Face Recognition in a Group Photograph using Haar Wavelet Coefficients and ED vector

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Abstract: ***Accurate and faster face identification task has always been the prominent task of any biometric based personnel identification system. However, due to high dimensional space of facial images, the computation tedious and time consuming. The computational cost can only be reduced if the dimensional space is reduced to at least 70% of the original image size. In the presented base work, it is observed that the Eigen values are used to evaluate the features from the face under test. The Eigen values are same in number as that of the size of the facial image. However, by using the principal component analysis, the Eigen vector size is reduced. The reduced Eigen vector size does not guarantee that only the principal feature from the facial images are extracted as it only reduces the image dimension. However, in the proposed work, we present a wavelet based approach where the facial image is divided into sub-bands and the HH-band image is used to identify the given image from the data base image. In the presented work, it is proposed to decompose the segmented facial image from the group photograph into LL, HL, LH and HH sub-bands using the haar wavelet. The HH sub-band image contains the maximum frequency component of the facial image. The image is already reduced to a size of (N/2 x N/2) of actual size of NxN. Therefore, the speed of operation is fast enough as compared to other methods and without loss of high frequency components.***

Keywords: about four key words separated by commas

1. Introduction

Face identification from a group photograph is very much required during investigation of a scene from crowd or cluster of faces. The most difficult challenge is to detect faces in clumsier group photos. While face recognition, in general the faces that retrieved from group photo are not giving sufficient information due to poor clarity. This kind of limitation is inherent in the imaging device and circumstances when the photographs are taken. The photographic conditions are uncontrolled when imaging the crowd or at public places in emergency situations. Therefore, poor visibility or incomplete photos are common problem in identification of faces from cluster of faces. In the presented work, special emphasis is given to these kinds of problems by analyzing the cluster of faces in frequency domain using DCT coefficients.

Face recognition is one of the biometrics traits that received a great attention of many researchers during the past few decades because of its potential applications in a variety of civil and government regulated domains. It usually involves: initial image normalization, preparing an image for feature extraction by detecting the face in that image, extracting facial features from appearance or facial geometry.

2. Related Works

Face recognition systems are progressively becoming popular as means of extracting biometric information. Face recognition has a critical role in biometric systems and is attractive for numerous applications including visual surveillance and security. This paper presents an interactive algorithm to automatically segment out and recognize a person's face from a group photograph. The method involves fast, reliable & effective algorithm that exploit [1]
Face recognition is one of the challenging problem is still facing in the recent years in many applications and may fields up to date and still there is no solution is to be find to face that problem. Face recognition is the biometric method, and it is one of the undefined solutions that still cannot rectify that problem, because human faces may be changed due to various reactions according to their different situations according to their age, emotional expressions. etc given at different times. [2]

Diego A.Socolinsky.et.al discussed a comparison of two standard face recognition algorithms based on visible and LWIR (long-wave infrared) imagery. The databases are basically formed with a novel sensor system. The algorithms used are eigenface and ARENA and the overall performance was good for LWIR imagery than visible imagery. Author also performed radiometric calibration on LWIR imagery to analyze the invariance properly. This calibration performs an initial segmentation of skin pixels in the correct temperature range. [26].

WeilongChen.et.al discussed a discrete cosine transform approach for illumination normalization and compensation. In normalization approach images are preprocessed using some preprocessing techniques so the images appear stable under different conditions. .

Vikas Maheshkar.et.al discussed block based DCT for illumination normalization. Discrete cosine transform is used for feature extraction steps in various studies of face recognition. DCT features have been used in a holistic appearance based or local appearance based approaches. [27].

Fischler and Elschlager [20], attempted to measure similar features automatically. Their strategy is based on deformable templates, which are parameterized models of the face and its features in which the parameter values are determined by interactions with the face image. The word biometrics refers to the use of physiological or biological characteristics of human to recognize and verify the identity of an individual.

We apply the proposed method to a variety of datasets and show the results [3].

Face detection and recognition are fascinating problems for image processing researchers during the last decade. The most difficult challenge is to detect faces in clumsier group photos. This is achieved in this paper. While face recognition, in general the faces that retrieved from group photo are not giving sufficient information due to poor clarity. But this problem is overcome by Eigen subspaces.

The proposed architectures comprise 2-D HWT with transpose-based computation and dynamic partial reconfiguration (DPR) that have been synthesized using VHDL and implemented on Xilinx Virtex-5 FPGAs. To evaluate the proposed architecture, comparison for both configurations and a detailed performance analysis in terms of area, power consumption and maximum frequency are also addressed in this paper [31].

3. Algorithm

The face recognition problem can be formulated as follows: Given an input group photograph (still image) having multiple face image and a database of face images of known individuals, then determine or recognize the identity of the persons present in the group photograph. The proposed work is primarily divided into two sections:
1. Segmentation of the face from the group photograph
2. Segmented Face Identification

In the presented work, it is proposed to decompose the segmented facial image from the group photograph into LL, HL, LH and HH sub-bands using the haar wavelet. The HH sub-band image contains the maximum frequency component of the facial image. The image is already reduced to a size of (N/2 x N/2) of actual size of NxN. Therefore, the speed of operation is fast enough as compared to other methods and without loss of high frequency components. The objectives are summarized below:

- Segmentation of facial images from group photograph
- Wavelet Decomposition (LL, LH, HL and HH sub-bands) using Haar Wavelet
- Computation of HH-sub bands wavelet coefficients
- Computation of Euclidean Distance (ED) between HH-sub band coefficients of test and data base images.
- Face Identification based on statistical analysis of ED vector

4. Face Segmentation from Group Photograph

A single face may be segmented using the following algorithms:
Finding faces in image with controlled background is the easiest way out and easy of all the approaches. In this approach, images are used with a plain mono color background, or images with a predefined static background. As removing the background gives the face boundaries.

I. Finding faces by color: This is the approach where face is detected using skin color. Once we have access to color images it is possible to use the typical skin color to find face segments. But in this approach, there is a drawback. Skin color varies from race to race and this does not work well with all kind is skin color. In addition, this approach is not very robust under varying lighting conditions.
II. Finding faces in unconstrained scenes: This approach is the most complicated approach of all and this approach tops all the other approaches. In this approach, face has to be detected from a black and white still image.
III. Geometry Based: These methods utilize geometrical information of face region. It represents face using shapes like ellipse. It cannot handle large intensity variations, occlusion and noise.
IV. Appearance Based: Gray values are the most important parameter for the face detection. Face detection performance is affected by light intensity and occlusions.
V. Edge Based: The edge information is extracted and used to detect face.

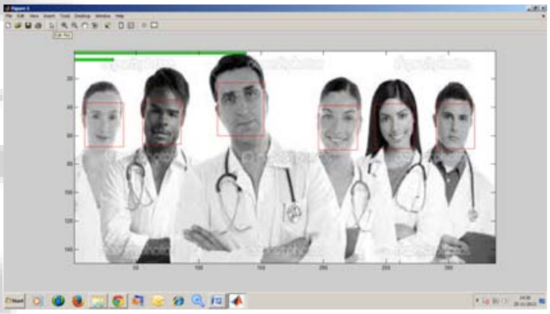


Figure 1: (Group Photograph)

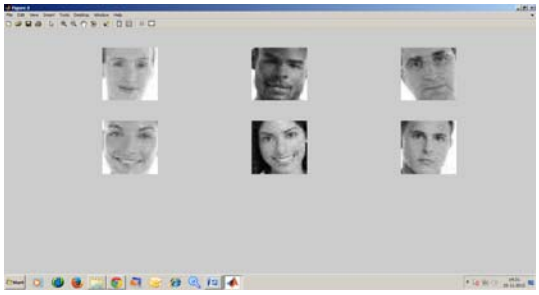


Figure 2: (Segmented Faces)

5. Segmented Face Identification Photograph

5.1 Resizing of the Face Image

The segmented face image is resized to 96x96 (row x column) so as to compute the image features as that of the data base images. This is done by using the following matlab command:
Resized Image = imresize (FaceImage, [96, 96]);

5.2 Face Image Enhancement

The resized face image is enhanced in order to remove the noise and suppressing the illumination effects etc. This is done by using the histogram equalization technique.

5.3 Face Image Decomposition

The enhanced face image is now subjected to haar wavelet decomposition. The segmented image is decomposed into different frequency sub bands (LL, HL, LH and HH sub bands). The HH sub band image contains the maximum frequency component of the facial image. The sub-band images are shown below:

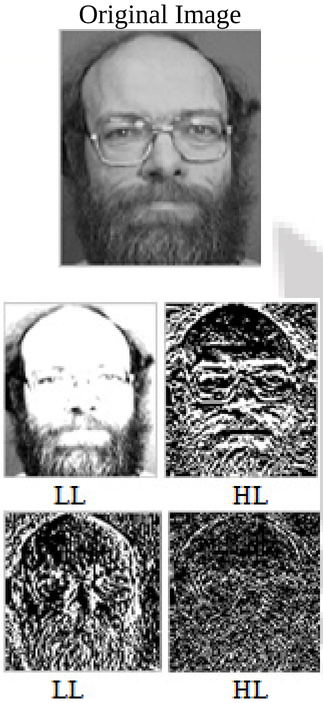


Figure 3: Original Image and different freq. sub-band images

The haar wavelet is implemented using the following matrix computation:

$$x = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

The equivalent haar wavelet sub-bands (Y) are given by:

$$y = \frac{1}{\sqrt{2}} \begin{bmatrix} a+b+c+d & a-b+c-d \\ a+b-c-d & a-b-c+d \end{bmatrix} \ldots$$

Similarly the data base images are decomposed using the haar wavelet transform and HH sub band images are taken for Euclidean distance vector generation.

6. Computation of Euclidean Distances

The Euclidean distance between HH sub band coefficients is computed using the following formula:

$$ED = \sqrt{\sum_{i=1,j=1}^{M,N} (D_{i,j} - T_{i,j})^2}$$

Where I = 1,2,3 … M and j = 1,2,3 … N and MxN is the HH sub-band image size. D and T are the data base and test image HH-sub band coefficients. ED vector is reshaped to a single column vector. The standard deviation is computed for each data base sub band image. A minima of SD of Euclidean distances from ED vector is extracted. This is the identified facial image.

7. Computation of Standard Deviation from Euclidean Distance

Let say, there are N no. of data base images of MxN size, and in turn, say N no. of HH sub-band images of RxC size. Therefore, we get w = RxN no. of EDs with the query image. This can be explained by the followings:

HH sub-band coefficients
Data Base Image Test Image
$D^1_1\ D^2_1\ D^3_{1\ldots\ldots}\ D^N_1\ T_1$
$D^1_2\ D^2_2\ D^3_{2\ldots\ldots}\ D^N_2\ T_2$
$D^1_3\ D^2_3\ D^3_{3\ldots\ldots}\ D^N_3\ T_3$
$D^1_4\ D^2_4\ D^3_{4\ldots\ldots}\ D^N_4\ T_4$
… … … … … … …
… … … … … … …
$D^1_W\ D^2_W\ D^3_{W\ldots}\ D^N_W\ T_W$

Then, we have ED as:

$$ED = \sqrt{\sum_{i=1,j=1}^{N,W} (D_{i,j} - T_{i,j})^2}$$

$ED^1_1\ ED^2_1\ ED^3_{1\ldots\ldots}\ ED^N_1$
$ED^1_2\ ED^2_2\ ED^3_{2\ldots\ldots}\ ED^N_2$
$ED^1_3\ ED^2_3\ ED^3_{3\ldots\ldots}\ ED^N_3$
$ED^1_4\ ED^2_4\ ED^3_{4\ldots\ldots}\ ED^N_4$
… … … … … …
… … … … … …
… … … … … …
$ED^1_W\ ED^2_W\ ED^3_{W\ldots}\ ED^N_W$

The average of the EDs is given by:

$$\mu = \frac{1}{W} \sum_{r=1}^{W} ED_r$$

μ1 μ2 μ3 … μC

The standard deviation is given by:

$$\sigma i = \sqrt{\frac{1}{W} \sum_{i=1}^{W} (\mu_i - ED_i)^2} \quad \text{where } i = 1,2,3 \ldots W$$

$\sigma^1\ \sigma^2\ \sigma^3\ \ldots.\ \sigma^N$

The standard deviation is sorted to find the minimum standard deviation. The minimum standard deviation image is equivalent to the query image from the group photograph. The counter is moved to next image in the group photograph and the same procedure is adopted until all the group photograph images are identified.

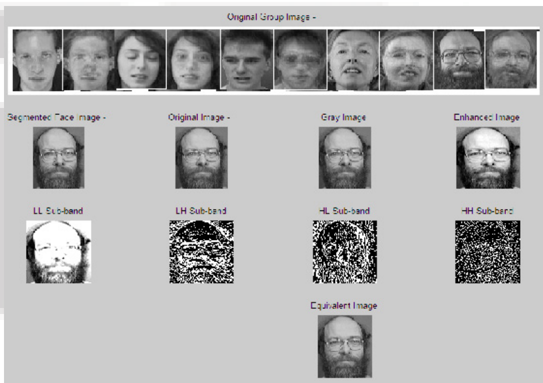


Figure 4: A Group Photograph

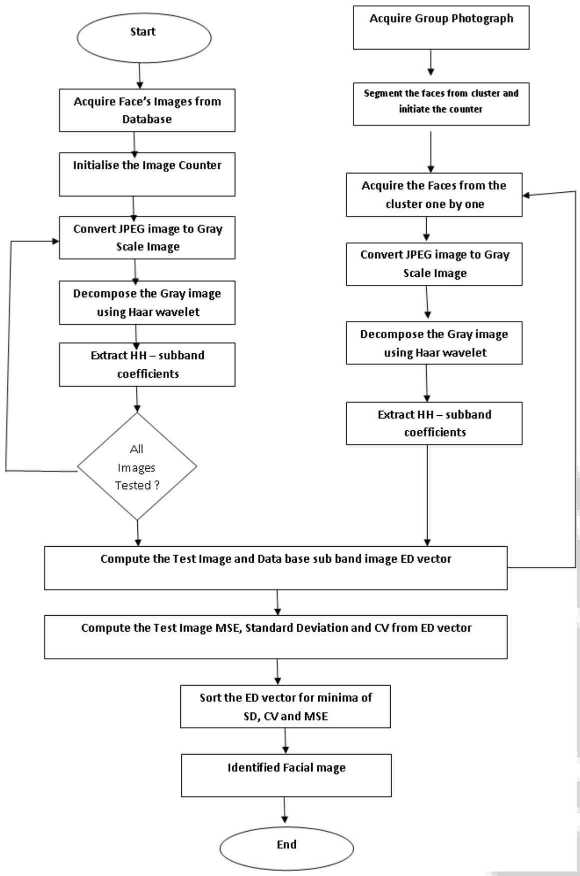
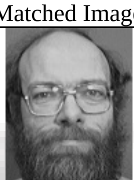
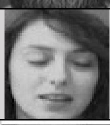
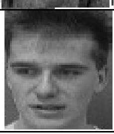


Figure 5: (Flow Chart of the proposed System)

8. Results

The proposed work is implemented in matlab version 7.5 using statistical analysis of Euclidean distances between the HH sub-band images of data base and query face images.. The different test images are given as an input to check the recognition rate of the proposed technique.

Fig. No.	Min. Standard Deviation	Matched Image
5	2.234	
5	1.980	
5	3.234	
5	1.529	

9. Conclusion

Face recognition is a challenging problem in the field of image analysis and computer vision that has received a great deal of attention over the last few years because of its many applications in various domains. Research has been conducted vigorously in this area for the past four decades or so, and though huge progress has been made, encouraging results have been obtained and current face recognition systems have reached a certain degree of maturity when operating under constrained conditions; however, they are far from achieving the ideal of being able to perform adequately in all the various situations that are commonly encountered by applications utilizing these techniques in practical life. The presented work shows fair identification of face images from the group photograph. The main hurdle in the face identification in a group photograph is to segment the individual faces and this has been achieved to a great and satisfactorily in the presented work. The face matching accuracy has been achieved to 95-100%, which is quite satisfactorily.

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