Age Invariant Face Recognition Using Wavelet Packet Transform and Regional Maxima

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Abstract—Face is the primary identification document in many fields like passport, driver’s licenses, and ID cards. Face features are changing along with the age. Now a day’s Age invariant face recognition is a serious problem in many computer vision applications. In this paper, we propose a novel method for age invariant image feature extraction using wavelet packet transform and regional maxima (WPT). Wavelets have played an important role in image processing for its capability to capture localized spatial-frequency information of images. But wavelet extracts the features in the low frequency region only and not gives the orientation invariant features. In wavelet packet transform, extract the features in both low and high frequency regions and take the features in high frequency regions, because the strongest feature is only a highest frequency compound in the image. After the feature extraction apply regional maxima to these key points to get the maxima and minima features in the face image. Face image matching using the statistical measures to these key points. Based upon statistical values match the images by correlation. Implementation results show that the feature extraction by using the proposed method is more reliable for real time applications when compared with existing methods.

Index Terms—Face recognition, age invariance, wavelet packet transform, and regional maxima.

I. INTRODUCTION

Face is the primary feature in the person identification system. Face recognition plays a key role in many computer vision applications like missing person identification, airport security, etc... Increasing the age some facial features have also changed like texture of the skin, shape of the face. Faces indicate the age of a person based upon the face features. The ages of a human is divided into babies, children, adults, and old age comparing babies and children with the adults there is large texture variations are present and comparing with adults and old age people any less number of Changes we present. Therefore, an age improvement scheme will help to balance these types of aging process [1]. A computer will not recognize human faces with different ages because of increasing the age the shape and texture of the face of human image is changed. But in the process of different ages, some constant feature we know is change they are eyes, lips, eyebrow shape etc.

In automatic face recognition feature extraction place an important role. In the literature survey so many researchers propose to extract facial features in the frequency domain, such as Fourier transform [4] and discrete cosine transform (DCT) [5], etc. These all methods extract the features in the low frequency region only, but the features are also present in the high frequency region. To extract the features both low and high frequency regions we propose a novel method for feature extraction called wavelet packet transform. After extracting the features the next step in the face recognition is matching for face matching we apply the statistical measurements to these features.

II. WAVELET TRANSFORM BASED FEATURE EXTRACTION

The Wavelet transform is widely used to represent an image. The aim of this transform is to extract revelent information from an image. It provides a time frequency representation of the image into different resolution sub-images, corresponding to the various frequency bands. This results in multi-resolution representation of an image with localization in both the spatial and frequency domains.

In discrete wavelet transform an image signal can be analyzed by passing it through an analysis filter bank followed by decimation operation. The analysis filter bank consists of low-pass and high-pass filters at each decomposition stage. When an image signal passes through these filters, it splits into two bands. The low-pass filter, which extracts the coarse information of the image. The high pass filter, which extract detailed information of an image. The process of decomposition shown in figure 2.

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 wavelets. Here \( \psi^{H} \) refers to the change along the columns which means the horizontal edges, \( \psi^{V} \) is the difference along the row, which
refers to the vertical edges, $\psi^D$ is the variation along the diagonals.

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

$$\psi^H(x, y) = \varphi(x) \psi(y)$$  (2)

$$\psi^V(x, y) = \psi(x) \varphi(y)$$  (3)

$$\psi^D(x, y) = \psi(x) \psi(y)$$  (4)

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

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

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

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

$$\psi^D_{j,m,n}(x, y) = 2^{j/2} \psi^D(2^j x - m, 2^j - n)$$  (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 $M$, $N$, $H$, $V$, $D$, $W_p(j; m; n), W^H_p (j; m; n), W^V_p (j; m; n), W^D_p (j; m; n)$. 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 $j, j_0$ respectively.

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

$$w^H_p(j; m; n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \psi^H_{j_0,m,n}(x, y)$$  (10)

$$w^V_p(j; m; n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \psi^V_{j_0,m,n}(x, y)$$  (11)

$$w^D_p(j; m, n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \psi^D_{j_0,m,n}(x, y)$$  (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.

### III. WAVELET PACKETS BASED FEATURE EXTRACTION

The limitation of wavelet transform is overcome by new wavelet transform method, known as wavelet packet transform. Wavelet packets are decomposing the image both low and high frequency regions in every time [6]. This leads to a complete binary tree. Structure of three level decomposition of wavelet packet is shown in figure 3.

![Structure of three level decomposition of wavelet packet](image)

The wavelet packet decomposition splits the approximation coefficients into two parts. The first part is called horizontal approximation coefficients and the next part is called the vertical approximation coefficients. The information lost between two successive approximations is captured in the diagonal coefficients. The new horizontal and vertical approximations again in the wavelet packet approach each detail coefficient also decomposed into two parts as in approximation coefficient splitting. Due to decomposition of only the approximation coefficients in each level of wavelet transform results of frequency resolution in high-level decomposition are less accurate. It may cause problems while applying wavelet transform in some applications which the important information is located in higher frequency regions. So the wavelet packet transform is used to capture the necessary frequency resolution can be achieved.

### IV. PROPOSED FACERECOGNITION METHOD

#### A. Feature Extraction

This paper presents a novel feature extraction algorithm based on wavelet packet transform. In this method first decompose the image using wavelet packet transform up to the second level and combine the all high frequencies in each level that means combining wavelet coefficients in the regions of LH, HL, and HH. After combining all the wavelet coefficients apply the fast Fourier transform of these wavelet coefficients to get the directionality to these wavelet coefficients. Finding the regional maximum to these wavelet packet coefficients to get the strong key points in the local region of the image. Project these points into the image by multiplying four times to the each wavelet coefficient to get the key points.

![Combine dilated frequency coefficients](image)
B. Feature Matching

Cross correlation is a significant implement in image processing, pattern recognition, and other fields. The use of cross-correlation for template matching is implement from the distance measure (squared Euclidean distance) [8], [9]

\[ d_{f,t}^2(u,v) = \sum_{x,y} [f(x, y) - t(x-u, y-v)]^2 \]

(13)

Where f is the target image and t is the future, the sum is over x, y under the window containing the feature t positioned at (u, v). In the expansion of \( d^2 \)

\[ d_{f,t}^2(u,v) = \sum_{x,y} f^2(x, y) - 2f(x, y)t(x-u, y-v) + t^2(x-u, y-v) \]

(14)

The term \( \sum t^2(x-u, y-v) \) is constant. If the term \( \sum f^2(x, y) \) is approximately constant, then the remaining cross-correlation term is a measure of the similarity between the image and the future.

\[ c(u,v) = \sum_{x,y} [f(x, y)t(x-u, y-u)] \]

(15)

C. Algorithm

1. Read two different ages of same person images and extract the features by using wavelet packet transform.
2. Finds the regional maxima in the input images. It returns a binary image of size is equal to the input image that identifies the locations of the regional maxima in the input image. In the output image, pixels that are set to 1 identify regional maxima; all other pixels are set to 0.
3. Find the statistical measures to these key points that means find mean to the key points.
4. After finding the mean of the key points measure the cross correlation between the two means.
5. If the output of cross correlation is equal to 1 then displayed the two face images are same.
6. If the output of cross correlation is equal to -1 then displayed the two images are different.
7. The above detailed algorithm is also shown pictorially as

V. RESULT

We present a novel method for feature extraction and the results are show that the experiments are conducted on face images of various ages. Different faces are taken from the FG - NET database. Take two input images of size 234X215 and 267X189 of the same person with different age groups.

Features are extracted by using wavelet packets to transform and regional maxima. Here the red and green color star (*) symbol indicates the maxima and minima key points. In the two images total number of maxima and minima key points obtained is 6741.

After extracting the maxima and minima key points in the two images find mean of these key points separately. The mean of the first image key points are obtained is
[114,122] and mean of second image key points obtained is [100,140].

In this paper match the images by using correlation. Here comparing the two mean of the key points by using correlation. If the correlation coefficient is 1 then display the two input images are same. If the correlation coefficient is -1 display the two images are not same. Here the correlation coefficient is obtained 1 the display the two input images are same.

VI. CONCLUSION

In this paper, we identify the problem of age invariant face recognition. A combination of wavelet packet transforms and regional maxima are proposed for extracting the features and match these features by statistical measures of mean and correlation. The proposed method’s performance is evaluated on FG-net database. The experiment shows that wavelet packet transform regional maxima method gives best performance for age invariant face recognition in comparison with other methods.

REFERENCES