# Face Recognition Based Wavelet-PCA Features And Skin Color Model

*Ali Hussien Mary*
*Mechatroncis Engineering Dept*
*AL-Khwarizmy Collage of Engineering*
*Baghdad University*
*Email: alihussien76@yahoo.com*

## Abstract

*In this paper, a face recognition system for personal identification using Discret Wavelet Transform(DWT), Principle component Analysis (PCA) and Back-propagation Neural Network is proposed. The system consists of three steps. In first step pre-processing (de-noising and face detection based on skin color in RGB color space) are applied on the input image. The DWT is used to generate the feature images from individual wavelet sub bands. Only the low frequency band constructed from Wavelet Coefficients are used as a feature vector for the further process.*

*The Principal Component Analysis (PCA) is used to reduce the dimensionality of the feature vector. Reduced feature vector are used for further classification using neural network Classifier. The proposed approaches are tested on a number of face images. Experimental results demonstrate the higher degree performance of this algorithm.*

*Keywords: Face Recognition, PCA .Wavelet ,Neural Network, Skin Colour.*

**الخلاصة**

*في هذا البحث تم اقتراح نظام لتمييز الأوجه للتعرف على الأشخاص باستخدام تحويل المويجة وعناصر المركبات الأساسية بالاعتماد على الشبكات العصبية.تتألف الطريقة المقترحة من ثلاث خطوات . في الخطوة الأولى تتم عملية معالجة أولية بالتخلص من الضوضاء الموجودة في الصورة ومن ثم تتم عملية اكتشاف الوجه بالصورة بالاعتماد على لون بشرة الجلد وبعد ذلك تتم عملية استخلاص الخواص الرئيسية للوجه باستخدام تحويل المويجة واستخدام المعلومات المهمة والمتمثلة بالترددات الواطئة واستخدامها باعتبارها تمثل الخواص الرئيسية والمهمة للوجه بعد ذلك يتم تقليل كمية البيانات عبر استخدام عناصر المركبات الرئيسية . ويتم تصنيف تلك الخواص باستخدام الشبكات العصبية. تم تطبيق الطريقة المقترحة على عدد من الصورة وأظهرت التجارب نجاح الطريقة المقترحة وكفاءته.*

## 1. Introduction

Face recognition systems have been grabbing high attention from commercial market point of view as well as pattern recognition field. Face recognition has received substantial attention from researches in biometrics, pattern recognition field and computer vision communities. The face recognition systems can extract the features of face and compare this with the existing database. The faces considered here for comparison are still faces.[1]

PCA method is a common approaches for face recognition. PCA is a popular approach in image processing and communication theory that is quite often referred to as a Karhunen–Loeve (KL) transformation. The PCA approach exhibits optimality when it comes to dimensionality reduction[2].PCA is often used as a preprocessing step to reduce the dimensionality[3]. Different approaches are used for extracting intrinsic facial features of image. One of the most powerful approaches for extracting intrinsic facial features is Wavelet transformation, which is capable of analyzing multi-resolution decomposition; indeed, wavelet decomposition technique is used for extracting intrinsic facial features. The other authors only have used one approximate image among four subimages relative to Wavelet decomposition. For instance, Chien performed face recognition using discriminant wavelet faces and nearest feature classifiers [4].

## 2. Principle component Analysis [4]

Let the training set of face images be $\Gamma_1$, $\Gamma_2$, ……………., $\Gamma_M$, then the average of the set is defined By

$$\Psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n \qquad \text{……………..(1)}$$

Each face differs from the average by the vector

$$\Phi_i = \Gamma_i - \Psi \qquad \text{……………(2)}$$

This set of very large vectors is then subject to principal component analysis, which seeks a set of $M$ orthonormal vectors, $Un$ , which best describes the distribution of the data. The $k_{th}$ vector, $U_k$ , is chosen such that

$$\lambda_k = \frac{1}{M}\sum_{n=1}^{M}(U_k^T \Phi_n)^2 \qquad \text{……………(3)}$$

is a maximum, subject to

$$U_I^T U_K = \delta_{IK} = \begin{cases} 1, & If\ I=K \\ 0, & Otherwise \end{cases} \qquad \text{……………..(4)}$$

Then the covariance matrix (c) will be determined as follows

$$c = \frac{1}{M}\sum_{n=1}^{M}\Phi_n\Phi_n^T = AA^T \qquad \ldots\ldots\ldots\ldots\ldots(5)$$

Where the matrix A=[$\Phi_1$ $\Phi_2$…….. $\Phi_M$].

Now any data $X$ can be projected into the eigenspace using the following formula:

$$Y = U_k(X-\Psi) \qquad \ldots\ldots\ldots\ldots\ldots..(6)$$

## 3.Color Models for Skin Color Classification

In order to detect human faces in an image, a good starting point may be to identify any face like object in the image. One possible way to achieve it is to find any region in the image that is skin coloured. In our work, skin tone is considered for detecting faces because of its efficiency and invariance to head pose, orientation[5].

The study on skin color classification has gained increasing attention in recent years due to the active research in content-based image representation. For instance, the ability to locate image object as a face can be exploited for image coding, editing, indexing or other user interactivity purposes. . In this section the color spaces are being described[6]

Skin detection using skin locus model or Color Models for Skin Color Classification although different people have different skin color, but several studies have shown that the major difference lies largely in their intensity rather than their chrominance [7]. Several value distribution models have been compared in different color spaces (RGB, HSV, YCrCb, etc.)[8]. Face localization also provides a good stepping stone in facial expression studies. It would be fair to say that the most popular algorithm to face localization is the use of color information, whereby estimating areas with skin color is often the first vital step of such strategy. Hence, skin color classification has become an important task. Much of the research in skin color based face localization and detection is based on RGB, YCbCr and HSI color spaces [6] .

### 3.1 Skin Colour Bounding Rules

From the skin colour subspace analysis, a set of bounding rules is derived from all three colour spaces, RGB, YCbCr and HSV, based on our training observations. All rules are derived for intensity values between 0 and 255. In RGB space, we use the skin colour rules. The skin colour at uniform daylight illumination rule is defined as [9].

$(R>95)$ AND $(G>40)$ AND $(B>20)$ AND

$(\max\{R,G,B\}-\min\{R,G,B\}>15)$ AND

$(|R-G|<15)$ AND $(R>G)$ AND $(R>B)$ ….(7)

While the skin color under flashlight or daylight lateral illumination rule is given by

(R>220)AND(G>210)AND(B>170) AND

(|R-G|≤15)AND (R>B)AND (G>B) ….(8)

To consider both conditions when needed, we used a logical OR to combine both rule (1)(eqn. 7) and rule (2)(eqn. 8). The RGB bounding rule is denoted as Rule A.

**Rule A**: Equation (7) $\cup$ Equation(8)

## 4. Discrete Wavelet Analysis

Wavelet transform is a representation of a signal in terms of a set of basis functions, which is obtained by dilation and translation of a basis wavelet. Since wavelets are short-time oscillatory functions having finite support length (limited duration both in time and frequency), they are localized in both time (spacial) and frequency domains. The joint spatial-frequency resolution obtained by wavelet transform makes it a good candidate for the extraction of details as well as approximations of images [10].The 2-D filter coefficients can be expressed as

$h_{LL}(m,n)=h(m)h(n),\ h_{LH}(k,l)=h(k)g(l)$ ……….(9)

$h_{HL}\ (m,n)=g(m)h(n), h_{HH}(k,l)=g(k)g(l)$ ……..(10)

Where, the first and second subscripts denote the low pass and high pass filtering, respectively,(Fig. 1) along the row and column directions of the image. Wavelet transform can be implemented (convolution and downsample) along the rows and columns separately.low-frequency components, which are decomposed by wavelet transform in each layer, contain most of energy of the original image

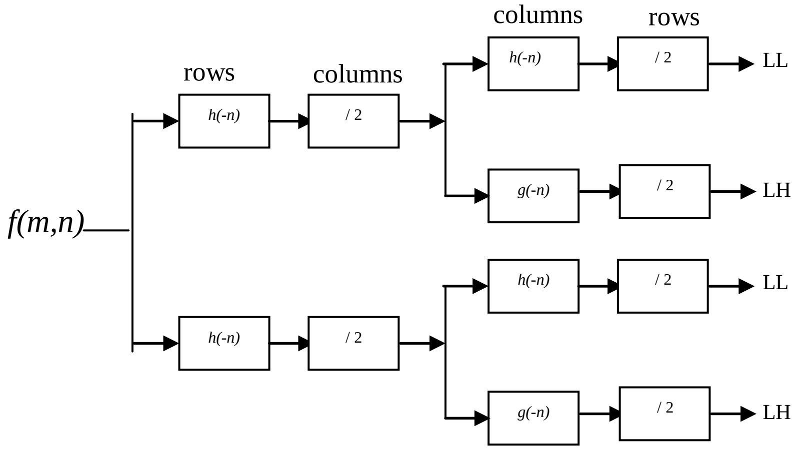



***Fig. 1 2D Wavelet Transform***

## 5. Training and Simulation of Neural Network

A large neural network for all people in the database was implemented. After applying DWT for the detected face in the input image and calculating the PCA for the low frequency coefficients of DWT. Then the resultant vector is used as inputs to train the neural network.

## 6. Proposed Method

The objective of the proposed work is to study the use of texture features in image Identification. The proposed method steps are.

*i)* Pre processing

*ii)* Feature extraction using wavelet transform and dimensionality reduction using PCA.

*iv)*Classification using neural network

In the next sections, we describe role of each part.

### 1) Pre processing

**a)Filtering**

The input face of the system may contain noise and garbage data that must be removed. Filter has been used for fixing these problems. For this purpose ,there are different methods for noise removing(in this paper de-noising method is implemented based on wavelet transform technique). After filtering, the image is clipped to obtain the necessary data that is required for removing the unnecessary background that surrounded the image. Also there are different method for subtracting the background[10].

**b) *Face Detection***

A skin color based technique is used for detecting frontal human faces in images where they appear. Fig. 2 represents the input image and the output one The output image then convert into gray scale image.

Additional measures are also introduced to determine the likelihood of a skin region being a face region. Two region properties – box ratio is used to examine and classify the shape of each skin region. The box ratio property is simply defined as the width to height ratio of the region bounding box. By trial and error, the good range of values lie between 1.0 and 0.4. Ratio values above 1.0 would not suggest a face since human faces are oriented vertically with a longer height than width. Meanwhile, ratio values below 0.4 are found to misclassify arms, legs or other elongated objects as faces. the box ratio property can be applied to the extracted skin regions either sequentially or paralleled, following a dilation, opening or flood fill.


***Fig.2 a)Input Image b)Face Detected. c)Bounded box for the face***

## 2) Feature Extraction

From the previous step(filtering and face detection ) a rectangular area(bounding box) containing the face is obtained. After this step of preprocessing, the wavelet decomposition is performed on the whole image but the wavelet coefficients will be considered only in the face bounding box. As mentioned above, discrete Wavelet Transform of 1st level is applied on the detected face image from the previous step. Each image is decomposed in to the Approximation, Horizontal, Vertical and Diagonal Coefficients. It is well-known that, as the complexity of a classi-fier grows rapidly with the number of dimensions of the pattern space, it is important to take decisions only on the most essential, so-called discriminatory information, which is conveyed by the extracted features. Thus, we are faced with the need of dimensinality reduction. An efficient way of reducing dimensionality is PCA.

## 3) Dimensionality Reduction

The feature extraction method used the approximation component of the wavelet coefficients and principal component analysis will be determined for these coefficients. We used these vectors to estimate the covariance matrix [14]. After estimation of the covariance matrix, significant eigenvectors of the covariance matrix are compute as follows.

Assuming that the approximation is $a_i$ $i=1,2..M$, and that there are $M$ images in the training set, then we have an image feature such that: $y=w^T(a-A)$ Where the mean image is:

$$A = \frac{1}{M}\sum_{i=1}^{M} a_i \qquad ...(11)$$

and $w$ represents the eigenvectors corresponding to large eigenvalues of the covariance matrix $(a-A)(a-A)^T$. Number of eigen-vector depend to our application and accuracy that we need, it is clear that if we compute large number of eigen-vectors accuracy of the method improved but computational complexity increased in this step and next step.

In this stage, we computed 100 most significant eigenvectors and related eigen-faces. By projection of every input image on these eigenafeces, they will convert to reduce size 100 × 1 vectors which will be go to the Neural network for training and classification

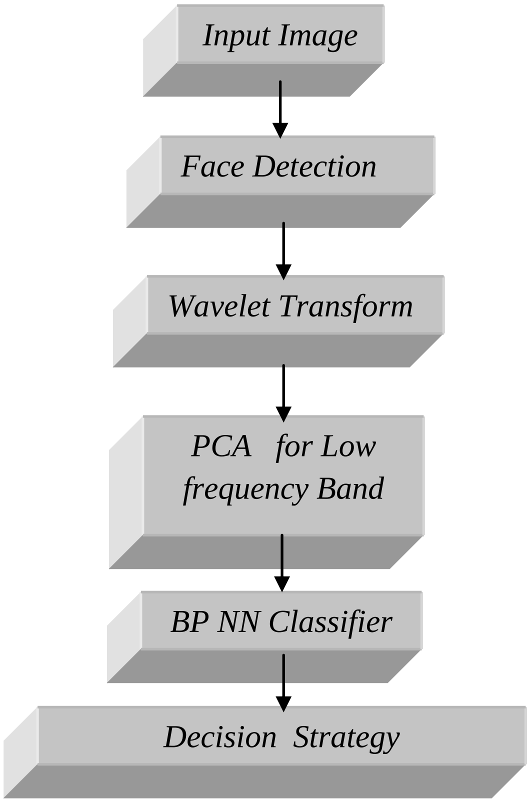



***Fig. 3 Proposed Algorithm***

### 4) Recognition

Extracted features of the face images have been fed in to the Back-propagation Neural Network for recognition. Fig.4 illustrates the overall process of calculating wavelet transform and PCA applied to the training images.

## 7. Experimental Results

To evaluate the performance of the proposed method, FACE RECOGNATION Databases and different images form the internet are used for testing the proposed method. All of the test images resize into 128*128. In this work, the resolution of images is changed in from of 128x128 to 16x16 using the wavelet decomposition. While 60% of the PCA coefficients are used.

We used a three layer perceptron neural network with 40 neurons in the input layer, 20 neurons in the hidden layer and 10 neurons in the output layer, for classification of the input data. A simple back propagation algorithm is used to update weights according to desired values. Three layers MLP neural network will train using training face images and at its output layer, it produces a 10×1 vector that each elements of that vector is a number between zero and one representing similarity of input face images to each of ten classes.

Training face image enter the neural network and according to their class, a back propagation error, spread on the network and correct the weights toward the right values. The input face image will classified to the class which has the greatest similarity to it. .All the algorithms are implemented in MATLAB 7.0.1 and executed using Mat lab 7.0 on a Celeron M 1.73GHz platform with 2G memories. To evaluate our experiments, we defined a two performance metrics to gauge the success of our schemes. Identification rate (IR) are [11] .

%IR=( True Identify / Number of tested Faces)*100% …..(12)

Three experiments used to test the proposed method, theses are:

## Experiment 1

In this experiment a noisy faces images are used as the testing image. Different types of noise are added to the testing faces images (Fig. 4). The results are displayed in table 1. (IR) in table 1 and other tables is calculated using eqn.(12) .

## Experiment 2

This experiment used 2 images of each individual (person) as training data and the third image as a test image (Fig. 5). The results are displayed in table 2.

*a)*  *b)*

***Fig.4 a) Training Image. b) Testing Image.***

a  b c

***Fig. 5 Three Image For One Person. Images (A) And (B) For Training And Image (C) For Testing.***

## Experiment 3

In the third category of experiments, different R, G, B variations of the original training and test images (Fig. 6) were carried out to test the robustness of the proposed method The R, G, B values of images were increased by 40% separately and the results were recorded as shown in

(a) (b) (c) (d)

***Fig. 6 a)Original Image b)Variations in R c) Variations in G d) Variations in B.***

***Table 1. Experiment 1 Results***

| Method | IR% |
|---|---|
| Proposed | 97 |
| PCA | 85 |
| Wavelet | 95 |

***Table 2. Experiment 1 Results***

| Method | IR% |
|---|---|
| Proposed | 98.4 |
| PCA | 85 |
| Wavelet | 96 |

***Table 3. Experiment 2 Results***

| Method | Increase Color Component | IR% |
|---|---|---|
| Proposed | R | 95% |
| | G | 91% |
| | B | 93% |
| PCA | R | 92% |
| | G | 90% |
| | B | 88% |
| Wavelet | R | 91% |
| | G | 87% |
| | B | 90% |

## 8. Conclusions

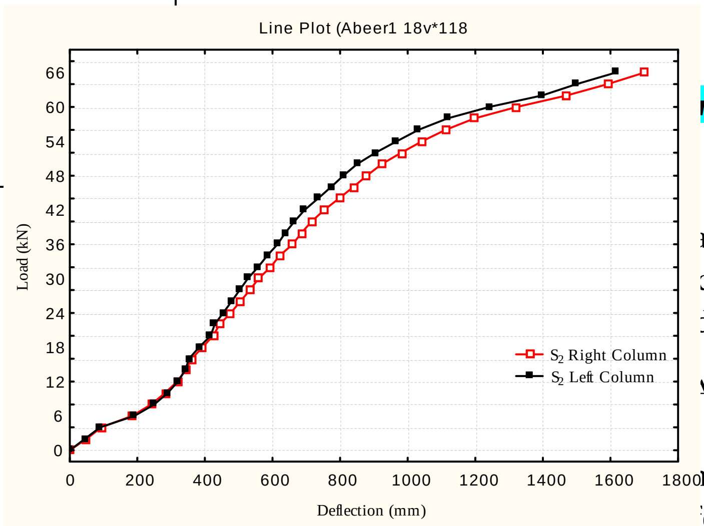
In this paper, a class of specific target problems in face recognition is proposed based features that extracted by wavelet and PCA and use BP neural network as classification methods, Feature extraction using wavelet-PCA is very fast as well as accuracy is very high on recognition rate. It also provides low dimensionality to reproduce and compare the results. This method uses wavelet decomposition to get different band information of face images. Different runs with the face dataset have proved a high accuracy of the face recognition system

Good results obtained (as shown in the previous tables) due to the following reasons:

**1)** Any variations in the background of the image will not effect on the result because the face detection procedure based on skin color does not affected by these variations.

**2)** The ability of wavelet transforms to remove the noise from the noisy image because noise is high frequency while only the low frequency used as the feature.

**3)** The ability of the PCA to reducing searching data by sorting the eigenvectors according to the eigen values.



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