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Evaluation of the Algorithms of Face Identification

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Abstract

The need to identify and discern identities gradually rises in social and economic interactions along with following the rules and other fields. Accordingly, biometric data as basic information of an individual's physical and behavioral features play an important role. This article reviews the duties of face recognition, thence to make a comparison among the function of five face-recognition algorithm, called PCA, ICA, FLDA, Eigen features, and Eigen face, in which the basis for comparing these algorithms was the rate of face identification accuracy. The mentioned algorithms have been analyzed in the databases of ORL, AR, FERET, and YALE. This article shows that ICA Algorithm give better results than the other algorithms in the introduced databases.

Keywords: *Face, ICA, ORL, Identification algorithms, Evaluation*

1. Introduction

Face detection has become such an ordinary task for people that they even do not pay any attention to its frequency during a day. Although researches on automatic face detection began from 1960, this issue has attracted much attention from scientific circles in recent years. Many techniques of face analysis and modeling in the recent decade has improved significantly. Biometrics, which are based on verifying inherent aspects of human nature, are a suitable substitute for most traditional and old methods like passwords. One of the oldest biometric techniques is the identifying fingerprints. Nowadays one of the developed biometric methods is to identify the iris, which is currently in use in some crowded airports in England, Canada, and Netherlands instead of passport. Yet among all popular biometric methods, face detection has a significant status, having in comparison to other biometric methods some advantages that include inherency, no contact, and easy use. Thus its convenience and impalpable use, give it an outstanding advantage compared to other biometric methods. Automatic face detection is employed in different security uses such as access control, verification systems, and security ones.

1.1. Duties of face detection systems

In general identification systems have three major roles:

- Verification (Authentication)
  In such systems we try to answer this question that whether I am who I claim to be. In fact the system matches a person's claim in having an identity with the information existing in the

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system of him, and eventually verifies or rejects the claim in question. In this system an input identity is compared with one, present in the system.

- Recognition (Identification)
  In this system the answer to the question "who am I?" is intended. In other words, the system determines an individual's identity, the face of whom it has received, and in fact identifies the person. In this system an individual's identity is searched in a big group of identified identities within the system.

- Watch List
  In such a system, we try to answer this question that whether a certain individual's identity belong to people who have been watched by the system or not. In fact, an individual is searched in a small group of people, watched by the system. In this system, there is no need for the clarity of the identities of all people, observed by the system; in other words, in the observed list, there exist unknown people as well.

2. Algorithms of face detection

2.1. PCA algorithm

Principal component analysis (PCA), also known as Karhvnen-Loeve conversion, is a linear conversion, extracting the input data's variance. Coordinate system, in which the data are located, is rotated by PCA Conversion so that the initial axis is placed in parallel to the maximum data variance (in one-dimensional imaging). The remaining axes, are regarded as parallel with the maximum data variance one by one until all axes are forced to be placed on previous ones orthogonally. In short, the first axis contains the greatest variance; the second one, greater variance; etc. Fig. 1 shows a two-dimensional example. A non-monitoring method, PCA is a strong tool to analyze the data, especially if they belong to a space with more than three dimensions, the graphical presentation of which would become difficult. One of the major uses of PCA is to decrease the dimensions by losing either no or minimum data differences. Such an ability omits the redundancy or compression of the data in use.

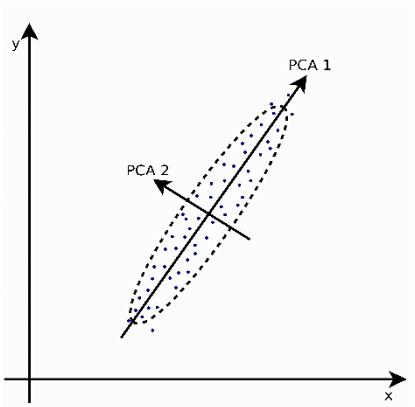

Figure 1: Linear separation axes in PCA

2.2. ICA algorithm

In principal element method, transfer vectors should be necessarily perpendicular, whereas in practice the data distribution might not be so. Independent Component Analysis seeks the best vectors, with the help of which it can model the data distribution and by transferring the data to such vector spaces make them independent. Bartlett et al. suggested two ways to detect faces by means of ICA, the first of which is the independent statistical pictures and the second the demonstration of factorial code. PCA only covers second-degree data, whereas ICA pays attention to higher-degree data as well, identifying independent sources from their linear composition. Therefore, ICA issues a stronger statement of the data in comparison to PCA, releasing an independent statement of them instead of an uncorrelated one of perpendicular vectors.

2.3. Fisher's linear discriminant analysis

Like PCA, FLDA is a linear transformation yet unlike PCA, it is a monitored method which implies that all educational data samples should become relevant through classification. Manually FLDA maximizes the variance between the classes, thus minimizing the inter-class variance in this way. Fig. 2 shows a graphical example of FLDA.

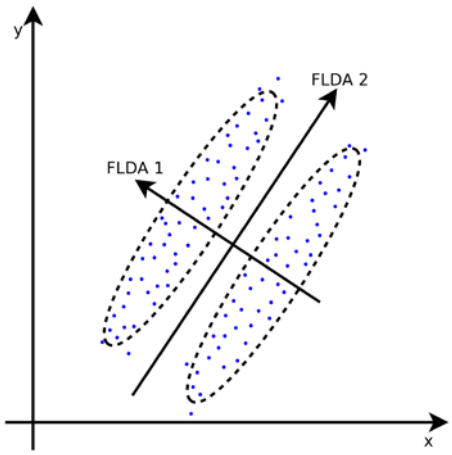

Figure 2: Direction of the increase in variance between the classes and decrease in FLDA changes of the vectors inside the class

2.4. Eigenface

In terms of information theory, when detecting a face the information inside a face's image are extracted and codified with maximum efficiency and afterwards are compared with a database of models, codified similarly. A simple approach to extract the information in a face image is to find differences in the group of face images. Then by using these information one can codify and compare the individuals' face images. In mathematical terms, principal components of faces distribution or specific vectors of covariance matrix of the group of face images behave in a way that an image is regarded as a point in a space with very high dimensions. Eigenvectors can be viewed as a group of features that can determine the difference between face images altogether. Since here eigenvectors concern faces, they are called eigenfaces.

3. Methodology

The article uses ORL, AR, FERET, and YALE databases to evaluate the algorithms of face detection such as PCA, FLDA, ICA, eigenfeatures, and eigenface. The criterion of algorithm evaluation is the accuracy rate in face detection.

4. Face databases

4.1. Introduction

Flexibility of faces as well as its three-dimensional complicated structure causes the face image to differ through various factors such as lighting severity, head angle, face state (laughter, fear, wonder, etc.), time passage, covering, and even hairstyle. Designing face detection algorithms require databases in which images are made ready for analyzing each factor of change with very much scrutiny. Also the researchers need general databases to compare their suggested methods and algorithms with other methods. Apart from improvement in methods and face detection algorithms and in line with it, there have been a growth in face databases. We should keep in mind that though most face databases have been prepared to meet a research team's needs, the importance and position of researches on face detection has led to the preparation of general databases such as ORL, YALE, FERET, AR, etc.

4.2. AR database

AR Database was created in 1998 by machine vision group of Barcelona in Spain, being composed of images from 63 men and 53 women (116 people) which have been demonstrated in Fig. 3.

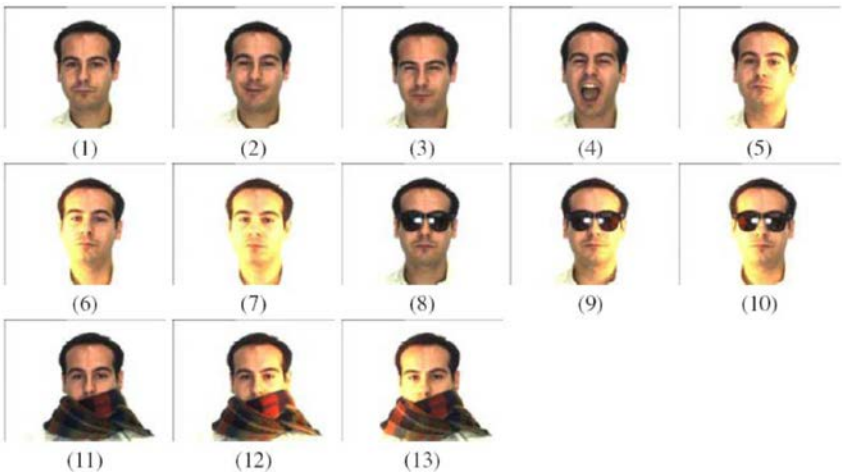

Figure 3: Sample of AR Database

4.3. ORL database

ORL Database was created between 1992 and 1994 by AT&T Institute, containing 400 images, which are brought in Fig. 4.

Figure 4: Sample images of ORL Database

4.4. YALE database

YALE Database is composed of images from 15 individuals in various facial expressions and different lighting conditions which involve from left, right, and environment's light. Among facial expression one can mention laughing, wearing glasses, shocked, blinking, and with eyes closed. Some samples of the images in this database are demonstrated in Fig. 5.

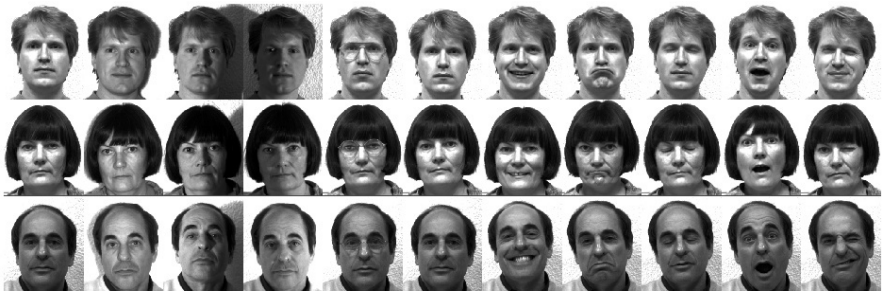

Figure 5: Sample images of YALE database

4.5. FERET database

FERET Database was created between 1993 and 1996 by George Mason University with the assistance of Research Group of US Army, containing 14051 images, brought in Fig. 6.

Figure 5: Sample images of FERET database

4.6. Algorithm analysis by means of databases

Tests on the databases have been carried out in the following five algorithms. Images' size, used in all tests, was 32×32 which was obtained by reducing the size of the original images. Apart from this size reduction there have been no other editing on the images. Table 1 gives the results of the analysis in each algorithm.

Table 1. Comparative study of five algorithm based on detection accuracy

	PCA	FLDA	Eigen face	ICA	Eigen features
FERET	90.23%	91.39%	88%	96.40%	86%
AR	81.60%	90.9%	87.7%	94.00%	80.5%
Yale	91.00%	94.1%	85.3%	99.33%	86.4%
ORL	94.30%	98	87.4%	99.14%	87%

5. Results

By performing different simulations in order to study the efficiency of optimum local basic algorithms in FERET, AR, YALE, and ORL Databases, it was proven that ICA Algorithm has a higher detection quality. Results show that ICA Algorithm in the four introduced databases gives a better outcome than PCA, FLDA, Eigen features, and Eigenface Algorithms.

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