Fast Facial Recognition System

2 authors:

Dr.Hlaing Htake Khaung Tin
University of Information Technology Yangon Myanmar
56 PUBLICATIONS 142 CITATIONS

Myint Myint Sein
University of Computer Studies, Yangon
157 PUBLICATIONS 256 CITATIONS

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Fast Facial Recognition System

Hlaing Htake Khaung Tin, Myint Myint Sein
University of Computer Studies, Yangon
hlainghtakekhaungtin@gmail.com

Abstract

Automatic age dependent face recognition system is developed. This approach is based on the Principle Component Analysis (PCA). Eigen face approach is used for both age prediction and face recognition. Face database is created by aging groups individually. The age prediction is carried out by projecting a new face image into this face space and then comparing its position in the face space with those of known faces. After that we find the best match in the related face database, the Eigen face representation of an input image is first obtained. Then it is compared with the Eigen face representation of face in the database. The closest one is the match. It will be reduced the time complexity using this approach. The proposed method preserves the identity of the subject while enforcing a realistic recognition effects on adult facial images between 15 to 70 years old. The accuracy of the system is analyzed by the variation on the range of the age groups. The efficiency of the system can be confirmed through the experimental results.

1. Introduction

Face recognition includes one of the biometric systems. Some examples of biometric features of humans are: Signature- studies the pattern, speed, acceleration and pressure of the pen when writing ones signature. Fingerprint- studies the pattern of ridges and furrows on the surface of the fingertip. Voice- studies way humans generate sound from vocal tracts, mouth, nasal cavities and lips. Iris- studies the annular region of the eye bounded by the pupil and the sclera. Retina- studies the pattern formed by veins beneath the retinal surface in an eye. Hand Geometry- measures the measurements of the human hand. Ear Geometry- measures the measurements of the human ear. Facial thermo gram- concerns the heat that passes through facial tissue. Among them face is the most natural and well known biometric.

Age prediction is concerned with the use of a training set to train a model that can estimate the age of the facial images. Among the first to research age prediction were, Kwon and Vitoria Lobo who proposed a method to classify input face images into one of the following three age groups: babies, young adults and senior adults [6]. Their study was based on geometric ratios and skin wrinkle analysis. Their method was tested on a database of only 47 high resolution face images containing babies, young and middle aged adults. They reported 100% classification accuracy on these data. Hayashi focused their study on facial wrinkles for the estimation of age and gender [8]. Skin regions were first extracted from the face images, followed histogram equalization to enhance wrinkles. Then, a special Hough transform, DTHT (Digital Template Hough Transform) was used to extract both the shorter and longer wrinkles on the face. Their experiments were not very successful on the age classification task though, achieving only 27% accuracy of age estimation and 83% on gender classification. It is important to note that they did not mention the size or source of their test to generate their accuracy values. Hayashi also noted the difficulty of extracting wrinkles from females' ages between 20 and 30 due to presence of makeup [8].

Lanitis empirically studied the significance of different facial parts for automatic age estimation [9]. The algorithm is based on statistical face models. Lanitis claims that introduction of the hairline has a negative effect on the results [9].His study was limited to subject ranging from 0 to 35 years old, and contained 330 images, of which only 80 were used for testing purposes. Evidently, faces with more wrinkles weren't used, leaving in doubt his ability to estimate the age of subjects older than 35 years. Some researchers have focused on particular age groups only, while others use an extremely wide classification range. Primarily, due to the lack of a good database, a global age prediction function, covering an extensive range of ages has yet to be developed.

J . R . Scolar and P . Navarreto [3] proposed an face recognition algorithm based on Eigen space. J . Yang and et al.[4] introduced the a new approach to appearance-based face representation and recognition. Most of the research in this area is very limited by the size and quality of the database used.

In this research, age dependent face recognition system based on the diagonal PCA Method is developed. First, the age of the input individual is predicted and then face recognition is performed with corresponding age group in face database. Finally, the record of the matched person is appeared as output.

2. System Overview

Face region is extracted from a real image. Firstly, noise filtering and image adjusting processes are performed for image enhancing. Thirteen age individual groups are included in a face database. Within a given database, all weight vectors of the persons within the same age group are averaged together. This creates “a face class”. When a new image comes in, its weight vector is created by projecting it onto the face space. The face is then matched to each face class that gives the minimum Euclidean distance. A ‘hit’ is occurred if the image nearly matches with its own face class. And then the age group that gives the minimum Euclidean distance will be assumed as the age of the input image. The record of the corresponding person is obtained by comparing with the estimated age group. The over view of the proposed system is illustrated in figure 1.

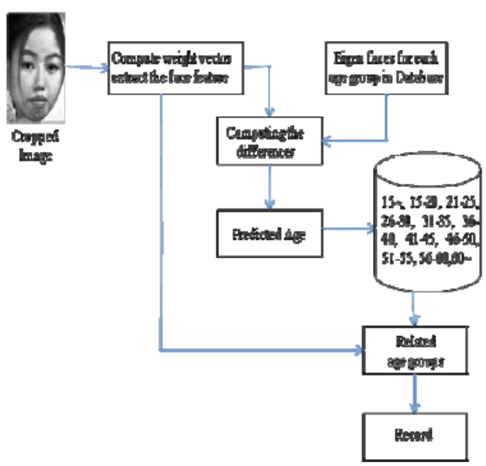

Figure 1. System Flow Diagram

3. Preprocessing

The first step of preprocessing is the face region extraction. Face region extraction means the input face image is extracted from input image by using cropping tool (see figure 2). The input image may be current scanned image or realities input image. And then enhancing state occurs. The proposed system allows the free size and format of color image.

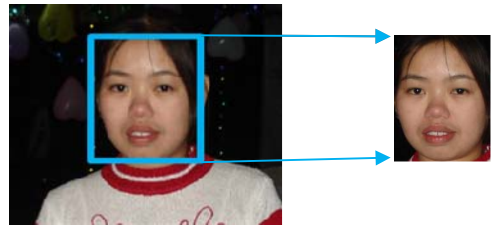

Figure 2. Face region extraction

Enhancing state includes the noise filtering, gray scale converting, and histogram equalization. Histogram equalization maps the input image’s intensity values so that the histogram of the resulting image will have an approximately uniform distribution [3-6]. The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function.

$$p(rk) = \frac{nk}{n} \tag{1}$$

where L is the total number of gray levels , r_k is the k^{th} gray level, n_k is the number of pixels in the image with that gray level, n is the total number of pixels in the image, and $k = 0, 1, 2, \ldots, L - 1$. $p(r_k)$ gives an estimate of the probability of occurrence of gray level r_k. By histogram equalization, the local contrast of the object in the image is increased, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensity can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast.

The input color image is converted to gray image and stored in database for processing. After gray converting, histogram equalization is performed. The converted gray image is shown in figure 3. Figure 4 described the histogram images of gray scale image and equalized image, respectively.

Figure 3. Gray level converting

(a)Gray image **(b) equalized image**

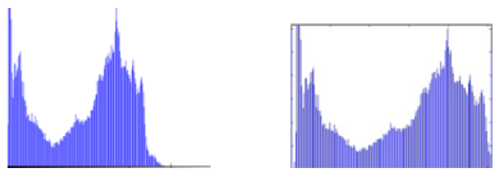

Figure 4. Histogram Equalization

4. Age Prediction System

There are seven implementation steps in age dependent face recognition. First step is converting the face image into matrix form. And then find the average faces for each age group for the images in the training database. Next, calculate the difference between the input and the average faces. Next step is built the matrix A from the face differences from the average faces. Find the Covariance Matrix $Cov=AA^T$. And then built Matrix $L=AA^T$ to reduce dimension. Find the eigenvector of Cov. Eigenvector represent the variation in faces. The face is projected onto the face space. Finally classify (Prediction and Recognition) the face by using Euclidean distance.

The age of the subject is predicted based on the minimum Euclidean distance between the face space and each face class. If the face image in the database and the recognized face image is match then the distance between the class and the face space is below the threshold level.

If the face image in the database and the recognized face image is not match then the distance between the class and the face space will be over the threshold level.

5. Face recognition

Face recognition has become one of the most important fields in automated biometric identification system [1]. Pattern recognition plays a crucial role in real world applications. To build high performance surveillance or information security systems, face recognition has been known as the key application attraction [3]. The face is our primary focus of attention in social intercourse, playing a major role in biometric security system. In this paper the adaptive face recognition system by using DiaPCA and KNN (K^{th} nearest neighbor) classifier. DiaPCA is used to reduce the dimension, KNN is used to extract the significant features and Euclidian distance is used to find the difference.

This paper focused on the adaptive face recognition for biometric security system. It also shows that if the minimum Euclidian distance of the test image from other images is zero, then the test image completely matches the existing image in the database. If minimum Euclidian distance is non-zero but less than threshold value, then it is a known face but having different face expression else it is an unknown face. Face recognition has become an important issue in many applications such as security systems, credit card verification and criminal identification [2]. Face Recognition is an emerging field of research with many challenges such as large set of images, improper illuminating conditions [3]. Much of the work in face recognition by computers has focused on detecting individual features such as the eyes, nose, mouth and head outline, and defining a face model by the position, size, and relationships among these features.

Eigenface approach is one of the simplest and most efficient methods in developing a system for Face Recognition. In eigenface approach, after the dimensional reduction of the face space, the distance is measured between two images for recognition. If the distance is less than some threshold value, then it is considered as a known face else it is an unknown face [5].

The approach transforms face images into a small set of characteristic feature images, called "eigenfaces", which are the principal components of initial training set of face images. Recognition is performed by projecting a new image into the subspace spanned by the eigenfaces and then classifying face by comparing its position in face space with the position of known individuals [4].

Before processing, the preprocessing module, including the face detection stage, gray converting and histogram equalization must be done.

5.2. PCA and DiaPCA

The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in image recognition and compression. PCA is a statistical method under the broad title of *factor analysis* [3]. The purpose of PCA is to reduce the large dimensionality of the data space to the smaller intrinsic dimensionality of feature space, which are needed to describe the data economically. PCA can do prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable.

We have implemented PCA procedure in a training set of M face images. Let a face image be represented as a two dimensional N by N array of intensity values, or a vector of dimension $N2$. Then

PCA tends to find a *M*-dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. This new subspace is normally lower dimensional (*M*<< *M* << *N*2) [4]. New basis vectors define a subspace of face images called face space. All images of known faces are projected onto the face space to find sets of weights that describe the contribution of each vector. To identify an unknown image, the image is projected onto the face space as well to obtain its set of weights. By comparing a set of weights for the unknown face to sets of weights of known faces, the face can be identified. PCA basis vectors are defined as eigenvectors of the scatter matrix S defined as:

$$S = \sum_{i=1}^{M} (xi - \mu).(xi - \mu)' \qquad (2)$$

where μ is the mean of all images in the training set and xi is the i^{th} face image represented as a vector i. As this face space is generated using eigenvectors of scatter matrix, sometimes this is also called as eigenspace.

The eigenvectors corresponding to nonzero eigenvalues of the covariance matrix produce an orthonormal basis for the subspace within which most image data can be represented with a small amount of error. The eigenvector associated with the largest eigenvalue is one that reflects the greatest variance in the image. That is, the smallest eigenvalue is associated with the eigenvector that finds the least variance.

A facial image can be projected onto $M'(<< M)$ dimensions by computing

$$\Omega = [v_1 v_2 \ldots v_{M'}]^T \qquad (3)$$

The vectors are also images, so called, eigenimages, or eigenfaces .They can be viewed as images and indeed look like faces. So describes the contribution of each eigenface in representing the facial image by treating the eigenfaces as a basis set for facial images. Face space forms a cluster in image space and PCA gives suitable representation

Pattern recognition in high-dimensional spaces have pattern problems because of curse of dimensionality. Significant improvements can be achieved by first mapping the data into a lower-dimensional sub-space. The goal of PCA is to reduce the dimensionality of the data while retaining as much as possible of the variation present in the original dataset.

Our motivation for developing the DiaPCA method originates from an essential observation on the PCA. PCA only reflects the information between rows, which implies some structure information (e.g. regions of a face like eyes, nose, etc.) cannot be uncovered by it. We attempt to solve that problem by transforming the original face images into corresponding diagonal face images. Because the rows (columns) in the transformed diagonal face images simultaneously integrate the information of rows and columns in original images, it can reflect both information between rows and columns [6]. DiaPCA directly seeks the optimal projective vectors from diagonal face images without image-to-vector transformation

In the core of our system lies the Diagonal Principal Component Analysis (DiPCA) Algorithm [2], which is a tested and widely adopted for face recognition. DiaPCA can be subdivided into two components – PCA subspace training and PCA projection. During PCA subspace training, the rows of the pixels of an N1 x N2 image are concatenated into a one dimensional 'image vector'. In practice, only a subset of the eigenfaces (*k = 1, …, M'*) is retained to form a transformation matrix which is used in the PCA projection stage. Only the principal eigenfaces accounting for the most significant variations are used in the construction.

During DiaPCA projection, a new face image vector is multiplied by the transformation matrix and projected to a point in a high dimensional DiaPCA subspace. In this case, the correlations among the projected images are minimized in order to facilitate easier classification [3]. The projected image is then saved as the face template of the corresponding user for future matching.

5.3. Nearest Neighbor Classification

Classification (similarity search) is a very crucial step in any pattern recognition application. One of the most popular non-parametric techniques is the Nearest Neighbor classification (NNC). NNC asymptotic or infinite sample size error is less than twice of the Bayes error [6]. The basic NNC rule behind these techniques is given by Cover and Hart [5]. NNC gives a trade-off between the distributions of the training data with a priori probability of the classes involved. NNC, where a high number of prototypes make the classifier more (training data) specific and a low number makes it more general [3].

KNN classifier has many advantages. This is easy to compute and very efficient. KNN is very compatible and obtain less memory storage. So it has good discriminative power. KNN is very robust to image distortions (e.g. rotation, illumination). Therefore KNN can provide the components that describe the highest variance and produce good result. So this research can produce good result by combining DiaPCA and KNN (K^{th} nearest neighbor classifier).

Euclidian distance determines whether the input face is near a known face. The problem of automatic face recognition is a composite task that involves detection and location of faces in a cluttered background, normalization, recognition and verification. There have been many methods proposed for face recognition. And one of the key components of any methods is a facial feature extraction. Facial feature could be a gray-scale-image.

6. Experimental Result

The face database contains the 13 individual groups. Within a given database, all weight vectors of the persons within the same age group are averaged together. A range of an age estimation result is 15 to 70 years old, and divided into 11 classes with 5 years old range. The age dependent face recognition system is developed. The age of the input individual is estimated firstly. Then the matched individual is examined from the corresponding age group in face database based on the diagonal PCA Method. Finally, the record of the matched person is extracted. The experimental result can be seen as illustrate in figure 5 including id number, name, NRC no, date of birth and access permission can be seen.

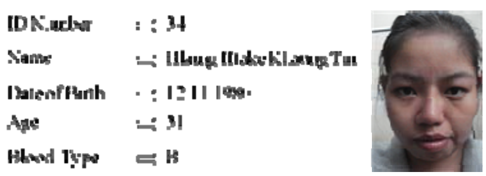

Figure 5. The result of the program

8. Conclusion

The proposed technique so can be used for much real time applications like face recognition in crowded public places, banking, airport, station, highway gate, border trade, etc., dependent age group, The proposed approach will reduced the memory and computation time complexities than instep of using the whole face database.

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