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Research Article

Binary Multiresolution Wavelet based Algorithm for Face Identification

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Abstract

A binary multiresolution wavelet based framework for face identification is presented in this paper. This paper proposes the feature extraction algorithm based on multiresolution information of face. Proposed feature extraction algorithm extract discrete wavelet transform based binary features to represent face images.DWT plays very important role in efficient feature extraction which results in the high recognition rates. Face images are decomposed upto fifth level using wavelet transform. After wavelet decomposition detail coefficients are coded in binary form. Hamming distance classifier is used for binary feature classification. Experimental results show the promising performance of the proposed technique on three face databases: ORL, JAFFE, IIT female database. Proposed wavelet based algorithm also causes reduction in feature vector size. The algorithm has successfully handled pose variances, expression variations, lightning condition variation. We have achieved recognition rate of 95% for ORL database, RR of 97.77% for JAFFE database and RR of 89.28% for IIT female database .The results of experiments with arbitrary variations in lightning, expression, poses and backgrounds show that the proposed methodology has proven to be promising technique

Keywords: *Multiresolution, wavelet transform, binary, face recognition.*

1. Introduction

Face recognition is becoming very popular technology from last few decades.(Rama,2002)(W.Zhao,*et al*,2003)The importance of utilizing biometrics to establish personal authenticity and to detect impostors has grown in the present scenario of global security concern. Biometric identification represents efficient technology as it is doesn't depend on knowledge from subject for its use. There is lot of increase in use of circuit television (CCTV) applications and other forms of surveillance applications. These applications act as smart methods to effectively recognize and authenticate persons within clip. Some applications can also require to identify features of the subjects, gender, ethnicity, age, etc. The Designing of algorithm for face recognition system is very difficult and complicated problem because probe face images are having lot of variations and may be located in a different changed environment. Face recognition performance is limited due to the wide variety of illumination, facial expression and pose variations, lightning conditions, ageing, disguises such as slight cut, glasses or makeup. These problems cause degradation in performance of face recognition system. Performance of face recognition can be excelled with selection of suitable and distinct features to represent a face under environmental, pose, expression, background changes. This paper proposes a new approach based on binary multiresolution wavelet transform algorithm. Multiresolution information is determined using discrete Wavelet transform. Face images are represented in terms binary coded wavelet coefficients which allows an approach for pose and expression invariant face recognition. Face images are decomposed by application of discrete wavelet transform. Further in order to capture better multiresolution information in face images, each face image is described by a subset of wavelet coefficients obtained from sub-band face images. The overall features of an image at each resolution are obtained through fusion of the coded detailed sub bands. Using these fused sub band coefficient, we extract compact and meaningful, distinct feature vectors. We can determine feature variance of these fused feature vector.

The present research work aims at development of robust feature extraction algorithm for identification of face images. Wavelet transform based feature extraction algorithm and coding of wavelet coefficients results in significant reduction in feature vector.

2. Related Work

Most research on face recognition falls into two main categories (Chellappa, *et al*., 1995): feature-based and holistic. Geometric approaches dominated in the 1980's where simple measurements such as the distance between the eyes and shapes of lines connecting facial features were used to recognize faces, while holistic methods became very popular in the 1990's with the well known approach of Eigen-faces .Feature-based approaches to face recognition basically depend on the detection and characterization of individual facial features and their

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geometrical relationships. Such features generally include the eyes, nose, and mouth. The detection of faces and their features prior to performing verification or recognition makes these approaches robust to positional variations of the faces in the input image. From the methods that are appearance based, Principal Component Analysis (PCA) which is also known as Eigenfaces (Turk, *et al*,1991)(G. Shakhnarovich ,*et al*,2004) has been very popular and has been shown to be very effective. Some of these techniques use feature extraction using Gabor wavelets (G. Wang, *et al*, 2006) (K. Vinay, *et al*,2006). Another method of feature based face recognition is based on using Scale Invariant Feature Transform (SIFT) (M. Bicego,*et al*,2009)(A. S. Mian,*et al*,2007) and was adapted from the broader application of object recognition using SIFT.(Lowe 2004). Gabor wavelet-based face feature representation provides an excellent methodology for design of robust face recognition system. For this reason, Gabor wavelets are most commonly used approach for development of face recognition system(Chengjun Liu,*et al*,2003)(Wenchao Zhang,*et al*,2005)(L. Shen,*et al*,2007)(Al-Amin Bhuiyan,*et al*,2007).Gabor wavelet-based face feature extraction algorithm is very efficient. Still it has two important limitations, it is computationally very complex and multiscale multidirectional approach results in increase in processing time and also memory requirements. For an input image of size 128x128 pixels, size of the Gabor feature vector will be equal to 655360 pixels for 8 directions and 5 scales representation. Several approaches based on wavelet transform have been proposed in the recent years to address the problem of face recognition (L. Bai , *et al*, 2003) (R. M. Ramadan, *et al*, 2009), (P. D. Wadkar.*et al*, 2012).

3. Proposed Work

We have proposed a novel feature extraction approach using wavelet transform features. In this we have performed multiresolution analysis of face images. These multiresolution sub-band images are represented in feature vector. Data compression is very much essential for computer signal processing. Transforms play a very important role in the signal and image processing areas (Ziad m. Hafed,*et al*,2001).A transform is a mathematical operation which is applied to a signal that is being processed converting into different domain and then again is converted back to the original domain. These transforms generate a set of coefficients from which it is possible to restore the original samples of the signal. A mathematical transform has an important property: when applied to a signal, i.e., they have the ability to generate decorrelated coefficients, concentrating most of the signal's energy in a reduced number of coefficients (Derzu Omaia.*et al*, 2009).

3.1 Wavelet Transform

Wavelet transform provides powerful signal analysis tools, which is widely used in feature extraction, image compression and de-noising applications. Wavelet decomposition is the most widely used multi-resolution technique in image processing. Due to the excellent time-frequency localization characteristic, Wavelet transform provide a powerful mathematical tool (Yong Chen,*et al*,2008).Images have typically locally varying statistics that result from different combinations of abrupt features like edges, of textured regions and of relatively low-contrast homogeneous regions. While such variability and spatial non-stationary defies any single statistical characterization, the multi-resolution components are more easily handled. Wavelet transform can be performed for every scale and translation, resulting in continuous wavelet transforms (CWT), or only at multiples of scale and translation intervals, resulting in discrete wavelet transform (DWT). Since, CWT provides redundant information and requires a lot of computation, generally DWT is preferred. The two-dimensional wavelet transform is performed by consecutively applying one-dimensional wavelet transform to the rows and columns of the two-dimensional data [H.Ekenel, *et al*, 2005]. DWT provides simultaneous spatial and frequency domain information of the image. In DWT operation, an image can be analyzed by the combination of analysis filter bank and decimation operation. The analysis filter bank consists of a pair of low and high pass filters corresponding to each decomposition level.The low pass filter extracts the approximate information of the image whereas the high pass filter extracts the details such as edges. The 2D transform is obtained from two separate 1D transforms. The implementation of wavelet transform is very similar to that of sub band coding scheme as shown in figure 1.

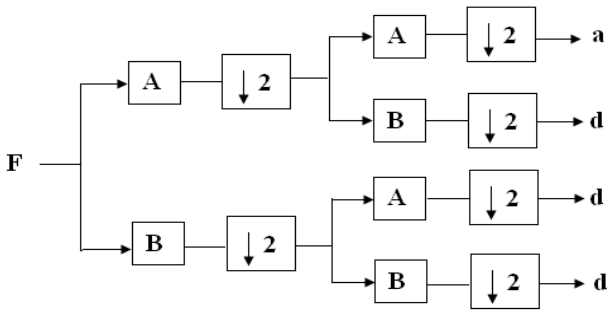


Fig.1 Wavelet Transform Sub-band Coding

We can illustrate working of wavelets with a simple example. Assume we have a 1D image with a resolution of four pixels, having values [9 7 3 5]. We can represent this image using wavelet transform by applying wavelet. Suppose Haar wavelet basis is used to represent this image. To do this, first average the pixels together, pair wise, is calculated to get the new lower resolution image with pixel values [8 4]. Clearly, in this averaging process some information is lost. We need to store some detail coefficients to recover the original four pixel values from the two averaged values. In our example, 1 is chosen for the first detail coefficient, since the average computed is 1 less than 9 and 1 more than 7. This single number is used to recover the first two pixels of our original four-pixel image. Similarly, the second detail coefficient is -1, since 4 + (-1) = 3 and 4 - (-1) =5. Thus, the original image is decomposed into a lower resolution (two-pixel) version and a pair of detail coefficients.(Marc Antonioni ,*et al*,1992)Repeating this process recursively on the averages gives the full decomposition of image as shown in table 1.

Table 1: Decomposition to lower resolution

Resolution	Averages	Detail Coefficients
4	[9 7 3 5]	
2	[8 4]	[1 -1]
1	[6]	[2]

3.2 Proposed Feature Extraction algorithm

The proposed technique is a four step procedure; (1) In first step we preprocess image to resize it fixed dimension. (2) In second step face images are decomposed at multiple level using Discrete Wavelet Transform (3) In the third step discrete wavelet transform features are fused together (4) In the fourth step multiresolution wavelet information is coded in binary form. Block diagram of proposed method is as shown in figure 2.

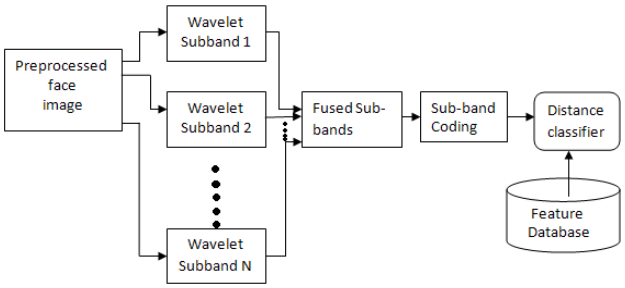
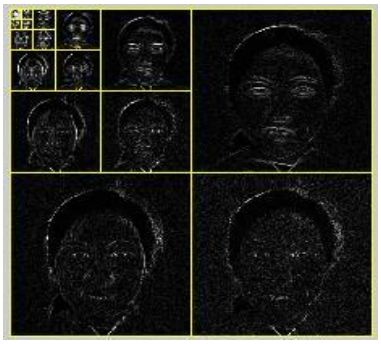


Fig.2 Block Diagram of proposed method

Proposed method performs multilevel wavelet decomposition of original face image. Detail coefficients obtained from multilevel wavelet transforms are fused together. Details coefficient carry structural details about image at various levels of decompositions. These detail coefficients are as shown in figure 3.

(3a)



(3b)

Fig.3a) Original Face image **b)** Fifth level wavelet decomposition

Fused detail coefficients are represented in terms binary form. If wavelet detail coefficient value is positive then it is coded as 1 otherwise 0.Binary encoding of wavelet coefficients causes significant reduction in feature vector size and memory requirement.

4. Template Matching

Statistical classifiers based template matching is most commonly used approach because of their simplicity. The classification step in face authentication system can be viewed as feature matching process between features of query face image and the fused feature vector saved in the database. Proposed algorithm uses hamming distance as a classifier to find similarity score in between fused feature vector of query and fused feature vector from database. Fused feature vector obtained from handwritten signature images and iris comprises 1's and 0's.So hamming distance is used to calculate distance between training images and testing images. The Hamming distance (HD) between two Boolean vectors can be defined in equation 1 as follows (C. Daugman, 1996)

$$Hamming\ Distance = \frac{1}{N}\sum_{j=1}^{N} H_A\,(j) \oplus H_B\,(\mathrm{j}) \qquad (1)$$

5. Discussion of the Proposed Face identification systems and Experimental Results

5.1. ORL

The ORL database (ORL Database 1992) of faces is composed of 400 grayscale images of size 112×92 pixels corresponding to 40 distinct individuals. It consists of 10 images of each individual taken in various sessions varying the lighting, facial expressions (open/ closed eyes, smiling/ not smiling)and facial details (glasses/ no glasses); taken against a dark homogeneous background in an upright, frontal position(with tolerance for some side movement).Sample images from database are as shown in figure 4.

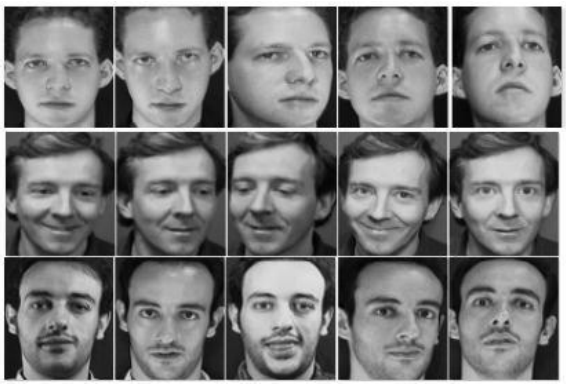


Fig.4: Faces from the ORL Database

5.2 JAFFE

JAFFE database (JAFFE database, 1998) consist of 213 images of 7 facial expressions (6 basic facial expressions +

1 neutral) posed by 10 Japanese female subjects. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects. Sample images from jaffe database are as shown in figure 5.

Fig. 5: One female from the JAFFE Database

5.3 Indian Face Database

This database (IIT database, 2002) contains a set of 11 different face images of 40 male and female subjects taken in February, 2002 in the IIT Kanpur campus. All the images were taken against a bright homogeneous background with the subjects in an upright, frontal position. The size of each image is 640x480 pixels, with 256 grey levels per pixel. The following orientations of the face are included: looking front, looking left, looking right, looking up, looking up towards left, looking up towards right, looking down. Available emotions are: neutral, smile, laughter, sad/disgust.IIT Female face database has been used for evaluation of proposed algorithm. Sample images from IITF female database are as shown in figure 6.

Fig. 6: One subject from Indian face database

Results

For evaluation of proposed methodology we have carried out experiments on three standard databases ORL, JAFFE, and Indian Face database. Result of proposed binary wavelet based face recognition system is shown in table 2.

Table 2: Results on expression and Pose invariant face recognition

Database	Feature Vector size	No. of training images	No. of testing images	Recognition Accuracy
ORL	666	6	4	95%
JAFFE	1008	6	9	97.77%
IIT Female	1008	7	4	89.28%

Conclusions

In this paper, a novel binary multiresolution wavelet based face recognition system is presented. A 2D-DWT based face feature extraction scheme is proposed for face recognition. The feature set of a face, is supposed to represent global attributes of the face whereas face is considered purely as a image. In proposed method we have used fifth level multi-resolution dwt features. This paper has also evaluated the performances of the wavelet based approach in terms of normal and changes in perspective and facial expressions faces of Jaffe, Indian face dataset and ORL datasets The principle contributor for higher accuracy in the proposed face identification systems has been wavelet based feature extraction algorithm which has played an important role in finding significant intensity changes. Successful attempt has been made to equally handle all image variations (pose, lightning, expression and background).In our approach, face structural information is represented in terms of binary data. The recognition is done on the basis of hamming distance classifier. The experimental results show that the proposed algorithm has achieved maximum accuracy of 97.77% on expression variation of subset of JAFFE database. Also we have got good results on ORL database as 95% and Indian face database with different orientations as 89.28%.Proposed method allows for significant reduction in dimensions of feature vector with the help of DWT and binary encoding algorithm. With the help of other classifiers like SVM instead of hamming classifier, the results are expected to improve further. In future also we can apply algorithm for further reduction of feature dimension.

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