Face Detection and Recognition using Eigen Faces by using PCA

Miss. Nupoor M. Yawale
M.E. First year CSE
P R Patil COET
Amravati, India.
nupoory1@gmail.com

Abstract

In this paper we propose a face recognition system based on Eigen faces. There has been significant progress in improving the performance of computer-based face recognition algorithms over the last decade. Although algorithms have been tested and compared extensively with each other, there has been remarkably little work comparing the accuracy of computer-based face recognition systems with humans. Given an image the goal of a face detection algorithm is to detect a human face and that of a face recognition algorithm is to match it against a known face database. The face detection algorithm works by locating eyes in the image and the face recognition algorithm uses Principal Component Analysis to calculate eigenvalues and eigenvectors of the face images. This paper discusses a generic framework for the face recognition system, and the variants that are frequently encountered by the face recognizer. It also discusses the requirements of a robust face recognition system. Also face detection algorithm based on eye-analogue segmentation and recognition algorithm based on Eigen-space have been developed by us.

1. Introduction

Face is our primary focus of interaction with the society. This can be observed in interaction among animals as well as between animals and humans. Face communicates identity, emotion, race, and age. It is also quite useful for judging gender, size and perhaps even character of the person. It has often been observed that human ability to recognize faces is quite remarkable. Faces are complex visual stimuli that are not easily described by shapes and patterns; yet people have the ability to recognize faces even after years of separation. Faces are so important in human interaction that no other avenue to person identification is as convincing as face recognition. There are several aspects of recognizing human identity and processing facial information that make the problem very vague. Recognition of a person’s identity is not necessarily a function of viewing the person’s face in isolation.

Face recognition is closely related to face detection, face tracking and facial expression analysis.

The ability to recognize people by their facial characteristics is nothing but the Face recognition. Just as the human task of face recognition is neither clearly defined nor clearly differentiated from related tasks, automatic face recognition is not a single defined problem. We can define automatic face recognition as a pattern recognition task performed specifically on faces. It can be described as classifying a face as either "known" or "unknown", after comparing it with stored known faces.

Face detection is a computer technology that determines the locations and sizes of human faces in arbitrary (digital) images.

2. Importance of face recognition

In today's networked world, the need to maintain the security of information or physical property is becoming both increasingly important and increasingly difficult. From time to time we hear about the crimes like credit card frauds, network intrusions, or security breaches. The criminals are taking advantage of a fundamental flaw in the conventional access control systems. The systems do not grant access by "who we are", but by "What we have", such as ID cards, keys, passwords etc. None of these means actually define us. Rather, they merely are means to authenticate us. It goes without saying that if someone steals duplicates or acquires these identity means, he or she will be able to access our data or our personal property anytime and anywhere.

3. Generic framework

Face recognition algorithm can be divided into the following two functional modules:-

Face image detector finds the locations of human faces in a normal picture, and a Face recognizer determines who the person is. Both the face detector and the face recognizer follow the same framework. They have a feature extractor that transforms the pixels of the facial image into a useful vector representation, and a pattern recognizer that
Searches the database to find the best match of the input image. In the face detection phase, the pattern recognizer categorizes the incoming feature vector according to one of the two image classes: “face” images or “non-face” images. On the other hand, the recognizer classifies the feature vector (assuming it is from a “face” image) as a known or unknown face.

4. FACE DETECTION ALGORITHM

Face detection algorithm is based on eye analogue segmentation

1) Convert the image into gray level image if it is colored.
2) Discard the light pixels of the image via thresholding and assign them the value of 255 (The value of white pixel is assigned as we want to concentrate on dark portions).
3) Apply the Laplacian high pass filter to sharpen the image and remove the isolated specks from the image.
4) Label the 8-connected segments of the resultant image.
5) Compute the centroid, area, width and height of the labeled segments.
6) Select the components that satisfy several predefined constraints. These constraints use many threshold variables that were decided after analysis of a large number of images. E.g. the segment area to image area ratio should lie within a specified range. The segment’s major to minor axis ratio should be greater than MINMJMIRATIO and less than MAXMJMIRATIO. All the threshold variables and constraints are invariant of the size and illumination of the image which makes the algorithm robust.
7) Make pairs of remaining eye analogue segments. Take each pair and check whether or not they are eyes. Several constraints are used for this purpose. E.g. Horizontal distance between the eye centroids should be less than MaxXdistance threshold. Vertical distance between the eye centroids should be less than MaxYdistance threshold. Discard the pairs that don’t satisfy these constraints.
8) If more than one pair is still left, select the best pair. If only one pair is left it is detected as eye. If there is no pair, no face is detected in the image.
9) Calculate the rotation angle (say A degrees) according to the difference of Y coordinates of the centroids of the detected eyes. Accordingly rotate the image by A degrees so that Y difference of eye centroids is zero. This is an indication of straight face. Rotational independence is achieved by this step.
10) Calculate the face rectangle boundaries by using difference of X coordinates of the centroids (diffx) of eyes. There are some predefined constants (itop, ibot, ileft, iright) that help in specifying the face rectangle. Thus by considering only the significant portions of the face for the recognition purpose we achieve robustness against temporary facial features such as a beard. E.g. top = diffx * itop Bottom = diffx * ibot Left = diffx * ileft Right = diffx * iright
11) Rescale the image according to predefined standard using nearest neighbor approach, bilinear approach or cubic approach. This
5. Eigen-space based approaches

This method has been developed by Mathew Turk and Alex Pentland [1]. Eigen-space based approach [4] is derived from information theory. In the language of information theory, we extract the relevant information, encode it as efficiently as possible, and compare one encoding with a database of models encoded similarly. A simple approach to extract the information contained in the image of a face is to capture the variation of images, independent of judgment of features, and use this information to encode and compare individual face images. In Eigen-space based approaches, Principal Component Analysis [7] is used to encode the information. In mathematical terms; we find principal components of the distribution of faces, or the eigenvectors of the covariance matrix of images, treating an image as a point in a high-dimensional space. This technique is known as Principal Component Analysis. The eigenface technique is a powerful yet simple solution to the face recognition. In fact, it is really the most intuitive way to classify a face. As we have shown, old techniques focused on particular features of the face. The eigenface technique uses much more information by classifying faces based on general facial patterns. These patterns include, but are not limited to, the specific features of the face. By using more information, eigenface analysis is naturally more effective than feature-based face recognition. Eigenfaces are fundamentally nothing more than basis vectors for real faces. The eigenface approach [8] is divided into two phases:

A. Training phase (Initialization phase):

This phase has three major steps:

i) Acquire an initial set of face images (the training set).

ii) Calculate the eigenfaces from the training set, keeping only the M images that correspond to highest eigenvalues. These M values describe a face space.

iii) Calculate the corresponding distribution in M-dimensional weight space for each known individual by projecting his or her face image onto the “face space”.

B. Query phase (Recognition phase):

It has four major steps:

i) Calculate the set of weights based on the input image and the M eigenfaces by projecting the input image onto each of the eigenfaces.

ii) Determine if the image is a face or not (by checking whether the image is sufficiently close to the face space).

iii) Classify the weight pattern as a person or unknown.

iv) Update the eigenfaces and weight patterns (optional).

Many algorithms are devised for face recognition using the eigen-space based approach.

6. Principle components analysis

PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. It includes various mathematical concepts such as eigenvalue, eigenvector, deviation and covariance. This background knowledge is meant to make the PCA section very straightforward.

Principal Components Analysis (PCA), [7] also known as Karhunen-Loève expansion or Eigen-XY analysis, has found a number of applications in the fields of computer vision and pattern recognition. PCA is based on representing typical images in terms of a compact set of orthogonal basis images. PCA is used in computer vision, first showing how images are usually represented, and then showing what PCA can allow us to do with those images. It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. It is use for extracting relevant information from confusing data sets.

7. Conclusion

Clearly, face recognition is being solved problem, either by eigenfaces. The progress during the past decade on the face recognition has been encouraging. Eigenface and (other appearance-based approaches) must be coupled with feature or shape based approaches to recognition in order to build system that will be robust. Generic framework gives a brief idea about face recognition and detection. Analysis of the eigenface recognition technique i.e. PCA gives evidence that the methods prove, at best, 90% accurate. Face recognition can be applied in Security measure at Airports, Passport verification and Criminals list verification in police department, Visa processing and Card Security measure at ATM’s. From these we conclude that, face
recognition and detection provides a security and its accuracy is quite remarkable.

8. References