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Abstract

The accuracy of any face recognition is important for many military and civilian real time applications. Based on current literature it has been proven that, the accuracy of a face recognition system can be extremely improved using a hybrid feature extraction technique. This paper presents a hybrid feature extraction technique to obtain high level of recognition accuracy. The facial topographical features are extracted using manual segmentation of facial regions of eyes, nose and mouth. The Gabor transform of the maximum of these regions are then extracted to calculate the local representations of these regions. In the classification stage, the Nearest Neighbour method (KNN) is exploited to calculate the distances between the three regions feature vectors and the corresponding stored vectors. The system results in excellent recognition accuracy using faces94, FEI and ORL databases. It is observed that, high recognition accuracy rate can be obtained when the facial images are taken carefully with front pose and with only slight expression changes. The future work will be on implementing this system in a FPGA device for a real time application such as a door access control system.

Keywords

extraction, feature, recognition, hybrid, face, technique

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A Hybrid Feature Extraction Technique for Face Recognition

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Abstract. The accuracy of any face recognition is important for many military and civilian real time applications. Based on current literature it has been proven that, the accuracy of a face recognition system can be extremely improved using a hybrid feature extraction technique. This paper presents a hybrid feature extraction technique to obtain high level of recognition accuracy. The facial topographical features are extracted using manual segmentation of facial regions of eyes, nose and mouth. The Gabor transform of the maximum of these regions are then extracted to calculate the local representations of these regions. In the classification stage, the Nearest Neighbour method (KNN) is exploited to calculate the distances between the three regions feature vectors and the corresponding stored vectors. The system results in excellent recognition accuracy using faces94, FEI and ORL databases. It is observed that, high recognition accuracy rate can be obtained when the facial images are taken carefully with front pose and with only slight expression changes. The future work will be on implementing this system in a FPGA device for a real time application such as a door access control system.

Keywords: Gabor, Local Feature, Nearest Neighbour, ORL, Face Recognition

1. Introduction

An accurate face recognition system is high in demand and important to determine the success of many applications in computer vision, pattern recognition, artificial intelligence and machine learning. As one of the most prominent biometric identification techniques, face recognition has robustness against drawbacks of non biometrics (password or access cards) which are susceptible to rigging and theft issues. Recently, face recognition research has become widespread for user identification due to its non-invasive use of simple cameras without annoying the public. The typical Face Recognition System has three phases: face detection, feature extraction and face identification (classification). The face detection phase can be described as the process that applied to the input image to detect whether there is a face or not. Feature extraction phase extracts data of some features in the detected face such as mouth, nose and eyes and relative distance between them to build a potentially unique dataset. This data is used to develop feature vectors for identification stage. In order to improve the accuracy of a face recognition system, the type of feature extraction algorithm has to be robust against environmental issues such as illumination pose and expression changes. Many algorithms have been proposed to deal with feature extraction tasks and generally, these algorithms can be divided into: holistic-based algorithms, local-based algorithms and hybrid-based algorithms. Based on the previous literature, the Hybrid-based techniques are extremely superior to Holistic and the Local approaches in terms of face recognition accuracy. Fewer studies [1] , [2], [3], [4] have been conducted on hybrid face recognition system and most of them have not used the Local representations to extract the facial feature which are desirable for their robustness against localized regions variations. One hybrid –based feature extraction technique was proposed by [2] which consist of a combination between LBP and Dual-Tree Discrete Wavelet Transform (DT-DWT) methods and Euclidean distance for

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identification on JAFFE [5] and L-Spacek [6] databases obtaining a recognition accuracy of 100% and 98.4% respectively. However, the computational time in this method is not mentioned and could be huge which is not acceptable for real time systems. The compensation of principle component analysis (PCA) and central moment, eigenvector and eyes , nose and mouth standard deviation was employed by [4]. This approach developed a hybrid face recognition system and this system obtaining an acceptable recognition accuracy of 97%. In this method a database of 120 images from 8 people was built at different pose, illumination, sizes and distance to the camera. However, this method required numerous pre-processing operations to remove noise, histogram normalization and illumination normalization. The method of independent component analysis (ICA) was combined with Gabor filter by [7] to build IGF hybrid feature extraction method. The Probabilistic Reasoning Model (PRM) classification method was also used for identification purposes and the system obtained a recognition accuracy of 98.5% on FERET database [8] and 100% on ORL database [9]. The purpose of this paper is to propose a Hybrid face recognition system using local representation techniques. The feature extraction stage in the proposed system is based on the Local Features of three main holistic regions (Eye, Nose and Mouth) using Gabor filters. The rest of this paper is formed as follow: section 2 contains a brief discussion about the proposed algorithm; in section 3 the experimental results are presented; and then in section 4, the paper is concluded.

2. Features selection and extraction

In the proposed algorithm, the topographical features are extracted from the regions of the eyes, nose and mouth as shown in Fig.1. The maximum Intensity of these regions are calculated after convolving them with Gabor filters of 40 different scales and orientations Using the two dimensional convolution

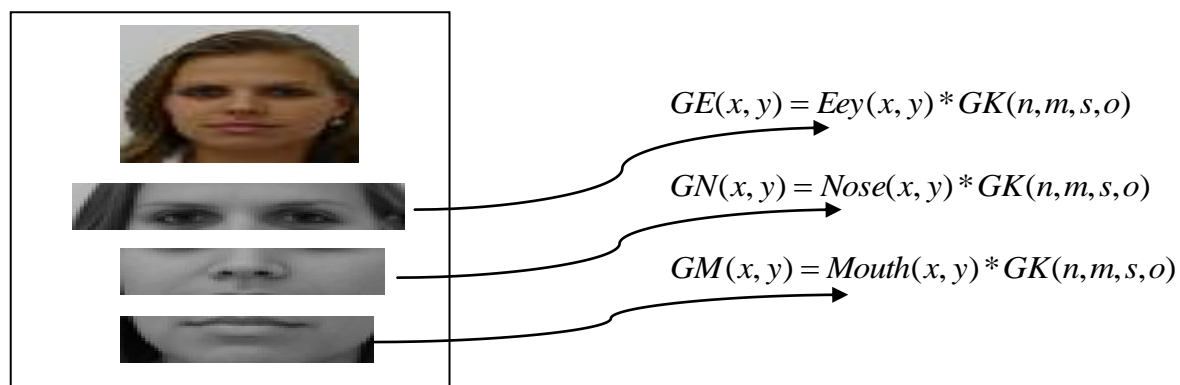


Fig. 1: Facial Image (top) and Three segmented regions

Where $*$ is the sample of convolution operator and the Gabor Kernel is calculated using the following equation:

$$GK(n, m, s, o) = \frac{1}{\delta^2} \left| \frac{k_{\max} * e^{\frac{j\pi s}{8}}}{f^2} \right|^2 * \exp \left[-\frac{\left| \frac{k_{\max} e^{\frac{j\pi s}{8}}}{\delta^2 f^2} \right|^2 * (n^2 + m^2)}{2\delta^2} \right] * \exp \left[-\left| \frac{k_{\max} e^{\frac{j\pi s}{8}}}{f^2} \right|^2 * (n, m) \right] - \exp \left[\frac{-\delta^2}{2} \right]$$

Where (n, m) are the kernel window dimensions $s \in [0,1,2,3,4]$ and $o \in [0,1,2,3,4,5,6,7]$ are the scales and the orientations of the Gabor kernel. The (k_{\max}) is the maximum frequency, f is spatial

frequency between the frequency domain kernels and δ is the standard deviation of the Gaussian in the kernel window. In this study these parameters' values chosen to be $k_{\max} = \pi/2$; $f = \sqrt{2}$; $\delta = \pi$.

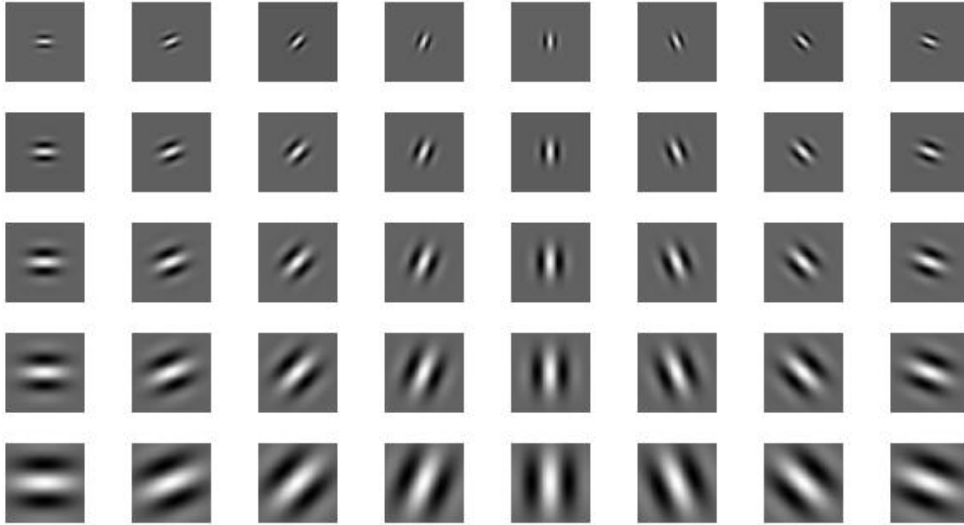


Fig. 2: 40 different scales and orientations of Gabor filters

A set of feature points from each region's Gabor filter at location with the maximum intensities values are calculated. These points are put in the following three matrices where each column represents one feature points of one Gabor Scale and one orientation of each region:

$$GE = \begin{bmatrix} E_{1,1} & E_{1,2} & \dots & \dots & E_{1,40} \\ E_{2,1} & E_{2,2} & \dots & \dots & E_{2,40} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ E_{n,1} & E_{n,2} & \dots & \dots & E_{n,40} \end{bmatrix}; \quad GN = \begin{bmatrix} N_{1,1} & N_{1,2} & \dots & \dots & N_{1,40} \\ N_{2,1} & N_{2,2} & \dots & \dots & N_{2,40} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ N_{n,1} & N_{n,2} & \dots & \dots & N_{n,40} \end{bmatrix}; \quad GM = \begin{bmatrix} M_{1,1} & M_{1,2} & \dots & \dots & M_{1,40} \\ M_{2,1} & M_{2,2} & \dots & \dots & M_{2,40} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ M_{n,1} & M_{n,2} & \dots & \dots & M_{n,40} \end{bmatrix}$$

Then the dimensionality is reduced by selecting only the maximum of these values. The Euclidean distance is also exploited to find the distances between these three regions. In the classification stage, the Nearest Neighbour technique is exploited to calculate the vector that hold the nearest distances between the three regions feature vectors or the distances between these regions and the corresponding values from the stored data.

3. Experimental Results

In this study, the ORL database which is one of the most extensive and a popular database of faces is used for training and testing the face recognition algorithm. This database is chosen because of its various instances of frontal views for each subject with slight changes in facial expression, facial details and some side movements. There are a total of 400 images for 40 people; each person has 10 images with different pose and expression changes. In this experiment, only 5 images from each person are trained and the remaining five images are used for the testing part. In addition to ORL database the FEI and the face94 databases are exploited to make the testing stage more robust by selecting groups of images from each database. FEI was developed by Artificial Intelligence Laboratory of FEI in São Bernardo do Campo, São Paulo, Brazil. FEI database consists of frontal facial normalized frontal pose facial images with constant illumination of 100 people for different expression changes (with and without smile). In this experiment, images without smile are trained and the images with smile are tested for various groups of individuals. The

face94 database is also used as it consists of frontal images for different genders clustered into two groups (male and female). It has a total of 153 individuals with very little head pose, tilt and slant variations with no lightening variations which is useful in some real time applications such as door access control system. In this experiment, only four images for each person are trained and the rest are kept for the testing part. Each group of the above databases are trained based on the region that selected from the face such as Eye, Nose and Mouth regions (Fig.1) or the distance between these three regions using the Euclidean distance. In the classification part, the nearest neighbor method is exploited and the results are shown in table 1.

Table 1: the results of applying the proposed algorithm on different regions of images

	FEI	Face94	ORL
<i>Eey Region</i>	97%	98.88%	87%
<i>Nose Region</i>	85%	100%	77%
<i>Mouth Region</i>	70%	97.77%	78%
Distance(<i>Eey - Nose</i>)	74%	90%	83%
Distance(<i>Eey - Mouth</i>)	72%	93%	73%
Distance(<i>Nose - Mouth</i>)	76%	95.5%	75%

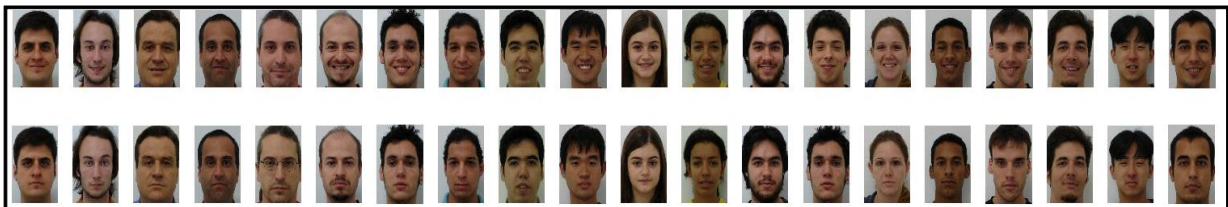


Fig. 3: the results of input images (lower part) and the output images (above part) from FEI database using Eye region

For comparison purposes, the results related to current study and the previous techniques are provided in Table 1. It was reported that the use of Gabor filter and the maximum intensity points technique in [10] could obtain a recognition accuracy of 94 % using a group of 70 images from faces94 database. In contrast, the proposed method of selecting a region of interest is shown to be more robust to obtain higher recognition accuracy especially for the Eyes region or the Nose region which is obtained excellent recognition accuracy over the same database (faces94). This recognition accuracy is the same as what was obtained by [7] who exploit the Gabor filter and ICA techniques using images with high resolution and frontal pose only from ORL database or LFA technique in [11] who used images from ORL database and selected a large number of features of 88 which is expensive in case of applying this algorithm in a hardware device for real time application such as door access control system. However, the proposed algorithm is expected to be faster and require lower storage memory than those in [7] and [11] which is necessary for the hardware implementation.

Table. 2: the face recognition accuracy for the currant and some previous techniques that used the ORL

The face recognition techniques	Recognition Accuracy	Facial database and notes
The proposed technique for one selected region(Nose Region)	100%	Faces94 database[12]
Gabor + ICA [7]	100%	ORL (88 features)[9]
EBGM [10]	94.29%,	face94 [12]
LFA [11]	100%	Images with high resolution and frontal pose only from ORL[9]

4. Conclusion

A Hybrid feature extraction technique for a face recognition system is proposed and good recognition accuracy is obtained. Based on the results, it can be observed that, high recognition accuracy rate can be obtained when the facial images are taken carefully with front pose and with slightly expression changes. The future work will be on implementing this system in a FPGA device for a real time application such as a door access control system.

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