

Face Recognition Analysis Using Multilevel Wavelet Based Coefficients

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ABSTRACT: Over the past few years, due to the perfect security control requirements of the world the user authentication is very important at every place. Initially Identity cards and passwords were mostly used for authentication and security was not that reliable. Now a days new authentication techniques based on biological factors like voice, iris, fingerprint, palm print, and face are in major use. Face recognition is a friendly way for authentication because it can be done without interrupting the user activities .But due to large variation in the human face because of light effects and expression reduces the recognition capability of the system. One method is to collect a number of images(prototype images) covering all possible variations. But, large memory occupied by the prototype images and computation requirements make it difficult to be used and implemented practically. Therefore to develop a small-training face recognizer to which is independent of environmental changes is a difficult research problem. In this paper the focus is given on determination of identity of the person using unknown test image, from a set of previously known faces stored in the database.

KEYWORDS: Face Recognition , Biometric ,Multilevel wavelet, Image processing

I. INTRODUCTION

In today's environment with increased importance of security and organization, identification and authentication methods have developed into a key technology in various areas, several systems require authentication before giving access to certain resources[2]. Such requirement for reliable personal identification in computerized access control has resulted in an increased interest in authentication issues. There are three different types of authentications. The first one was based on a password, a PIN second was a card key, a smart card and third one was biometric. Among these, a biometric is the most secure authentication tool because no other person can steel it, borrow and there is no chance of forging[5]

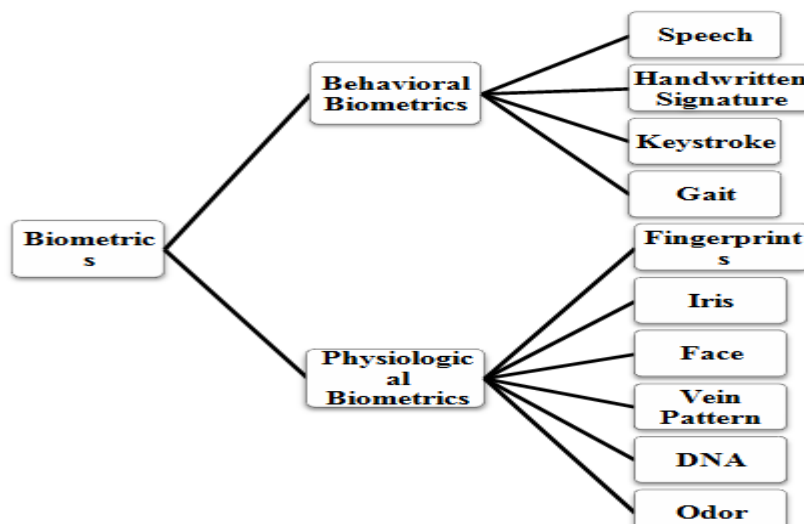


Fig. 1: Classification of common Biometrics [16]

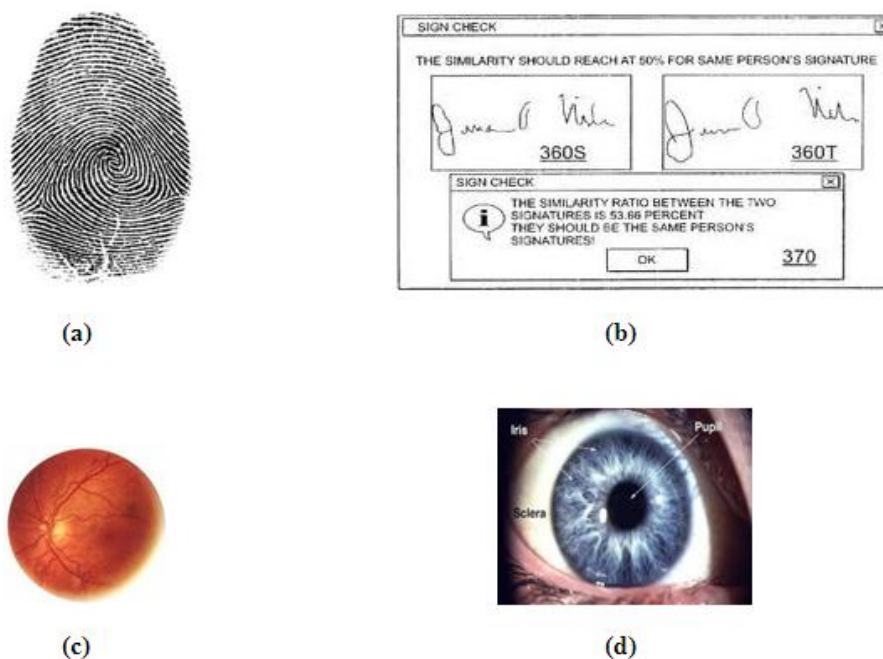


Fig. 2: Some Examples of Biometrics (a) Fingerprints (b) Signature (c) Retina (d) Iris

The necessity for personal identification in the fields of private and secure systems made face recognition one of the main fields among other biometric technologies. The importance of face recognition rises from the fact that a face recognition system does not require the cooperation of the individual while the other authentication systems need such cooperation [7]. One of the newest biometric technologies, automatic facial recognition, is based on this phenomenon

II. PROBLEM FORMULATION

The problem of face recognition is completely different from that of face detection, as the task of face detection, is to report the location, and typically also the size of all the faces present in a given image. The system for face detection, works on faces from an uncontrolled environment. But on the other hand, the field of face detection is a fundamental part of many face recognition systems, due to its ability to focus computational resources on the part of an image containing a face. In other words, face recognition system is the next step of a face detection system. The task of detecting and locating human faces in arbitrary images is complex due to the variability present across human faces, including skin color, pose, expression, position and orientation, and the presence of 'facial furniture' such as glasses or facial hair. Differences in camera gain, lighting conditions, and image resolution further complicate the situation. [13]

The basic process of face recognition constitutes of two phases. In the first phase, the feature vectors are prepared on the training samples, and in the second phase, a classifier is applied on the prepared features and the test image given by user to find the identity of the person. The first phase may also contain more than one algorithm for the preprocessing upon the prototype faces to generate the feature vectors in a low dimensional space. In the first phase, multilevel wavelet transform is applied on training data for the purpose of dimensionality reduction [6].

The purpose of this technique is to highlight fine details in an image or to restore, at least partially, details that have been blurred either in error or as a consequence of a particular method of image variations. The wavelet transform for face recognition uses directly wavelet coefficients as features. The wavelet transform can locally detect the multiscale information of facial images, the coarse information exists in the lowest spatial-frequency Subband called approximation coefficients, while finer edge information presents in the higher spatial-frequency subband those are

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known as detail coefficients.. After that further dimensionality reduction is done by Linear Discriminant Analysis (LDA) then feature vectors are prepared and are ready to be used by the next phase. The classifier designed is the nearest neighbor classifier, it report with the class which is nearest to the test image as its identity.

III. IMPLEMENTATION AND METHODOLOGY

There are a number of techniques that can be used to design a face recognition system. From those the Linear Discriminant Analysis (LDA) which is a type of Linear Appearance based face recognition technique, is implemented in this thesis. Before performing LDA a multilevel wavelet transform is applied on the data matrix. The main purpose of applying wavelet transform is to reduce the dimensionality of the input data samples so that the extracted feature is as representative as possible. Another purpose of the wavelet transform is to obtain different coefficients of the image in the frequency domain. Wavelets capture the image in its time frequency domain and feature extraction is done afterwards[2].The implemented process of face recognition can be divided into following stages as

1. Preprocessing using Multilevel Wavelets
2. Training using LDA
3. Classification

(a) Algorithm for wavelet

The advantages of using Haar transform is that it is very simple technique, easy to implement and memory efficient. The steps for it are as follows.

Step 1: Read the face image to be transformed.

Step 2: For each row of the image repeat the following steps,

- (a) Calculate the average of two adjacent intensity values.
- (b) Take the difference between the calculated average and the intensity value.
- (c) Set the first half of the row with the averages.
- (d) Set the second half with the differences.

Step 3: Repeat step 2 for each column of the image.

Step 4: Write the resulted transformed image.

The same procedure can be performed a number of times on the approximation coefficients known as multilevel wavelet transform. The size of the output matrix or image will remain same as that of original input image but will contain four different components or subbands. The size of approximation and detail components will be $i/2 \times j/2$ for input image of size $i \times j$ after one-level decomposition, and the output components' size with $i/4 \times j/4$ and $i/8 \times j/8$ are generated by two-level and three-level decomposition, respectively.

(b) Algorithm for LDA

The LDA is implemented in MATLAB .The main steps of the LDA algorithm are as follows.

1. Select and Read the Training images.
2. Choose the specific DWT level to work upon with.
3. Now select the desired wavelet coefficients from available four as approximation and detail.
4. Extract the waveletfaces from all images.
5. Convert waveletfaces into column vectors.
6. Prepare the data matrix X by concatenating column vectors of the waveletfaces.
7. Calculate S_b and S_w .
8. If $D > N-c$ then (i.e. dimensions are greater than no. of training faces)
 - a) Use PCA for subspace $N-c$ to ensure nonsingular S_w .
 - b) Generate the resulted transformation matrix W .
9. Otherwise
 - a) Calculate eigenvectors and eigenvalues form S_b and S_w .
 - b) Prepare the transformation matrix W .
10. Now project the training waveletfaces on to the LDA subspace
$$Y = W^T \cdot X$$
11. Read the Test image X' .

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12. Convert test image into column vector.
13. If size of training image and test image do not match then Exit.
14. Project test image onto LDA subspace
 $Y' = W^T \cdot X'$
15. Store Y and Y'.

(c) Algorithm for classification

After calculating LDA subspace in previous phase now perform classification. The algorithm for classification is as given below.

1. Load Y and Y'
2. Calculate the Euclidean distance between the training and test classification space projection, Y and Y' respectively, and prepare the distance matrix.
3. Select the minimal distance from the prepared matrix.
4. Output the class of the image with the minimal distance.

The test image is assumed to be in the class whose distance is the minimal among all other class distances.

IV. RESULTS AND DISCUSSION

The designed methodology was tested against face databases. The test results are summarized in this chapter. The results are presented in the form of Recognition Rate, Training Time, and recognition Time. The analysis of face recognition technique has been done on the different levels of Haar wavelet transform, with using different components of images as Approximation, Horizontal, Vertical, and Details coefficients.

Here are presented results of the whole process when applied on Yale Face Database A. As we know the first step in the technique is to apply Haar wavelet transform. It is applied on the training images at different levels as, two-level, three-level, and four-level. The results after performing multilevel wavelets are shown in following figures.

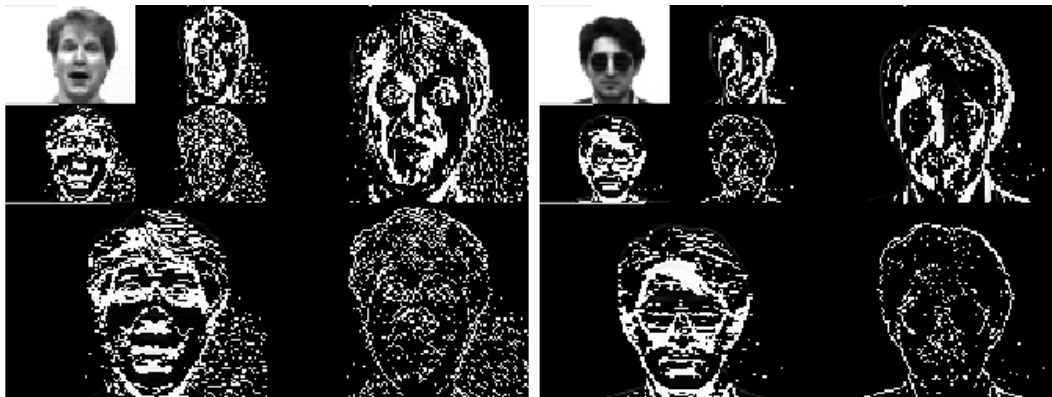


Fig 4 Face Images after Two-level Haar Wavelets

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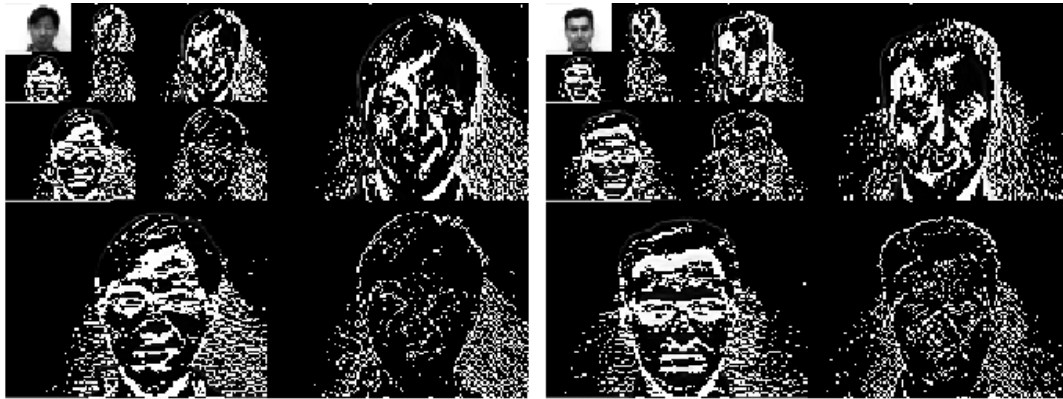


Fig 5 Face Images after Three-level Haar Wavelets

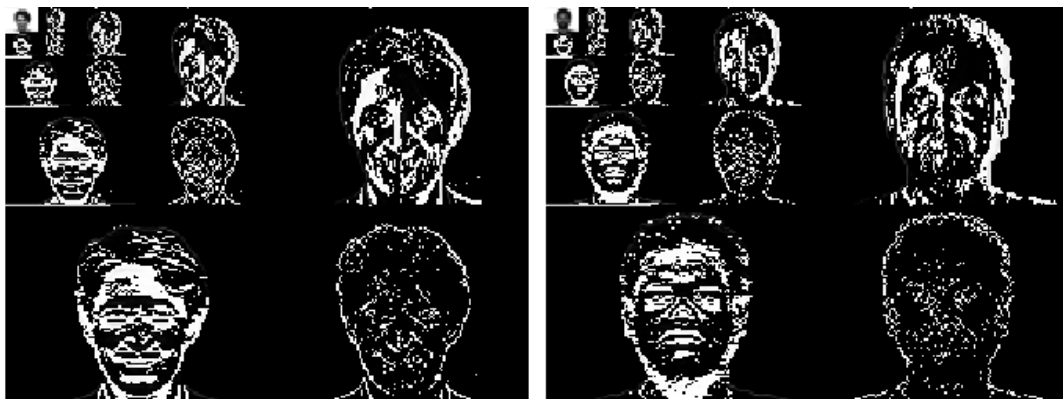


Fig 6 Face Images after Four-level Haar Wavelets

After completing the wavelet transformation on the training images these are prepared for LDA, before that the proper level and the type of component to be used is specified by the user. Then after calculating the scatter matrices, the LDA subspace is prepared. Projections of test image and training images are then used to see the face recognition rate.

Table 1
Recognition Rates (%) at *four-level* of Wavelet
Decomposition for Five, Six, and Seven Distinct Prototype Images per Class

Prototype images per class	Components			
	Approximation	Horizontal	Vertical	Diagonal
5	59.5	91.11	83.33	88.89
6	61.33	93.33	86.67	90.67
7	63.33	95	83.33	81.67

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Table 2
Recognition Rates (%) at Three-level of Wavelet
Decomposition for Five, Six, and Seven Distinct Prototype Images per Class

Prototype images per class	Components			
	Approximation	Horizontal	Vertical	Diagonal
5	61.11	93.33	88.89	77.78
6	64	93.33	89.93	82.67
7	66.67	96.67	88.33	80

Table 3
Recognition Rates (%) at two-level of Wavelet
Decomposition for Five, Six, and Seven Distinct Prototype Images per Class

Prototype images per class	Components			
	Approximation	Horizontal	Vertical	Diagonal
5	54.44	91.11	86.67	44.44
6	54.66	93.33	86.67	46.67
7	48.33	91.67	83.33	45

Table 4
Training Time (sec) at Different Levels of Wavelet
Decomposition for Five, Six, and Seven Distinct Prototype Images per Class

Wavelet Transform	Dimensions	Number of distinct prototype images per class		
		5	6	7
Two-Level	3072	1.970*	1.787*	2.399*
Third-Level	768	0.543	0.572	0.604
Four-Level	192	0.156	0.176	0.215

Table 5
Recognition Time (millisec) at Different Levels of Wavelet
Decomposition for Five, Six, and Seven Distinct Prototype Images per Class

Wavelet Transform	Number of distinct prototype images per class		
	5	6	7
Two-Level	0.618	0.207	0.227
Third-Level	0.334	0.384	1.37
Four-Level	0.271	0.298	1.1

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From the above taken results we can see the analysis of face recognition performance now. The Recognition rate is best achieved by using the Horizontal coefficients. The best overall performance is shown by the level three wavelet transform. The highest rate of face recognition on the Yale Face Database A is achieved 96.67%, it is obtained by using the Horizontal components at the three-level of wavelet transform. Vertical coefficients also perform better than that of approximation components. But the performance of diagonal components vary. Level four performs least in general. The result sets on Yale Database B also signifies the importance of horizontal components. The recognition rate up to 100% is also achieved here. The approximation components also performs well for recognition. The three-level wavelet transform gives best results.

The training time increases with the increase in dimensionality, as two-level wavelet transform images take highest training time as the highest dimensions are here equal to 3072 and it took almost 2.5 minutes for the training. The recognition time is measured in milliseconds and is not much comparable as very small in amount. One experiment has also been performed by using combined Horizontal and diagonal features. These components perform satisfactory at the three-level up to 91% of recognition performance.

V. CONCLUSION AND FUTURE SCOPE

Face recognition has received considerable attention from both industry and the research community. The reason for this interest is the ease with which a face image can be acquired with minimum hardware added. However face recognition is susceptible to real life conditions like light, expression pose variation, etc. Hence, image-based face recognition is still a very challenging topic after decades of exploration. A number of typical algorithms have been derived by many researchers, and are categorized into template based, model based, appearance-based, and model-based schemes.

In this paper, dimensionality reduction techniques are implemented. The investigated techniques are not novel techniques; they are previously proposed and studied in the literature. The second method is LDA to reduce dimension space to another extent. The recognition performance has been measured and analyzed under different levels of wavelets by exploring different coefficients present in images. The horizontal components withstand the illumination changes to faces.

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