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A Novel Algorithm for Face Detection from Database Matching

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ABSTRACT

Importance of face recognition systems have speed up in the last few decades. A face recognition system is one of the biometric information processing. Applicability is easier and working range is larger than other biometric information processing, i.e.; fingerprint, iris scanning, signature, etc. A face recognition system is designed, implemented and tested in this thesis study. The system utilizes a combination of techniques in two topics; face detection and recognition. The face detection is performed on images without any application field in mind. Processes utilized in the system are white balance correction, skin like region segmentation, facial feature extraction and face image extraction on a face candidate. The system is tested with a database generated in the laboratory. The tested system has acceptable performance to recognize faces within intended limits. System is also capable of detecting and recognizing multiple faces in live acquired images.

Keywords:—*Face recognition system, detection, recognition, skin segmentation, facial feature extraction, Gesture Recognition, Principal Component Analysis.*

I. INTRODUCTION

The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion. Although the ability to infer intelligence or character from facial appearance is suspect, the human ability to recognize faces is remarkable. We can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards or changes in hair style.

Face recognition has become an important issue in many applications such as security systems, credit card verification and criminal identification. For example, the ability to model a particular face and distinguish it from a large number of stored face models would make it possible to vastly improve criminal identification. Even the ability to merely detect faces, as opposed to recognizing them, can be important. Detecting faces in photographs for automating color film development can be very useful, since the effect of many enhancement and noise reduction techniques depends on the image content.

A formal method of classifying faces was first proposed by Francis Galton in 1888 [1, 2]. During the 1980's work on face recognition remained largely dormant. Since the 1990's, the research interest in face recognition has grown significantly as a result of the following facts:

- The increase in emphasis on civilian/ commercial research projects.

- The re-emergence of neural network classifiers with emphasis on real time computation and adaptation,
- The availability of real time hardware
- The increasing need for surveillance related applications due to drug trafficking, terrorist activities, etc.

Although it is clear that people are good at face recognition, it is not at all obvious how faces are encoded or decoded by the human brain. Developing a computational model of face recognition is quite difficult, because faces are complex, multi-dimensional visual stimuli. Therefore, face recognition is a very high level computer vision task, in which many early vision techniques can be involved. The first step of human face identification is to extract the relevant features from facial images. Research in the field primarily intends to generate sufficiently reasonable familiarities of human faces so that another human can correctly identify the face. The question naturally arises as to how well facial features can be quantized. If such a quantization if possible then a computer should be capable of recognizing a face given a set of features. Investigations by numerous researchers [3, 4, 5] over the past several years have indicated that certain facial characteristics are used by human beings to identify faces.

There are three major research groups which propose three different approaches to the face recognition problem. The largest group [6, 7, 8] has dealt with facial characteristics which are used by human beings in recognizing individual faces. The second group [9, 10, 11, 12, 13] performs human face identification based on feature vectors extracted from profile silhouettes. The third group [14, 15] uses feature vectors extracted from a frontal view of the face. Although there are three different approaches to the face recognition problem, there are two basic methods from which these three different approaches arise.

The first method is based on the information theory concepts, in other words, on the principal component analysis methods. In this approach, the most relevant information that best describes a face is derived from the entire face image. Based on the Karhunen-Loeve expansion in pattern recognition, M. Kirby and L. Sirovich have shown that [6, 7] any particular face could be economically represented in terms of a best coordinate system that they termed "eigenfaces". These are the eigenfunctions of the averaged covariance of the ensemble of faces. Later, M. Turk and A. Pentland have proposed a face recognition method [16] based on the eigen faces approach.

The second method is based on extracting feature vectors from the basic parts of a face such as eyes, nose, mouth, and chin. In this method, with the help of deformable templates and extensive mathematics, key information from the basic parts of a face is gathered and then converted into a feature vector. L. Yullie and S. Cohen [17] played a great role in adapting deformable templates to contour extraction of face images.

II. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) is a standard tool in modern data analysis - in diverse fields from neuroscience to computer graphics - because it is a simple, non-parametric method for extracting relevant information from confusing datasets. With minimal effort PCA provides a roadmap for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified structures that often underlie it [6].

It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once you have found these patterns in the data, and you compress the data, i.e. by reducing the number of dimensions, without much loss of information. This technique used in image compression.

PCA is a rather general statistical technique that can be used to reduce the dimensionality of the feature space. The idea behind PCA is quite old. Pearson first introduced it in 1901 as linear regression. Hotelling then proposed it for the purpose of revealing the correlation structures behind many random variables. During the 1940s, Karhunen and Loeve independently extended it into a continuous version by using K-L Transform (KLT).

Given a set of training objects represented by their feature vectors, x_i (1<i<M), where M is the number of samples, the training set can be written as

$$x_m = \frac{1}{M}\sum_{i=1}^{M} x_i$$

$$R_x = \frac{1}{M}\sum_{i=1}^{M}(x_i - x_m)(x_i - x_m)^T$$

The mean vector is a column vector and the covariance matrix is a real symmetric square matrix of size N by N, where N is the length of the feature vector. T defines the transpose of a matrix..The training set X corresponds to a cluster of data points in an N dimensional feature space. There exists redundancy in the feature space since the features, i.e. the dimensions, are not independent of each other. By PCA we can eliminate the redundancy by transforming the original feature space into a so-called PC space in terms of Principal Components (PCs). The transformation is an orthogonal, linear procedure, formalized in the following way:

$$y = W^T x$$

Where y is the new feature vector in the PC space, and W is defined as follows:

$$W = [e_1, e_2, \dots, e_N]$$

e_i is the ith Principal Component (PC), or the orthonormal basis, of the feature space. All PCs have to be normalized, that is, $e_i^T e_i$ **=I.** The dimensionality of the PC space is still N, the same as that of the original feature space. However, the correlation between the features disappears. Thus by the transformation we map a feature vector from the original feature space into the PC space as a single isolated point where the basis are independent from each other.

No information is lost during this transformation. The original feature vector can be fully reconstructed using the transpose of the PCs:

$$x' = Wy = WW^T x$$

Where x' is the reconstructed image. Since there is no loss of information, x' = **x.** The question is now how to find the PCs? Various methods have been developed. For example simple neural network architectures have been suggested for recursively estimating the subsets of the PCs. However, the most widely used method is to take advantage of the covariance matrix of the feature values of the training set and solve the eigenvalue decomposition problem. Given the mean vector $\mathbf{x_m}$ and the covariance matrix $\mathbf{R_x}$ of a set of training samples, the eigenvalue decomposition problem is to find the solution for the following equation:

$$R_x e_i = \alpha_i e_i$$

Where, α_i is the eigenvalue corresponding to the ith PC. This solution can be found by solving its characteristic equation. Since $\mathbf{R_x}$ is positive, all eigenvalues would be non-negative real numbers.

For an N by N covariance matrix, N eigenvalues and N PCs exist. In the PC space, the data lies on a low dimensional subspace because of the correlation between the features, i.e. the data variation focuses only on some of the dimensions while the variation along the remaining dimensions is almost zero. Given the fact that each eigenvalue represents the data variation along its PC, those eigenvalues corresponding to the small data variation are close to zero. If we arrange the eigenvalues in decreasing order, y can be represented in acompact way by maintaining only the PCs corresponding to the first few largest eigenvalues while ignoring the rest. That is, the feature vector y is computed in the following reduced way:

$$y = W_c^T x = [e_1, \dots, e_k]^T x$$

Where, W_c is the matrix that contains only the first K PCs. K is the number of PCs that are retained and e_1 is the largest eigenvalue, e_2 is the second largest eigenvalue, and so on. Usually K<<N, and the dimensionality is reduced from N to K. The reconstruction of the original feature vector is given by:

$$x' = W_c y = [e_1, \dots, e_k][e_1, \dots, e_k]^T x$$

IV. Implementation And Results

Database of eight test images of 80x60 pixels has been taken under consideration. Similarly, Database containing the concerned people in different gesture has been developed.

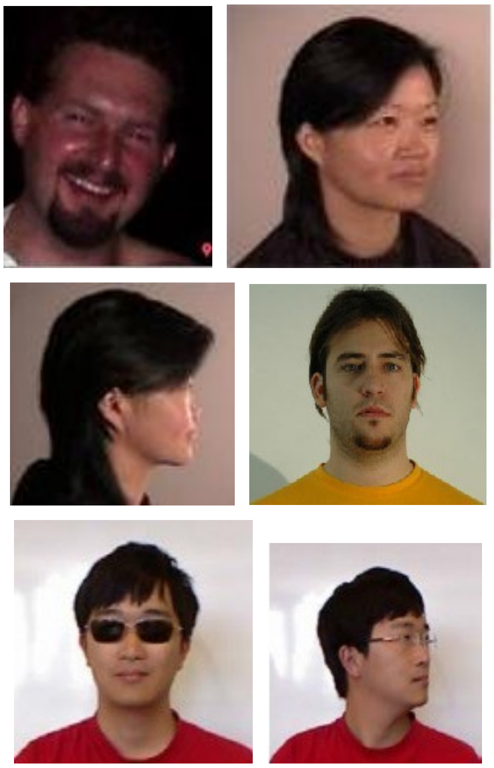
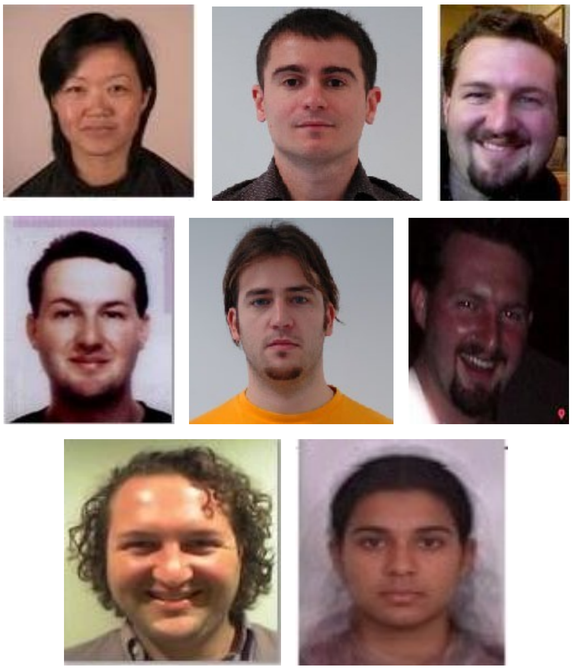


Figure 1:-Eight Test Image for facial matching



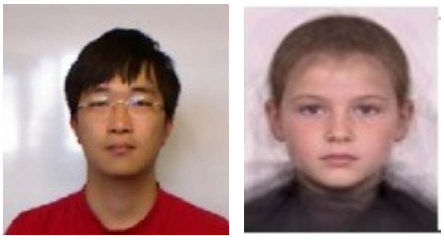


Figure 2:-Database of ten images for test image matching

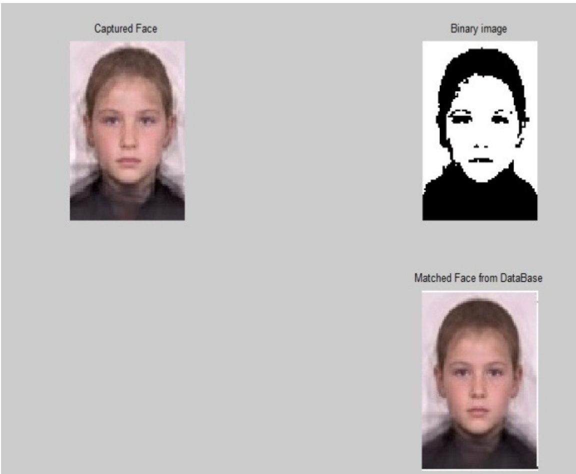


Figure 3:- Result 1

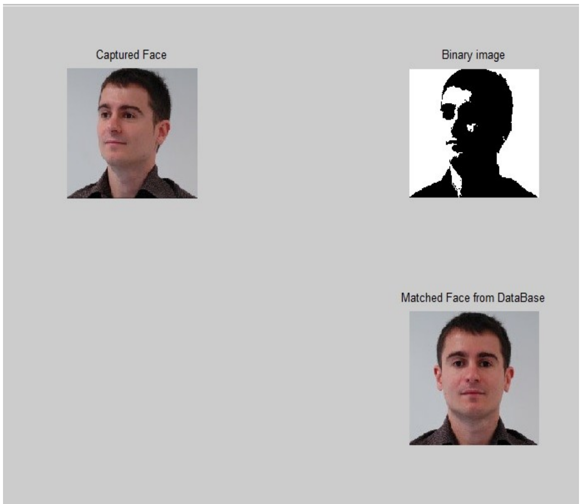


Figure 4:- Result 2

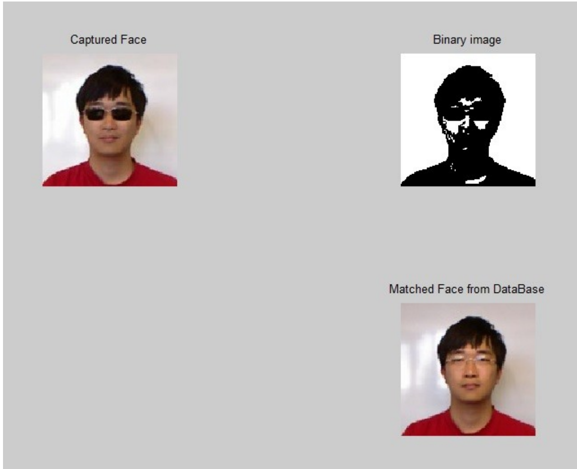


Figure 5:- Result 3

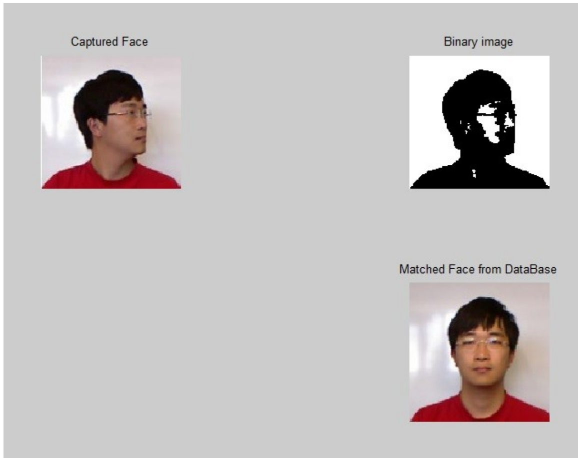


Figure 6:- Result 4

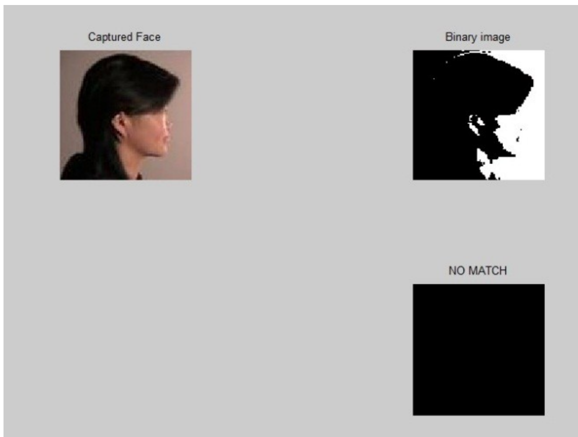


Figure 7:- Result 5

The procedure of matching faces by this algorithm is as follows:-

- In the first step user selects a training image from the database of test images.

- In second step, after running the algorithm, it extracts the feature all details of the image, like colour tone, gesture, contrast, position of face part etc.
- In the third step, the binary image based on extracted inmoamation is generated.
- In the fourth step, the algorithms search for the matching image from the database of different images. Depending upon the parameters like threshold variation from 10-100 the selection detepnds.
- These steps can be understood by the obtained results figure-1 to figure-5. As it can be seen that in first four results a face from database is matched corresponding to test image. The reason is in the test images taken in the first four observations have clear recognition of facial details. But in the fifth observation the test image is side view and one can extract minimal facial details. As a result in constructed binary image because of the unavailability of required details the result was no face matched.

VIII. CONCLUSION

The results can be altered by varying the threshold for 10 to 100. This variation declares the selectivity of user on the basis of details of images. More harsh the threshold would be precise would be the result. Future scope of this work is next the system can be developed with webcam and an android device. This system could be useful for a deaf and dumb person carrying an android device or a system connected with webcam. Database of sign gesture is stored into binary form of size 60X80 pixels so that it takes less time and memory space during pattern recognition.

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