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Comparative studies of feature extraction in face recognition system by using Haar wavelet transform

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Abstract-------Detecting and recognizing human faces automatically in digital images is one of the most active research areas in computer vision and pattern recognition. For the face recognition three phases are used face detection, feature extraction and classification. This paper discusses feature extraction in different face recognition problems such as illumination, age, surgery using haar wavelet transform. Wavelet is extracting very good features from the images, but it extracts features from the low frequency region only. But the features are also present in the high frequency region. To overcome this limitation we are taking features in detailed coefficients in each sub image. The experimental result shows that our method gives strong features comparing to other wavelet transforms based feature extraction methods.

Index terms------ face recognition, Haar wavelets transform, illumination

I.INTRODUCTION

Face Recognition has emerged as an extensively studied topic over the last few years, having repercussions on fields such as pattern recognition, signal processing and computer vision. Face Recognition is at the heart of human-computer interaction and is indispensable in other applications such as security (Identity authentication), indexing of image and video databases, etc., and the various approaches to Face Recognition have been discussed in [1, 2]. Face Recognition under varying illumination, age, before and after surgery is a challenging task and has been discussed in [3, 4, 5].

The feature extraction is a special form of dimensionality reduction process. Transforming the input data into the set of features is called feature extraction. A feature extraction methodology plays a major role in the recognition process and a good extraction methodology selects the best Discriminant features which are not sensitive to variations in illumination, age and before and after surgery.

Image feature extraction methods can be classified broadly into direct method and feature based method. Direct Method uses information from all pixels. It iteratively updates an estimate of Homography so that a particular cost function is minimized. Sometimes Phase-Correlation is used to estimate the a few parameters of the Homography. In Feature Based Method a few corresponding points are selected on the two images and Homography is estimated using these reliable points only. Feature Based Methods are in general more accurate. It can handle large disparities. Direct methods may not converge to the optimal solution is the presence of local minima.

Edge detection is an essential task in feature extraction. In image an edge is a encircle across the luminosity of the image changes abruptly. An edge detector is normally a high-pass filter that can be applied to elicit the edge points in an image. In addition to edges, the corners are also considered the best features that can be extracted from an image. Other than edges and blobs, corners are also the best candidates for eliciting the prominent features in an image. Blobs are regions in the image that may contain objects of interest and are either brighter or darker than its surroundings. Some of the methods engaged to expose blobs are Laplacian of Gaussian (LoG), Difference of Gaussian (DoG), Determinant of Hessian etc. which are chosen appropriately for the aimed application.

The major limitation of these techniques is features are directly proportional to the accuracy and inversely proportional to the speed. It means if the selected features are more the probability of accuracy also more and rate of speed is less because the selected features are more, it required more time for computation of more features. The main reason and advantage for applying the wavelet transform to the detection of edges in an image is the possibility of choosing the size of the details that will be detected. In DWT, the choice of the scale is performed by multiple signal passage through the wavelet filter. When processing a 2D image, the wavelet analysis is complying individually for the vertical and the horizontal directions.

Thus, the horizontal and the vertical and edges are extracted separately.

II. LITERATURE SURVEY

Survey of feature extraction techniques [6] has divided into four basic techniques are Knowledge based, Mathematical Transform based, Neural Network or fuzzy extraction and others. [7] Geometrical, color, appearance and template based techniques. Harris corner detector [8] is a well-known interest key point detector due to its invariance to rotation, illumination variation. But it doesn't scale-invariant. Lowe in [9] [10], has addressed the problem of affine invariance for feature extraction and proposed the so called scale-invariant feature transform (SIFT) descriptor, that is invariant to image translations and rotations, scale changes (blur), and robust to lighting changes, but has slow execution time. Various popular techniques such as Principal Component Analysis (PCA), Kernel PCA, Linear Discriminate Analysis (LDA), and SVM are pixel based feature extraction techniques having good results

A Comparative Study of Feature Extraction Using PCA and LDA for Face Recognition [11]. Semi supervised Local Discriminant Analysis for Feature Extraction in Hyper spectral Images [12]. Local invariant features detector a survey [13]. So many researchers propose to extract facial features in the frequency domain, such as Fourier transform [14] and discrete cosine transform (DCT) [15], etc. These all methods extract the features in the low frequency region only, but the features are also present in the high frequency region.

III. WAVELET TRANSFORM BASED FEATURE EXTRACTION

The wavelet is proved to be a powerful mathematical tool. It can be used in many image processing applications such as compression, image edge enhancement, and feature extraction. Wavelet transforms can decompose images into elementary building blocks that are well localized both in space and frequency. A wavelet is used to divide a given function into different frequency components. A wavelet transform [16] is the representation of a function by wavelets, which represent scaled and translated replicas of a finite length. Wavelet analysis consists of decomposing an image into a hierarchical set of approximations and details. For image analysis uses two-dimensional wavelets and corresponding scaling functions obtained from one-dimensional wavelets by tonsorial producing. It decomposes the image into low and high frequency bands and analysis the information in an image with less number of coefficients. Extracting the features this method is simple and fast.

The 2D DWT break down the images into sub images, 3 details and 1 approximation. The approximation looks same as input image but size is only 1/4 of original image. The 2D DWT is continuing of the 1D DWT in both the vertical and the horizontal direction. We label the resulting sub-images from an octave (a single iteration of the DWT) as LL (the approximation or we say the smoothing image of the original image which contains the most information of the original image), LH (preserves the horizontal edge details), HL (preserves the vertical edge details), and HH (preserves the diagonal details which are predominance by noise greatly), according to the filters used to generate the sub-image. For example, HL is used as a high pass filter along the rows and a low pass filter along the columns. Continuously repeat this procedure by inserting the first octave's LL sub image through another set of low pass and high pass filters. This iterative process built the multi-resolution analysis shown in below Fig 1

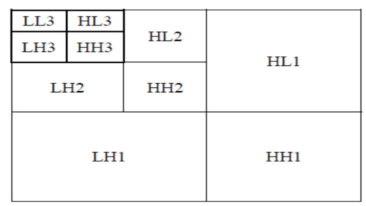

Fig1. Wavelet decomposition

Mathematically the wavelet can be represented by scaling function and wavelet functions, so Eq. (1) Is the scaling function, Eq. (2) - Eq. (4) is the wavelet function. Here Ψ^H refers to the change along the columns which means the horizontal edges, Ψ^V is the difference along the row, which refers to the vertical edges, Ψ^D is the variation along the diagonals.

$$\varphi(x,y)=\varphi(x)\varphi(y) \quad (1)$$

$$\Psi^H(x,y)=\Psi(x)\Psi(y) \quad (2)$$

$$\Psi^V(x,y)=\Psi(x)\Psi(y) \quad (3)$$

$$\Psi^D(x,y)= \Psi(x)\,\Psi(y) \quad (4)$$

Now separable scaling and wavelet functions, we can assign the scaled Eq. (5) And translated basis Eq. (6) -Eq. (8)

$$\varphi_{j,m,n}(x,y) = 2^{j/2}\varphi(2^j x - m, 2^j - n) \quad (5)$$

$$\psi^H_{j,m,n}(x,y) = 2^{j/2}\psi^H(2^j - m, 2^j - n) \quad (6)$$

$$\psi^V_{j,m,n}(x,y) = 2^{j/2}\psi^V(2^j - m, 2^j - n) \quad (7)$$

$$\psi^{D}_{j,m,n}(x,y) = 2^{j/2}\psi^{D}(2^{j}-m,2^{j}-n) \quad (8)$$

Once we have the basis function, we can now define the discrete wavelet transform of the image which can be found at Eq. (9) - Eq. (12) where M, N, H, V, D, $W\varphi(j0; m; n)$, $W^{H}_{\psi}(j; m; n)$, $W^{V}_{\psi}(j; m; n)$, $W^{D}_{\psi}(j; m; n)$, represents the number of columns in the image, number of rows in the image, horizontal, vertical, diagonal, approximate coefficients at scale j_0 which is usually equal to 0, horizontal, vertical, and diagonal detail coefficients at scale j where $j \geq j_0$ respectively.

$$w_{\varphi}(j_0,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\varphi_{j,m,n}(x,y) \quad (9)$$

$$w^{H}_{\psi}(j;m;n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi^{H}_{j,m,m}(x,y) \quad (10)$$

$$w^{V}_{\psi}(j;m;n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi^{V}_{j,m,m}(x,y) \quad (11)$$

$$w^{D}_{\psi}(j,m,n) = \frac{1}{\sqrt{MN}}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\psi^{D}_{j,m,n}(x,y) \quad (12)$$

In wavelet decomposition every time we decompose the image in the low frequency region only and not concentrate on a high frequency region. This is the major drawback in the feature extraction because the features are also present in the high frequency region also.

IV. HAAR WAVELET TRANSFORM BASED FEATURE EXTRACTION

The first method of feature extraction is discrete wavelet transform (DWT). The DWT was invented by the Hungarian mathematician Alfred Haar in 1909. A key advantage of wavelet transform over Fourier transforms is temporal resolution. Wavelet transform captures both frequency and spatial information. The DWT has a huge number of applications in science, engineering, computer science, and mathematics. The Haar transformation is used here since it is the simplest wavelet transform of all and can successfully serve our purpose. Wavelet transform has merits of multiresolution, multi-scale decomposition and so on. To obtain the standard decomposition [17] of a 2D image, the 1D wavelet transform to each row is applied first. This operation gives an average pixel value along with detail coefficients for each row. These transformed rows are treated as if they were themselves in an image. Now, 1D wavelet transform to each column is applied. The resulting pixel values are all detail coefficients except for a single overall average coefficient.

V.FEATURE MATCHING:

Feature matching aims to detect the matched features from the two images. In this paper, we use correlation method to determine matched features between two images. In this method analyze pixels around each point in the first image and compares them with the pixels around every other point in a second image. The most common points are taken as matching pairs. It can be seen very well from the picture, however, that many points have been wrongly correlated. To overcome this drawback we use Homography Estimation. It can be used to project one of the two images on top of the other while matching the majority of the correlated feature points we require a Homography matrix, which has the opportunity to match the two images. First identifying the correct key points by using RANSAC. It is the algorithm to estimate the mathematical model of a set of observed data. Observed data contain both inliers and outliers. Where inliers correspond to a set of data that can be described by some set of parameters, whereas outlets cannot be described by a model. So, for an accurate model fitting, these outlets have to be eliminated.

For example consider two images of before and after surgery images of size 137X184 and 135X181 as shown in figure

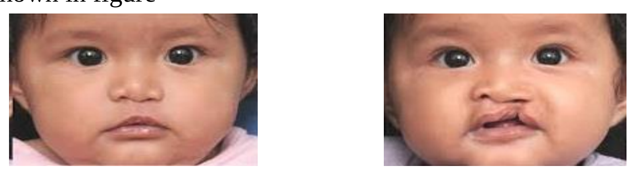

Fig2 input image of size137X184 and 135X181

By using haar wavelet transform the total number of key points detected in both images is 568 as shown in figure. From the figure the red and green color circles indicates maxima and minima key points.

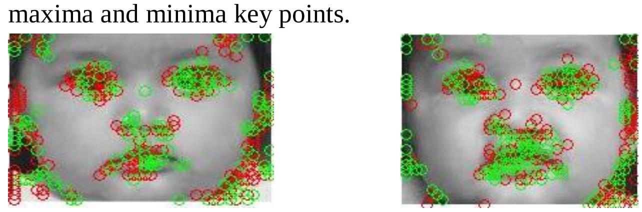

Fig3 maxima and minima key points detected in both images

For identifying the correct matches we use RANSAC based Homography estimation. Therefore the total matching key points obtained in both images is 93.

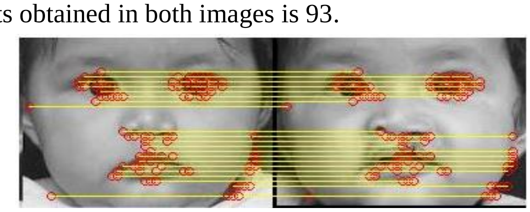

Fig4 matched features in both images

Similarly for face recognition problems such as illumination and age by using haar wavelet the number of key points detected and matched points in two images are show below table

type of face recognition	wavelet transform	key points detected in first image	key points detected in second image	Number of matching points detected in both images
Illumination	Haar	530	548	55
Age	Haar	559	622	127
Surgery	Haar	285	283	93

Table1: key points and matching point details in different face recognition problems

VI .CONCLUSION

Feature extraction places a major role in face recognition systems. In this paper we proposed a new method of feature extraction by using Haar wavelet transform decomposes the image into different levels and combining detailed coefficients in each level. The experiment results show that our feature extraction is better compared to other techniques.

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