Face Recognition System – A Survey

Richa[1], Jagroop Kaur Josan[2]

[1]M.Tech Scholar, Department of Computer Engineering, Punjabi University, Patiala, Punjab, India

[2]Assistant Professor, Department of Computer Engineering, Punjabi University, Patiala, Punjab, India

Abstract: *Face Recognition is the problem related to the field of machine learning, computer vision and image analysis. It is the combination of these three fields. This paper represents the various phases involved in the system, the description of different techniques used, the challenges/issue and the approaches to overcome them. The application, advantages, disadvantages of the methods and performance measures of the system are also discussed.*

Keywords: Face Recognition, Face Detection, Face Extraction, Application, Approaches, Issues/Challenges

1. Introduction

Face Recognition is the task of identifying the detected face as a known face or not. It is the application of Digital Image Processing and Computer Vision. Computer Vision is an advance branch of Artificial Intelligence and moreover it is attained by Machine Learning. So, we can say that Face Recognition System is implemented with the help of Machine Learning, Computer Vision and Image processing.

2. Phases in the System

The Face Recognition System has normally four phases i.e. Face Detection, Feature Extraction, Classification and Face Recognition but last two phases are combined together. So these phases are discussed below:
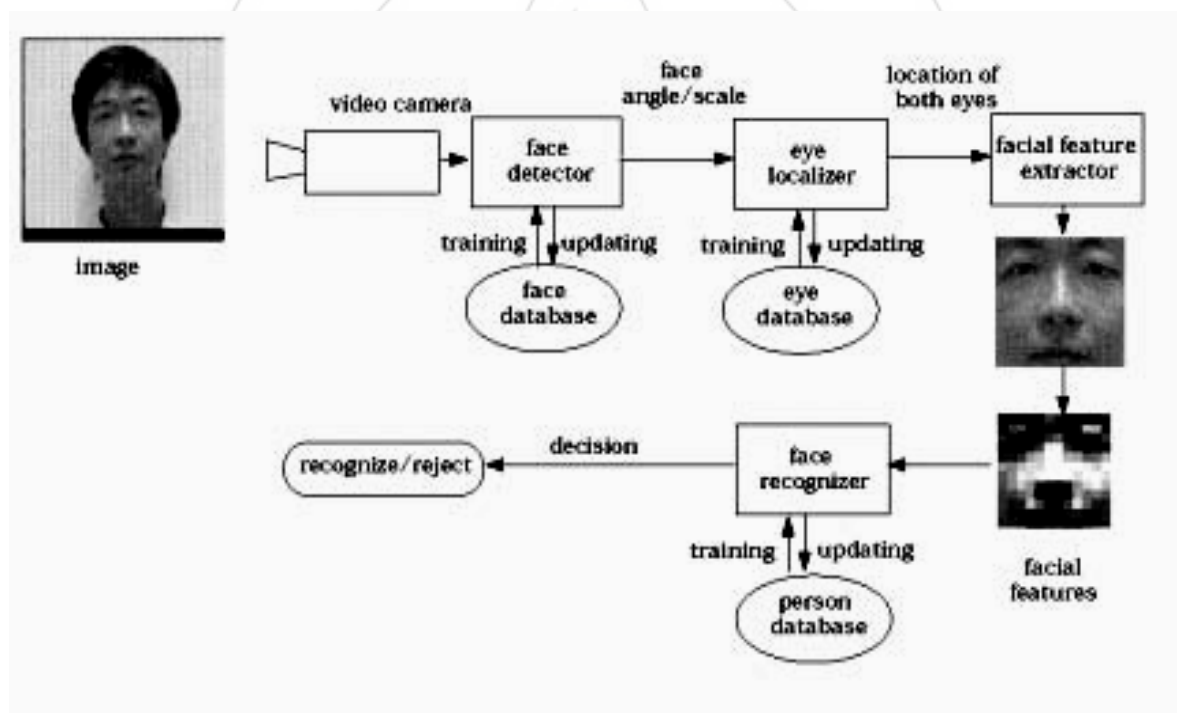

Figure 1: Face Recognition System [5]

A. Face Detection

As the name suggests, it is the detection of the face. In this phase, faces are detected in the image. To detect the face from the image there are four methods:

1) *Knowledge-based Method*
   The rule-based method uses the knowledge of human to get the information about the typical face. Usually, the rules capture the relationships between facial features to design the location of the features in the face.

2) *Template Matching Method*
   In this, several standard patterns of a face are stored in the database or the system to describe the face as a whole or the facial features separately. The link between an input image and the stored patterns are evaluated for detection. These methods have been used for both face localization and detection.

3) *Appearance based Method*
   In contrast to template matching, the models are learned from a set of training images which should capture the representative variability of the appearance face. These

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learned models are then used for detection and are mainly designed for face detection.

4) *Block rank patterns*
In this, a block rank pattern is generated by dividing two gradient magnitude images into nine(3×3) blocks and then a face is roughly detected by these 3×3 block rank patterns generated from the gradient magnitude images.

5) *Viola Jones Face Detector*
The Viola–Jones face detector is the first object detection framework which provides competitive object detection rates in real-time. It was developed in 2001.

6) *Feature Invariant Approach*
This algorithm aims to find structural features that exist even when the pose, viewpoint, or lighting conditions vary, and then we use this approach to locate face.

B. Feature Extraction

It is the extraction of features like eyes, nose and lips from the face which can be used further to differentiate people from each other. The approaches for face extraction are:

1) *DCT*
The Discrete Cosine Transform expresses a sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. Therefore, it can be used to transform images, compact the variations and allows an effective dimensionality reduction. They have been widely used for data compression.

2) *JPEG (DCT Zigzag)*
It is the scanning technique which moves in the zigzag form and from low frequency component to high frequency component because most of the energy is stored in low frequency component.

3) *Gabor Filter*
A set of Gabor filters with different frequencies and orientations may be useful for extracting important features from an image. They have been widely used in pattern analysis applications

4) *PCA*
Principle Component Analysis is a mathematical procedure that performs a dimensionality reduction by extracting the principle components of the multi-dimensional data. It is based upon Eigenvector and a linear map.

5) *LBP*
LBP is Local Binary Pattern. This algorithm divides the image of the face into various small local regions that are further represented as binary digits. After this, the statistics histogram of these binary digits is used for representing that image of face.

6) *LDA*
Linear Discrimination Analysis (LDA) finds the directions for maximum discrimination of classes in addition to dimensionality reduction. It is also based upon Eigenvector and a supervised linear map.

C. Face Recognition/ Classification

It is the matching of the face with the existing face saved in the database of the system. To match these faces we again have some methods:

1) SVM
Support Vector Machine (SVM) is a powerful technique to classify the unseen test patterns by using a hyper-plane which is defined by the weighted combination of a small subset of the training vectors, called support vectors.

2) HMM
In developing Hidden Markov Model (HMM) for a recognition problem, a finite number of states are needed which must be hidden to form a model. Then, one can train HMM to learn the transitional probability between states from the examples where each example is represented as a sequence of observations. In this, we are making machine to learn from the examples.

3) Neural Networks
Neural Network (NN) is an interconnected cluster of artificial neurons that uses a computational model for processing any information based on a connectionist approach to computation. In most of the cases, an artificial neural network is an adaptive system that changes its structure based on external or internal information that flows through the network.

4) SOM
Self-Organizing Map (SOM) belongs to the competitive learning networks. It is a kind of a neural network which is trained by using unsupervised learning to produce a two dimensional(2-D) representation of the input space of the training samples.

3. Issues/Challenges

There are various issues and challenges due to which the recognition rate may drops. These are:

a) *Pose Variation*
Pose plays a vital role in face recognition. It is the major issue and happens due to change in camera's angle and subject's movement.

b) *Illumination*
It is the variation in the angle of light falls on the face. It changes the result so far that the difference between the two pictures of same person is large than the difference between the two different persons.

c) *Ageing*
With change in the age of the person, facial features also get change which creates problem in recognition of the face.

d) *Facial Expression*
It changes due to change in facial gestures like sadness, happiness, angry, tired etc.

e) *Occlusion*
It is due to the presence of glasses, beards, stroll or caps which covers the face or object.

f) *Low Resolution*
Image of very small face has low resolution which consists of very less information which may drops the recognition rate of the system.

g) *Imaging Condition*
Different surroundings and different camera can change the quality of the image and affecting the face appearance.
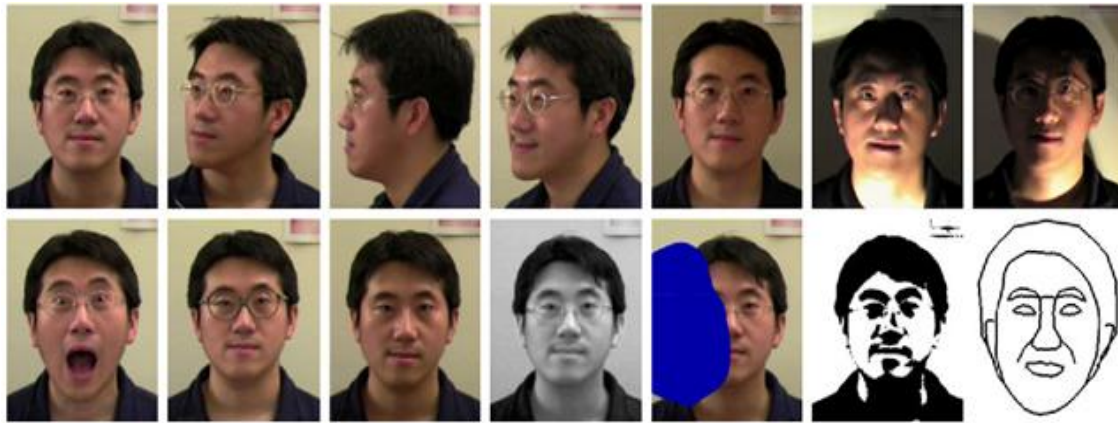
Figure 2: Issues/challenges i.e. pose variation, illumination, imaging condition, facial expression etc.[5]

4. Applications

There are various areas in which face recognition system is used:

a) Entertainment
In the area of entertainment it can be used in the monitoring of the behavior at childcare or old people's centers, human-robot/computer-interaction, video gaming and virtual reality etc.

b) Information Security
In the area of information Security, it can be used as personal device logon, border checkpoints, database security, file encryption, intranet security, medical records, banks, biometric-log-in.

c) Smart Cards
As smart cards it may be used as drivers' licenses, passport, employee's ID, immigration, bar code or magnetic stripe, national ID, aadhaar Cards, voter card.

d) Law Enforcement and Surveillance
It is also used in advanced video surveillance, traffic control, ATM machines, enhancement of CCTV images, police bookings, suspect tracking and investigation.

5. Conclusion

I have read various research papers and came to know about the face recognition system, phases included in implementing that system. The each phase can be done by using different approaches and methods. I have also learned about the issues/challenges, advantages, disadvantages and applications related to the system.

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Author Profile

Richa, M.Tech Scholar, Department of Computer Engineering, Punjabi University, Patiala, Punjab, India.

Jagroop Kaur Josan, Assistant Professor at Department of Computer Engineering, Punjabi University, Patiala, Punjab, India.