viola and Michael Jones in their paper Rapid Object Detection using a Boosted Cascade of Simple Features .Haar Cascade is a machine learning-based approach where a lot of positive and negative images are used to train the classifier.

- **Positive images –** These images contain the images which we want our classifier to identify.
- **Negative Images –** Images of everything else, which do not contain the object we want to detect.

Requirements

- Make sure you have python, Matplotlib and OpenCV installed on your pc (all the latest versions).
- The haar cascade files can be downloaded from the OpenCV Github repository.

Code Snippet:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt % matplotlib
inline
face_cascade = cv2.CascadeClassifier('../DATA / haarcascades / haarcascade_frontalface_default.xml')
eye_cascade = cv2.CascadeClassifier('../DATA / haarcascades / haarcascade_eye.xml')

def adjusted_detect_face(img):
    face_img = img.copy()
    face_rect = face_cascade.detectMultiScale(face_img, scaleFactor=1.2, minNeighbors=5)

    for (x, y, w, h) in face_rect:
        cv2.rectangle(face_img, (x, y), (x + w, y + h), (255, 255, 255), 10)
        return face_img

def detect_eyes(img):
    eye_img = img.copy()
    eye_rect = eye_cascade.detectMultiScale(eye_img, scaleFactor=1.2, minNeighbors=5)
    for (x, y, w, h) in eye_rect:
        cv2.rectangle(eye_img, (x, y), (x + w, y + h), (255, 255, 255), 10)
        return eye_img

img = cv2.imread('../sachin.jpg')
img_copy1 = img.copy()
img_copy2 = img.copy()
img_copy3 = img.copy()

face = adjusted_detect_face(img_copy)
plt.imshow(face)
```

Fig 2. Code Snippet for Haar Cascade Classifier

Output:

Fig 3. Output for Haar Cascade Classifier

Haar Cascades can be used to detect any types of objects as long as you have the appropriate XML file for it. You can even create your own XML files from scratch to detect whatever type of object you want.

2.3 NUMPY- Numpy is a general-purpose array-processing package. It provides a high-performance multidimensional array object, and tools for working with these arrays. It is the fundamental package for scientific computing with Python.
Besides its obvious scientific uses, Numpy can also be used as an efficient multi-dimensional container of generic data.

Array in Numpy is a table of elements (usually numbers), all of the same type, indexed by a tuple of positive integers. In Numpy, number of dimensions of the array is called rank of the array. A tuple of integers giving the size of the array along each dimension is known as shape of the array. An array class in Numpy is called as **ndarray**. Elements in Numpy arrays are accessed by using square brackets and can be initialized by using nested Python Lists.

Arrays in Numpy can be created by multiple ways, with various number of Ranks, defining the size of the Array. Arrays can also be created with the use of various data types such as lists, tuples, etc. The type of the resultant array is deduced from the type of the elements in the sequences.
Note: Type of array can be explicitly defined while creating the array.

Code snippet:

```
# Python program for
# Creation of Arrays
import numpy as np

# Creating a rank 1 Array
arr = np.array([1, 2, 3])
print("Array with Rank 1: \n", arr)

# Creating a rank 2 Array
arr = np.array([[1, 2, 3],
                [4, 5, 6]])
print("Array with Rank 2: \n", arr)

# Creating an array from tuple
arr = np.array((1, 3, 2))
print("\nArray created using "
      "passed tuple:\n", arr)
```

Fig 4. Code Snippet for Numpy

3. IMPLEMENTATION METHODOLOGY

The first step is face detection, the second is normalization, the third is feature extraction, and the final step is face recognition. These steps are separate components of a facial recognition system and depend on each other. It tries to find eye-analogue pixels so as to remove unwanted pixels from the image. After performing the segmentation process, it considers each eye-analogue segment as a candidate of one of the eyes.

Then, a set of rule is executed to determine the potential pair of eyes. Once the eyes are selected, the algorithm calculates the face area as a rectangle. The four vertexes of the face are determined by a set of functions. Thus, the potential faces are normalized to a fixed size and orientation. Then the face regions are verified. The geometry feature based methods analyze both local features and their geometric relationships. This approach is often called feature based method.

Appearance based methods represent a face in terms of several raw intensity images. An image is considered as a high-dimensional vector. Then statistical techniques are usually used to derive a feature space from the image distribution. The sample image is compared to the training set. On the other hand, the model-based approach tries to model a human face. The new sample is fitted to the model, and the parameters of the model are used to recognize the image.

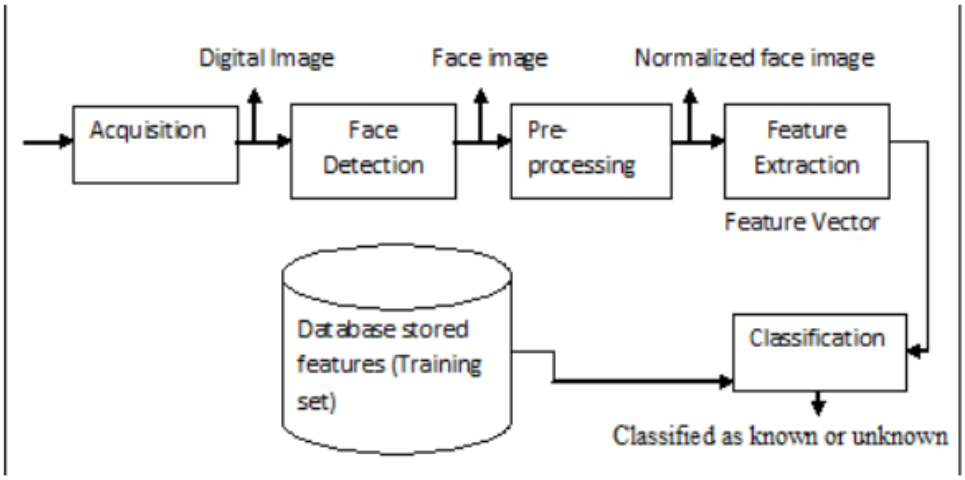

Fig 5. Face Detection & Recognition System

A face recognition system comprises five models:

- **Image Acquisition**- Acquisition the image of an individual face model is the entry point of the face recognition process. There are two ways to acquire an image:
    A) Digitally scan an existing photograph, the source is a file;
    B) Acquire a live picture of a subject

- **Face Detection-** Face Detection Model is the first step in automated face recognition. Its reliability has a significant impact on the performance and usability of the whole face recognition system. Given a single image, the best face detector should be capable of identifying and locating all the present faces regardless of their scale, orientation, age, position, and expression. In addition, the detection should be irrespective of unrelated illumination conditions in the image content.

- **Image Preprocessing-** Pre-processing model should be applied before feature extraction. It includes images processing to improve the input image in order to get better quality and therefore making the recognition process with less effort by decreasing time complexity; this can significantly enhance and improve the performance of the overall face recognition system.

- **Feature Extraction-** Feature Extraction for face representation is a central issue in face recognition. Feature extraction algorithms aim at finding effective information that is useful for distinguishing between faces of different persons.

- **Image Classification-** In the classification, based on identification concept, face identification system has to determine the identity of the input face image based on comparisons among all templates stored in a database (DB). . An image is considered as a high-dimensional vector. Then statistical techniques are usually used to derive a feature space from the image distribution. The sample image is compared to the training set. On the other hand, the model-based approach tries to model a human face. The new sample is fitted to the model, and the parameters of the model are used to recognize the image.

4. ACTIVITY TABLE

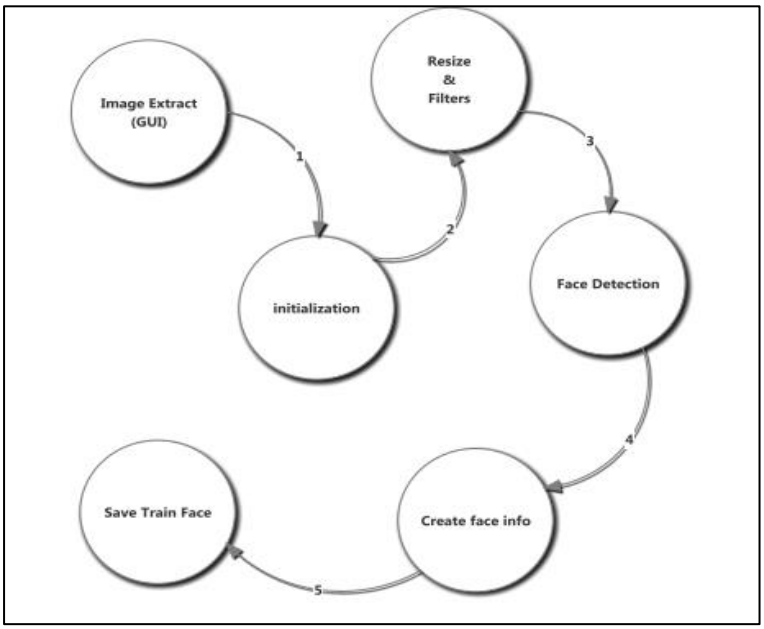

Fig 6. Activity Diagram of Training Phase

- **Step 1-** Sends Image from folder to start the module work.

- **Step 2-** Image resizing in to a fixed size; determined by the administrator; then applying some image processing filters to increase image quality.

-

- **Step 3-** New Image applies Haar-cascades algorithm to detect the face and remove other parts of image.

- **Step 4-** Clone the image and insert the subject name.

- **Step 5-** Create file in a hard disk to new image and save the image path and image name in XML DB.

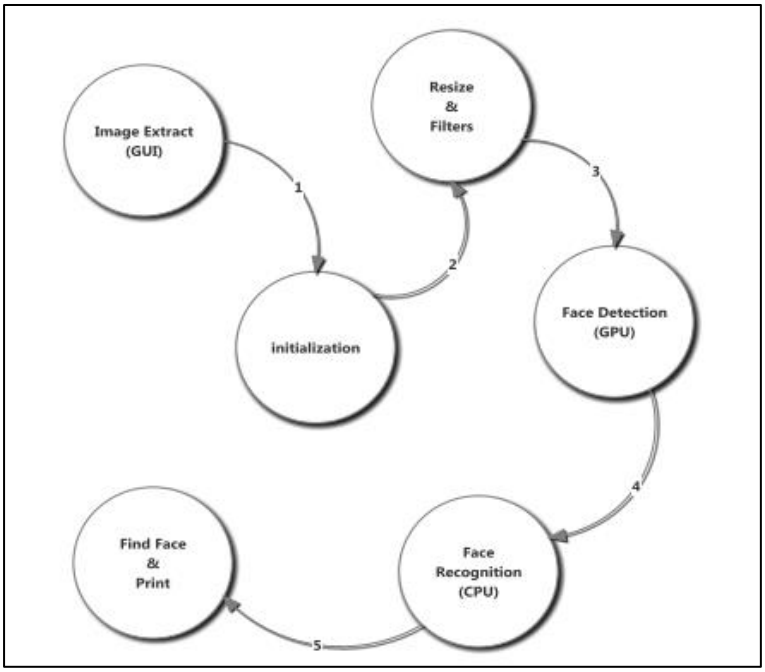

Fig 7. Activity Diagram of Recognition Phase

- **Step 1-** Sends Image from folder to start the module work.

- **Step 2-** Image resizing in to a fixed size; determined by the administrator; then applying some image processing filters to increase image quality.

- **Step 3-** New Image goes to GPU to apply Haar-cascades algorithm to detect the face and remove other parts of image, then the result is returned to CPU.

- **Step 4-** Load train images from DB to RAM and extract features from them in parallel. Next, the CPU extracts the face features from new face and compares with other face features of the training images.

- **Step 5-** If find a face from DB closest to the detected face the system recognized the person by displaying the name in the GUI; otherwise; the system displays a message for an unknown person.

5. DATA FLOW DIAGRAM (DFD)

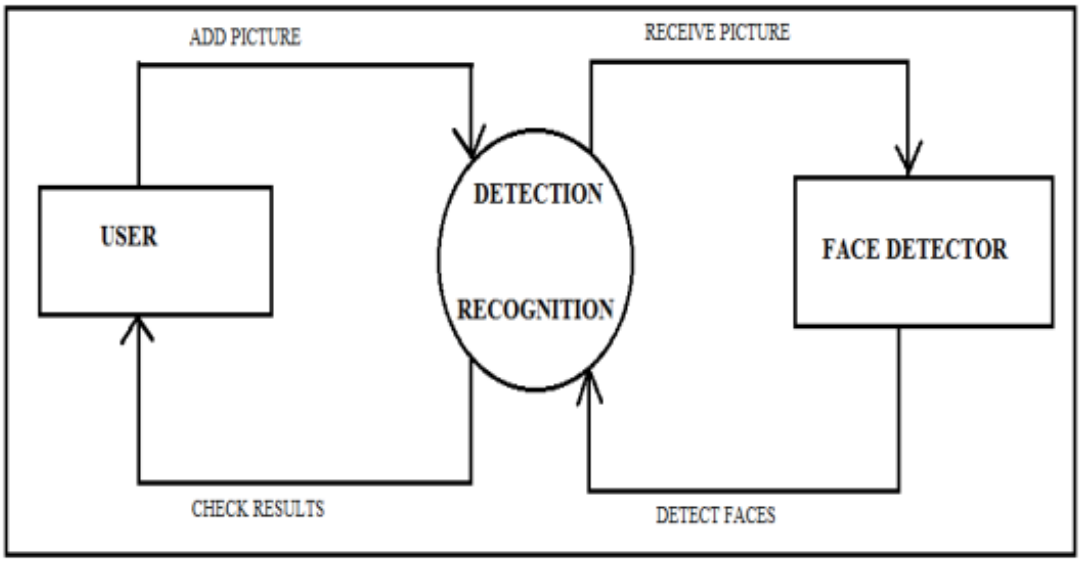

Fig 8. DFD (Level 0)

- **Image Gathering-** This is the first phase of our project. We will simply create a dataset, where we will store for each id, a group of photos in gray with the portion that will be used for face detection.

- **Image Training-** This is the second phase of our project. We will take all user data from the dataset and the data will be fed to the OpenCV Recognizer. This is done directly by a specific OpenCV function. The result will be a .yml file.

- **Image Recognizer-** This is the final phase of our project. We will capture a fresh face on our camera and if this person had his face captured and trained before, our recognizer will make a "prediction" returning its id and an index. In concern to facial recognition, when the image whose face we want to detect will be fed to the system, feature matching will take place and the corresponding output will be provided.

6. USE CASE DIAGRAM

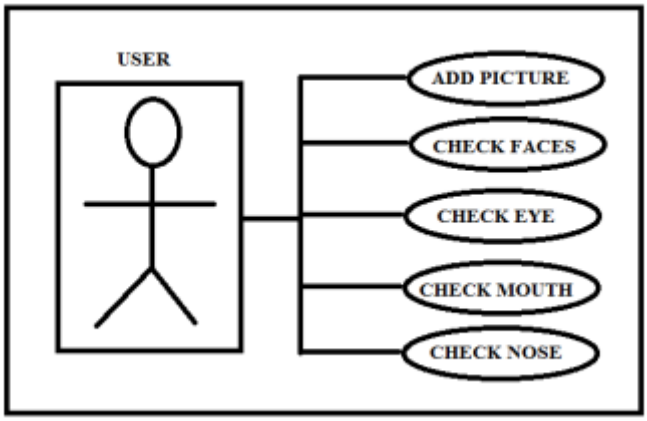

Fig 9(a). User Module

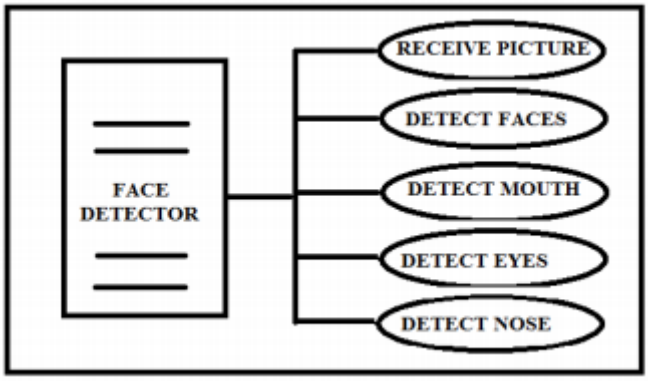

Fig 9(b). Software Module

Actors- User, Face Detector

The corresponding use cases for these actors are:-

- User- Add picture, check faces, check eye, check nose, check mouth
- Face Detector- Receive picture, detect faces, detect mouth, detect eyes, detect nose

7. ADVANTAGES

As a key element in facial imaging applications, such as facial recognition and face analysis, face detection creates various advantages for users, including:

- **Improved security**. Face detection improves surveillance efforts and helps track down criminals and terrorists. Personal security is also enhanced since there is nothing for hackers to steal or change, such as passwords.
- **Easy to integrate**. Face detection and facial recognition technology is easy to integrate, and most solutions are compatible with the majority of security software.
- **Automated identification**. In the past, identification was manually performed by a person; this was inefficient and frequently inaccurate. Face detection allows the identification process to be automated, thus saving time and increasing accuracy
- **Faster Processing**. The process of recognizing a face takes a second or less — and this is incredibly beneficial for the companies. In the era of constant cyber attacks and advanced hacking tools, companies need a technology that would be both secure and fast. Considering that facial recognition is almost instant, it grants a quick and efficient verification of a person. In addition, it's hard to fool this technology so this is another bonus.
- **Reduces the number of touch points.** Facial recognition requires fewer human resources than other types of security measures, such as fingerprinting. It also doesn't require physical contact or direct human interaction. Instead, it uses AAI to make it an automatic and seamless process. It also limits touch points when unlocking doors and smart phones, getting cash from the ATM or performing any other task that generally requires a PIN, password or key.
- **Makes shopping more efficient.** The convenience of facial recognition extends beyond security too. Instead of making purchases at stores with cash or credit cards, facial recognition technology can recognize your face and charge the goods to your account.

8. DISADVANTAGES

The threat to individual privacy is a significant downside of facial recognition technology. People don't like having their faces recorded and stored in a database for unknown future use.

- **Imposes on personal freedom**. Being recorded and scanned by facial recognition technology can make people feel like they're always being watched and judged for their behavior. Plus, police can use facial recognition to run everyone in their database through a virtual criminal lineup, which is like treating you as a criminal suspect without probable cause.
- **Violates personal rights**. Countries with limited personal freedoms, such as China, UAE, North Korea, Iran and Iraq, commonly use facial recognition to spy on citizens and arrest those deemed troublemakers.
- **Provides opportunities for fraud and other crimes**. Lawbreakers can use facial recognition technology to perpetrate crimes against innocent victims too. They can collect individuals' personal information, including imagery and video collected from facial scans and stored in databases, to commit identity fraud. With this information, a thief could take out credit cards and other debt or open bank accounts in the victim's name, or even build a criminal record using the victim's identity.
- **Innocent people could be charged.** There are inherent dangers in false positives. Facial recognition software could improperly identify someone as a criminal, resulting in an arrest. This issue is exasperated when you add that the technology struggles with people of color, which increases the potential for racial profiling accusations.
- **Technology is Imperfect.** Facial recognition isn't perfect. For example, it's less effective at identifying women and people of color than White males. The technology depends upon algorithms to make facial matches. Those algorithms are more robust for White men than other groups because the databases contain more data on White men than women and people of color. This creates unintentional biases in the algorithms.

9. APPLICATIONS

- **Security companies are using facial recognition to secure their premises.** The fact that machines can today accurately recognize individuals, presents a slew of opportunities for the security sector, chief among them the ability to identify unauthorized access to locations where non-authorized people shouldn't be. It's a well-known fact that IP cameras today can be equipped with facial recognition software, to enable complex access control of premises, with enabling of individual white lists and blacklists for specific locations, enabling perimeter and asset monitoring, on top of threat and intrusion detection.

- **Ride-sharing companies can use facial recognition to ensure the right passengers are picked up by the right drivers.** In a similar vein to the fleet management solutions presented above, passengers in the ride-sharing industry can also benefit from facial recognition. In the case of the sharing economy, facial recognition presents an added layer of verification—and security—to rides.

- **IoT benefits from facial recognition by allowing enhanced security measures and automatic access control at home**. Once again, a security-driven application of facial recognition finds its way in the IoT sphere. In homes, the key use of facial recognition is on intrusion systems that detects if someone enters a home when an intrusion alarm is left armed. Progress within this sector could be in the form of enhanced capabilities of existing intrusion devices, to extend into access control ones. In the future, doors could unlock when homeowners reach their front door, negating the need for traditional door locks and fumbling with keys, or relying on mobile devices to manually unlock "smart" lock solutions of today.

- **Retailers can use facial recognition to customize offline offerings and to theoretically map online purchasing habits with their online ones**. The retail industry recognizes that facial recognition is the next step in their continuous pursuit to provide personalization for shoppers. Facial recognition could allow retailers to capture what shoppers are looking at in physical shops, turning what was long-known as "offline" shopping habits, into online ones as well. This essentially means greater insights and analytics into the purchasing habits of their customers.

10. FUTURE SCOPE

Facial Recognition using feature classification of a person based on only a frontal view image is something a human can easily accomplish. It can be decided by the facial features such as hair, nose, eyes, mouth and other properties with relatively high degree of accuracy. However this will be a problem when it comes to automating the processing using a computer program. This project therefore is to solve this matter. In this project it is assumed that each image is of same size, the image quality and resolution is assumed to be sufficient enough, the illumination is uniformed and the input images are colour images.

- In order to prevent the frauds of ATM in India, it is recommended to prepare the database of all ATM customers with the banks in India & deployment of high resolution camera and face recognition software at all ATMs. So, whenever user will enter in ATM his photograph will be taken to permit the access after it is being matched with stored photo from the database.

- Duplicate voter are being reported in India. To prevent this, a database of all voters, of course, of all constituencies, is recommended to be prepared. Then at the time of voting the resolution camera and face recognition equipped of voting site will accept a subject face 100% and generates the recognition for voting if match is found.

- Passport and visa verification can also be done using face recognition technology as explained above.

- Driving license verification can also be exercised face recognition technology as mentioned earlier.

- To identify and verify terrorists at airports, railway stations and malls the face recognition technology will be the best choice in India as compared with other biometric technologies since other technologies cannot be helpful in crowdy places.

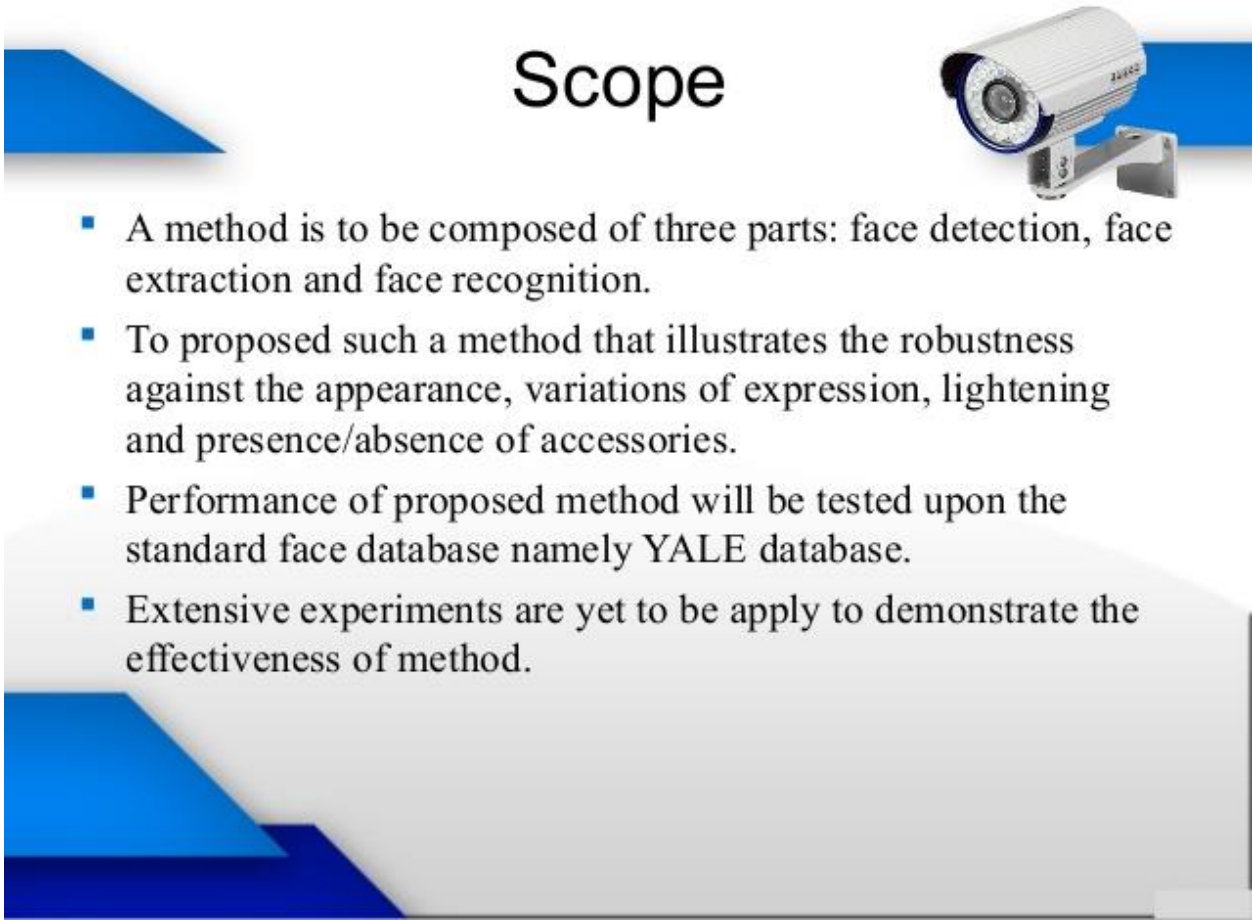

Fig 10. Scope of the Project

11. CONCLUSION

The facial recognition system presented in our project which contributes a resilient face recognition model based on the mapping of behavioral characteristics with the physiological biometric characteristics. The characteristics of the human face with relevance to various features are associated with geometrical structures which restored as base matching template for the recognition system.

Face recognition technologies have been associated generally with very costly top secure applications. Today the core technologies have evolved and the cost of equipments is going down dramatically due to the integration and the increasing processing power. Certain applications of face recognition technology are now cost effective, reliable and highly accurate.

As a result there are no technological or financial barriers for stepping from the pilot project to widespread deployment. Though there are some weaknesses of facial recognition system, there is a tremendous scope in India. This system can be effectively used in ATM's ,identifying duplicate voters, passport and visa verification, driving license verification, in defense, competitive and other exams, in governments and private sectors.

Face recognition technology has come a long way in the last twenty years. Today, machines are able to automatically verify identity information for secure transactions, for surveillance and security tasks, and for access control to buildings etc. These applications usually work in controlled environments and recognition algorithms can take advantage of the environmental constraints to obtain high recognition accuracy. However, next generation face recognition systems are going to have widespread application in smart environments -- where computers and machines are more like helpful assistants.

To achieve this goal computers must be able to reliably identify nearby people in a manner that fits naturally within the pattern of normal human interactions. They must not require special interactions and must conform to human intuitions about when recognition is likely. This implies that future smart environments should use the same modalities as humans, and have approximately the same limitations.

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