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Wrist and Palm Vein pattern recognition using Gabor filter

Mohammed Hamzah Abed
Department of Computer Science
College of Computer Science and Information Technology
University of Al-Qadisiyah, Iraq
mohammed.abed@qu.edu.iq

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Abstract

Wrist and palm vein pattern can be considering as a promising biometric technique for identification, through the study of the pattern of blood vessels that visible from the skin. This kind of recognition is very important for many reasons; vein exists inside of the human body makes it difficult to change pattern like shift the position of vein from part to another, unlike another method of techniques of recognition. In this paper work wrist and palm vein are studied for identification and verification, this work divided into three phases preprocessing, features extraction and recognition. in preprocessing phase apply resize and image enhancement using CLAHE and 2-D Gaussian high pass filter , the features of each image are extracted by using Gabor filters. LDA and PCA are used to minimize the dimension of the features set. For vein image, identification used Euclidean distance to measure the similarity. The average CRR of vein palm in proposed work is 94.49% and the average CRR of vein wrist is 92.33.

Keywords: wrist vein, palm vein, identification, recognition, Gabor filter

1- Introduction

Since the past, people have cared much about the privacy and security as the privacy of their property or their places, therefore they put keys and locks to homes and houses. The main aim of all that is to preserve the security of what they own. The growth was very fast in the use of internet applications and deal with intelligent applications over the cloud or internet and using smart and personal computers or phones requires suitable and faithful methods to user verification for effective and secure access control to keep data or our personal machine safe and secure from unauthorized people to access and manipulate these data. “Biometrics is the science of testing methods for people identification and authentication on the basis of their physical or behavioral features “[1], [2], [3]. Vein pattern suggested used as biometric features by “Dr.K Shumizu” from “Hokkaido University” in 1992 and from that time vein pattern gain increasing interest from human identification researchers. Among other human biometric like iris and fingerprint, the recognition based on the vein pattern has many powerful than other techniques. It is different for every human, does not change with growing up, also it requires blood in veins, to be registered, which solves the liveness problem and stealing the identification key [3]. Vein matching is a technique or way of biometric verification [4]. Palm vein exists inside of the human body it makes it difficult to change vein pattern like move vein’s place or to fake than

other biometrics such as iris and fingerprint, and it is impossible to be forgotten. Vein identification uses the unique patterns of the vein to identify individuals at a high level of precision [5]. In this work, the system includes three stages preprocessing, features extraction and matching.

2- Image database

Palm and wrist vein images database are selected from "The Institute of Control and Information Engineering, Poznan University of Technology, Poland". During their research work, they gathered image database. Were used in training part and testing the palm and wrist vein recognition system, PUT Vein pattern database consists of 2400 images. Half of them collected from left and right palm, and another half collected from wrist for left and right of 50 volunteer of institute's student. The pictures of each person of palm and wrist region were taken in three sessions four images each one "palm and wrist" at least one week between each series. Images in the PUT database have 1280x960 resolution and are saved as 24-bit bitmap file image format [1], [2].

3- Proposed Methodology

As shown in Figure.1, the proposed method consists of two major parts first is enrollment and second is verify. Each of them consist of three phases preprocessing, feature extraction and matching. Features extraction based on Gabor filter, dimension reduction then select and generate new features. Based on the new features matching phase work. And check the input vein image verified or not.

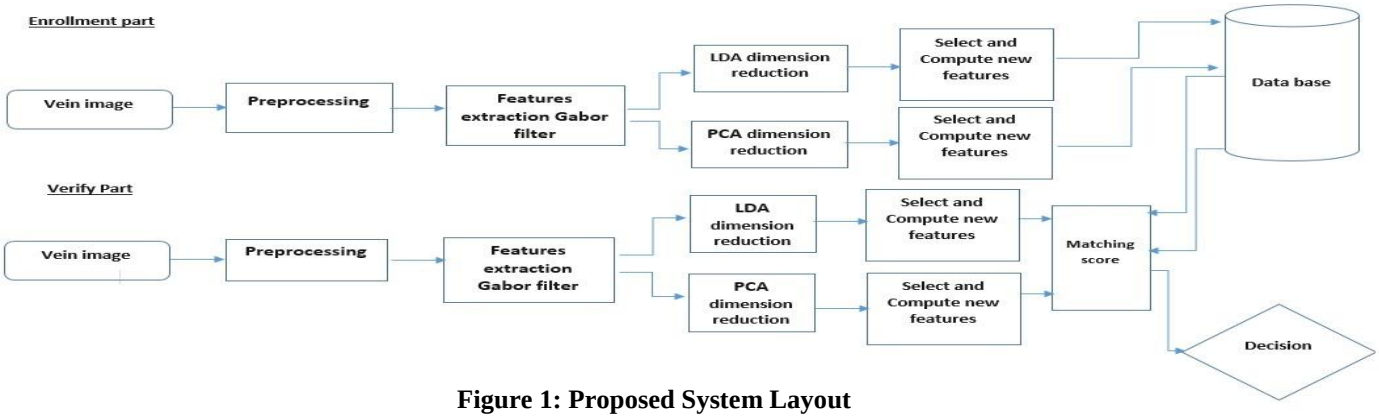

Figure 1: Proposed System Layout

3-1 Preprocessing based on Discrete Fourier Transform

The preprocessing phase used to obtain images which have normalized intensity and uniform size of all images in database, and depict only the most important part of palm and wrist vein images. In this phase vein palm images are scaled to the same size of 200 ×150 pixels and convert it into one band gray image to be ready for enhancement stage. Discrete Fourier transform "DFT" is a fundamental tool in signal processing but it is relatively seldom used in image processing because of difficulties with image interpretation in the frequency domain [6]. DFT in image processing used for the linear filter design. This method used in this proposed work to enhance the vein to be darker than the background to extract the features from the structure of the vein. In this work two-dimensional DFT and IDFT are applied to get the images back and take the real part of the 0-255 gray level value. The following steps can be describing the preprocessing phase:

1. For the input image (I) adjust the intensity of each pixel and then apply enhancement methods contrast-limited adaptive histogram equalization (CLAHE) to enhances the contrast of the grayscale image by transforming their values.

2. For the output image of the first step, a spectrum is calculated using Discrete Fourier transform.
3. The DFT coefficient are multiplied by Gaussian high-pass filter with "σ = 0.8" chosen experimentally [1].
4. Apply inverse Discrete Fourier transform of the result from step number three.
5. After applying IDFT, calculate negative image for all images in the database to be ready for extract features. Figure.2. show the result of the reprocessing phase.

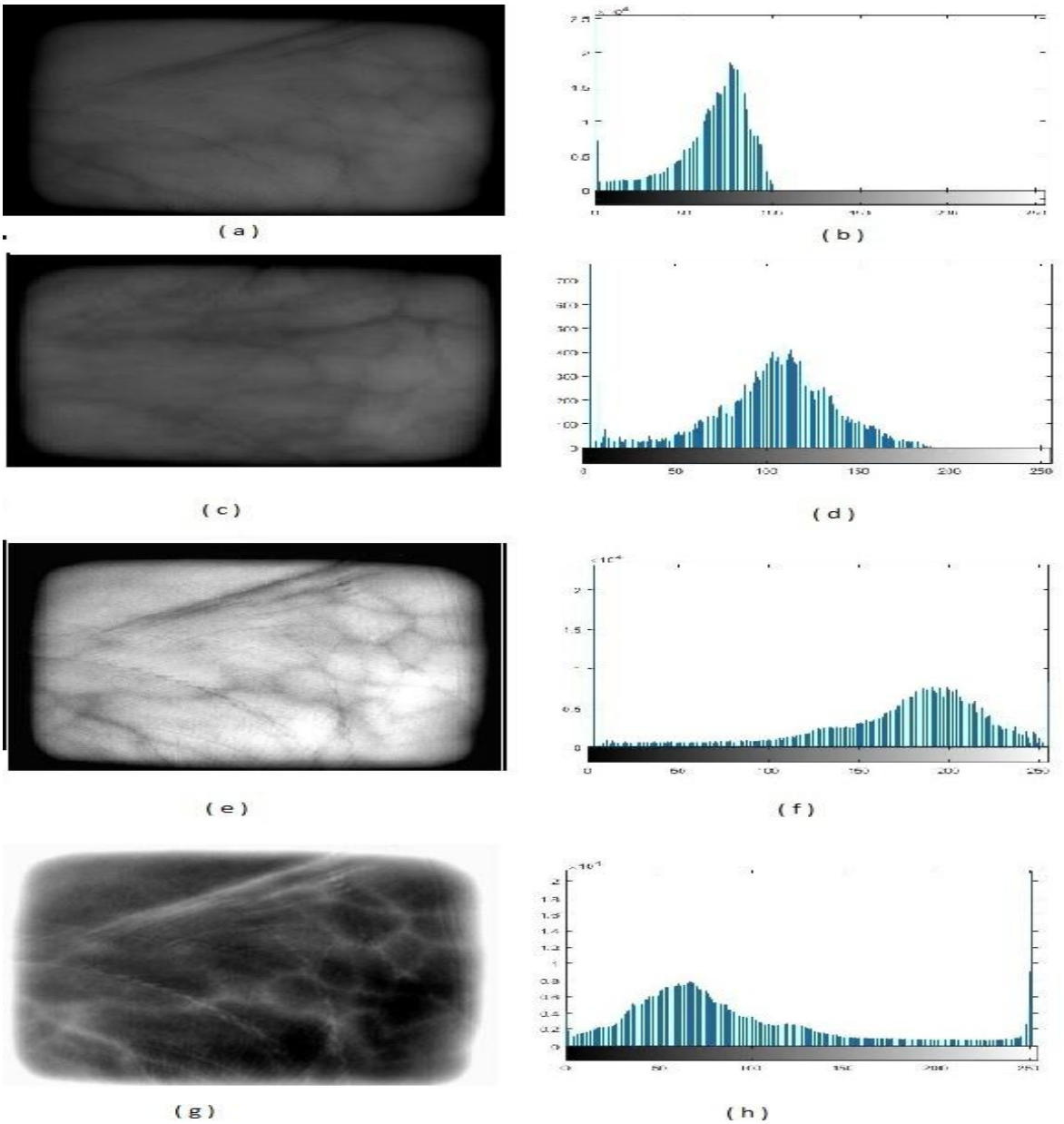

Figure 2: (a) original image (b) histogram of original image (c) Enhanced image (d) histogram of Enhanced image (e) 2-D Gaussian high pass filter (f) histogram of (e), (g) negative of enhancing image (h) histogram of negative image

3-2 Features extraction based on Gabor filter

In all pattern recognition system that most important phase is features extraction, because the features that extracted from each image who is belong to any person in the database can be consider as an ID, that used in identification phase. "The feature extraction phase represents a key component of any pattern recognition system "[6].in this case features extracted based on Gabor filter for a whole vein palm and wrist images.

3-2-1 Gabor filter

Gabor filters are commonly known [7] as one of the good choices for obtaining localized frequency information. "It is a band pass filter which has orientation selective and frequency-selective features and optimal joint resolution in both spatial and frequency domain [3]". "Gabor filters have been used for pattern analysis" [3], the feature extracting and texture analysis that they were most known as a good method in capturing some specific local features in the texture image. A two-dimensional Gabor filter is a two component combined together real part and imaginary part. A complex plane wave and a Gaussian-shaped function. As shown in the equation number 1

$$g(x,y)=\left(\frac{1}{2\pi\sigma_x\sigma_y}\right)\exp\left[-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)+2\pi jWx\right] \quad (1)$$

Where б x and б y denote the scaling parameters of the filter in the horizontal (x) and vertical (y) directions, and W denotes central frequency of the filter. The Fourier transform of the Gabor function g (x, y) is defined as:

$$G(u,v)=\exp\left[-\frac{1}{2}\left(\frac{(u-W)^2}{\sigma_u^2}+\frac{v^2}{\sigma_v^2}\right)\right] \quad (2)$$

Where $\sigma_u = 1/2\pi\sigma_x$ and $\sigma_v = 1/2\pi\sigma_y$

The Gabor filter has two-part imaginary and real part. The imaginary part "odd symmetric ", Gabor filter is mostly used for determined edge. The real part "even symmetric" Gabor filter is mostly used for detecting the ridge in the image [7], [8]. In this proposed work features extraction based on Gabor filter used and a bank of Gabor filter built with 5 scales and 8 orientations. After creating filter bank and get the set of features of each image in database reduction operation apply to reduce the features and used only the useful.

3-3 Features selection

When the features extraction phase has been done the image's features represented as a vector one-dimension row consist of many variables.so the main aim of this phase to reduce the number of features into uncorrelated features to be considered for recognition. In this paperwork, two methods are subjected to select features.

3-3-1 Principal component analysis "PCA"

The main linear technique for dimensionality reduction [9], "principal component analysis", is a statistical method that uses a perpendicular transformation to reduce a set of associated data into a set of values of linearly uncorrelated data called principal components. "The number of principal components is less than or equal to the number of features or original variables "[9].

3-3-2 linear discriminant analysis "LDA"

"LDA is a generalization of Fisher's linear discriminant" [10], a technique that used in pattern recognition and machine learning to find a linear set of features that classified into two or more classes of objects or event. The resulting of combination features may be used "in general as a linear classifier, or, more commonly, for dimensionality reduction before classification". LDA is also closely related to "principal component analysis PCA" both of them work on the original variables to find a linear combinations of variables which can be consider as a best explain the data [11] and can be used to

recognition system. LDA mostly used to model the difference between classes of data. PCA does not consider any difference in class. After applying dimension reduction to select good features, in both of methods LDA and PCA, applying statistical measurement on the selective features to generate a set of values to be considered in recognition or matching phase.

3-4 Features transformation

In this phase the features transformation were calculated of the features that have been selected in both of LDA and PCA dimensional reduction. The new features are mean, Standard deviation, variance and entropy, for each person generate new features depend on the features that selected by dimensional reduce techniques.

First of the new features is mean is the average value, so tells us something about the general brightness of the image [12], in this case, the mean calculated of selected features. The mean can be formulated in equation number 3:

$$mean = \frac{1}{n} * \frac{1}{m} \sum_{x=1}^{n} \sum_{y=1}^{m} I(x,y) \quad (3)$$

Also Standard deviation consider as a new feature, which also known as the square root of the variance gives some knowledge about the contrast. It describes the expansion in the data, an image with high contrast should have a high standard deviation [12], and it is defined as a formula in equation number 4.

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\sum (X - \overline{X})^2}{N}} \quad (4)$$

Finally, variance and entropy the last of the new features are a measure of how evenly energy is spread and distributed in an image or data, entropy provides a measure of the amount of energy that can be formulated in equation number 5.

$$e = -\sum_{i=1}^{L} P(zi) \log P(zi) \quad (5)$$

These variables belong to each person of the database for both left and right hand and wrist.

3-5 Similarity measurement

A minimum distance classifications are used to check the similarity and dissimilarity between two patterns of different classes or two set of features in the same size. The smaller distance value between two patterns is a similar more than other patterns or classes. The classifier finds the distances between a query input vectors to all vectors of the data set of all database. In this paper work used Euclidean distance to measures the similarity between the input vein image "palm and wrist "and database [13]. The Euclidean distance between two points, x_1, and x_2, with j dimensions, can be calculated as an equation number 6

$$Euclidean\_dis = \sqrt{\sum_{1}^{j} (x_{1j} - x_{2j})^2} \quad (6)$$

3-6 Experiment result

In an experiment, a total number of Vein pattern images consists of 2400 images, 1200 images contain a palm vein pattern and another 1200 images contain a wrist vein pattern. Images were collected from left and right hand and wrist of 50 volunteer, which means in this work the total number of pattern is 100 different characteristics for palm and wrist area. Pictures were taken in 3 sessions, 4 images each time, with a one-week at least between each session.in the proposed work the testing database and training database are mutually exclusive, with 300 images of palm vein and wrist vein for each left and right as a training set and another 300 images as a testing set of palm and wrist for left and right. The size of each image 200×150 resolution with 256 gray level BMP image. To implement effective system for recognition, the experiments were implemented to identification

and verification of palm vein and wrist vein. In the identification phase the correct recognition ratio (CRR) was considering as a measurement of the effectiveness of the accuracy of the algorithm, and in verification mode the measuring of the effectiveness of the methods tested by "false rejection rate "(FRR) and "false acceptance rate" (FAR) and the relation between them depict by receiver operating characteristic ROC [15], [16].This section consists of three experiments result to check the performance of the proposed work for wrist and palm vein recognition. The first experiment shows the preprocessing phase in every step and validity of it, the second experiment shows the identification result and comparison of two different methods of dimensional reduce, the third experiment discuss the verification and ROC graph FAR against FRR.

3-6-1 Performance of preprocessing and features extraction

The first experiment in the proposed work is an enhancement of the database's images. to be easy for extract region of interested of palm and wrist vein image.in this work enhancement including "CLAHE" and "2-D Gaussian high pass filtering" [2], then apply negative image for all database's image to be vein pattern visible and easy to extract features from the pattern. In figure number 3 example the give to show every step of enhancement phase, in this figure a is the original image and b is the histogram of a, c is an enhancement of a with CLAHE, d is a histogram of c, e is an enhancement of c with 2-D Gaussian high pass filtering, f is a histogram of e finally g is the negative image of e and their histogram presented in h, this image will extract the features from it by using "Gabor filter". In this proposed work the bank of Gabor filter built with 5 scales and 8 orientations. After creating filter bank and get the set of features for all database, the number of features more than 200000 value, and for sure not all that values are useful for recognition. In this case used dimension reduction to reduce the number of redundancy values. To reduce the set of features in this work used PCA and LDA. Then from the new set of features compute the mean, standard deviation, entropy and variance to be final features of each image in this database as shown in equation number 3, 4 and 5. The first test of the features without reduction get the recognition rate not exceed 80%, in the second test apply dimension reduction to reduce the redundancy values and generate new set of features for each image mean, SD, Entropy and variance in this case as shown in table number 1 and 2 the reduction using PCA achieve good result compare with LDA in this case.

3-6-2 Identification

In identification mode, the efficiency and performance are evaluated by computing the parameter "Correct Recognition Rate" (CRR) is the ratio of the number of correct recognition to the total testing pattern. Table 1 and table 2 show the successful ratio of recognition for both vein palm image and wrist vein palm image for left and right. In the experiment the threshold is "0.05" of the correct match in Euclidean distance selected during multi-run of the system that implemented using "Matlab R2015a" for palm vein, depend on the minimum error rate of recognition, and for the wrist vein the ratio that has been selected is "0.04".

Table1: Performance comparison of palm vein database base on features reduction

Database name	Reduce features	Right match	Wrong match	rejection	Successful rate	Minimum distance
R palm vein	PCA	287	8	5	95.66%	Euclidean
R palm vein	LDA	280	14	6	93.33%	Euclidean
L palm vein	PCA	288	6	6	96%	Euclidean
L palm vein	LDA	279	15	6	93%	Euclidean

Table 2: Performance comparison of wrist vein database base on features reduction

Database name	Reduce features	Right match	Wrong match	rejection	Successful rate	Minimum distance
R wrist vein	PCA	278	12	10	92.66	Euclidean
R wrist vein	LDA	271	16	13	90.33	Euclidean
L wrist vein	PCA	282	11	7	94	Euclidean
L wrist vein	LDA	277	14	9	92.33	Euclidean

3-6-3 Verification

The performance of the verification mode is evaluated and measure by calculating the Receiver Operating Characteristic (ROC) curve; it explains the FRR against the FAR at different threshold on the matching score. The performance is evaluated by computing EER measure; which is defined as the rate of error based on FAR and the FRR when they are equal. The threshold values have been selected based on minimum error. Threshold value selected by experiments test during multi run to the recognition system. As shown in table 3 and table 4 the "FRR" and "FAR" values in different threshold value for palm and wrist in sequence for both right and left. And Figure 3 shows the ROC curve of the right vein palm image depend on the result of "FRR" against "FAR" and Figure 4 shows the details of left vein palm image. And for wrist vein image table 4 discussed the "FRR" and "FAR" of left and right vein image. Figure 5 and Figure 6 shown the ROC curve of the wrist vein image for right and left in sequence.

Table 3: FAR and FRR versus different threshold value for vein palm image

Threshold	FRR right palm	FAR right palm	FRR left palm	FAR left palm
0.05	0.016667	0.003333	0.02	0.003333
0.06	0.013333	0.013333	0.013333	0.006667
0.07	0.01	0.023333	0.006667	0.013333
0.08	0.003333	0.026667	0.003333	0.02

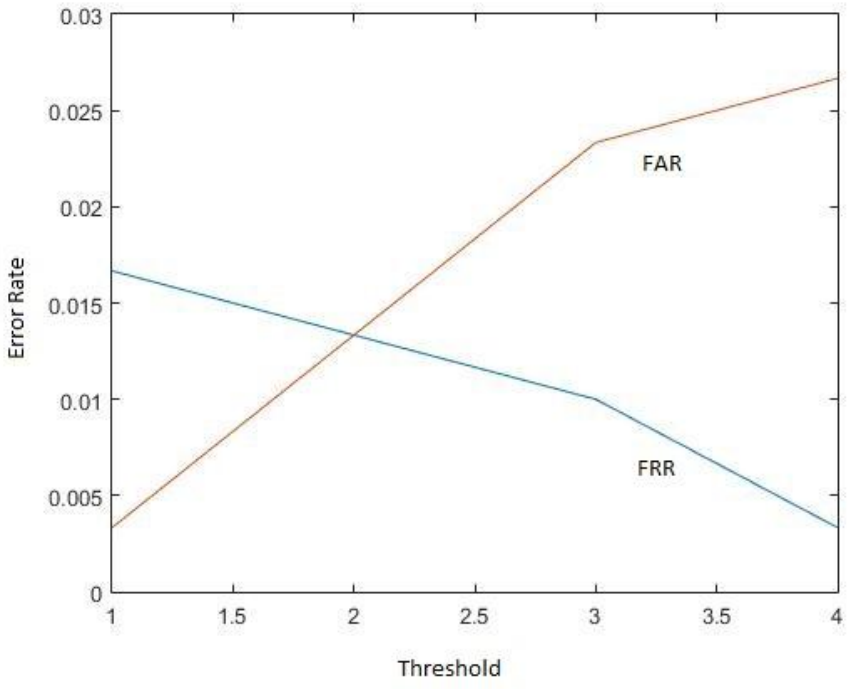

Figure 3: The ROC curve of right vein palm using PCA

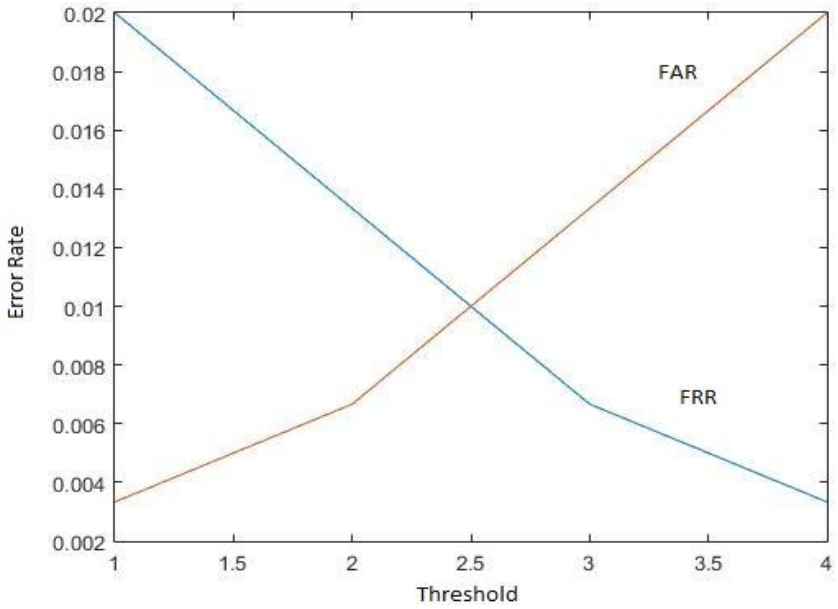

Figure 4: The ROC curve of left vein palm using PCA

Table 4: FAR and FRR versus different threshold value for vein palm image

Threshold	FRR right wrist	FAR right wrist	FRR left wrist	FAR left wrist
0.05	0.04	0.006667	0.036667	0.003333
0.06	0.033333	0.016667	0.023333	0.01
0.07	0.02	0.023333	0.013333	0.016667
0.08	0.01	0.033333	0.006667	0.023333

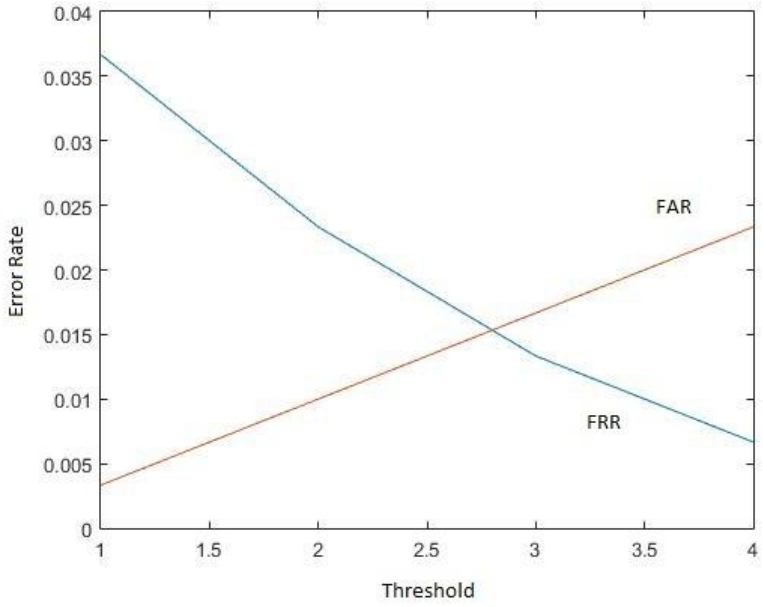

Figure 5: The ROC curve of right vein wrist using PCA

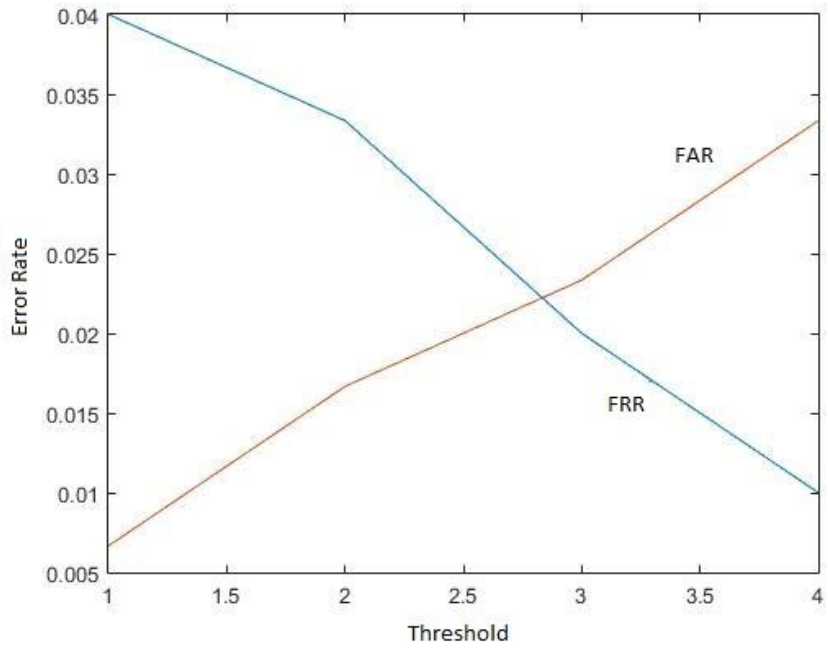

Figure 6: The ROC curve of left wrist palm using PCA

4- Conclusion

In this paper work, personal verification and identification based on wrist and palm vein has been discussed in detail. The system operation can be divided into three image processing phases: preprocessing "resize and enhancement", features extraction and matching. The vein images are enhancement using contrast-limited adaptive histogram equalization (CLAHE), and then using 2-D Gaussian high pass filter. Then a bank of Gabor filter is created and convolution for the enhanced vein images and used the convolution images as feature vectors. The dimensional reduction is implemented using LDA and PCA to get best features for verification and identification. In this work database that used consist of 2400 images gathering from 50 students. The proposed work achieve a good result and performance proved by the experiment. Finally, the system has been implemented using Matlab R2015a. The rate of result for recognition system based on "PCA" achieved good values better than that used "LDA" features reduction for both palm and wrist.

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تمييز نمط اوردة اليد والرسغ بأستخدام مرشح كابور

محمد حمزة عبد الصالحي
جامعة القادسية
كلية علوم الحاسوب وتكنولوجيا المعلومات
قسم علوم الحاسوب
البريد الالكتروني : mohammed.abed@qu.edu.iq

المستخلص :

نمط الاورده وشكلها في اليد والرسغ من الممكن جداً ان تعتبر كأحد الطرق الواعدة في مجال تحديد الاشخاص ومعرفتهم من خلال الاجزاء البايولوجية لديهم مثلا بصمة اليد والابهام وقزحية العين. من خلال تصوير للمنطقة المطلوبة خلال تدفق الدم في الاوعية الدموية الذي من الممكن تحديدة من سطح البشرة. هذا النوع من تمييز الانماط مرغوب جداً للباحثين في مجال تمييز الانماط لعدة اسباب اهمها ان الوريد يكون داخل جسم الانسان ومن المستحيل تغيير مكانه الا اذا ما تعرض لحادث وفي هذه الحاله يكون الوعاء غير مملوءة بالدم وبالتالي يخسر شكله ولا يتم التمييز على خلاف الطرق الاخرى التي من الممكن ان يتم اختراقها. في هذا البحث تم التركيز على نمط الوريد في اليد والرسغ لتحديد الاشخاص الموثوقين او لمعرفة هويتهم وهذا العمل تم تقسيمة الى ثلاث اجزاء : مرحلة المعالجة الاولية ، استخلاص الخصائص و المطابقة في اول مرحلة تتم اعادة تحجيم الصور في قاعدة البيانات بحيث تكون ملائمة للعمل عليها وتحديد المنطقة المفيدة للعمل والتركيز عليها بالاضافة الى عملية التحسين التي تتم من خلال تطبيق مرشح كاوسيان و"CLAHE" . في الخطوة الثانية يتم استخلاص الخصائص الاولية للصورة من خلال تطبيق مرشح كابور بعدها تتم عملية تقليل الخصائص من خلال تطبيق " LDA" و "PCA " . بعدها يتم اعادة توليد خصائص جديده لكل صورة من خلال تحديد الطاقة والتباين والانحراف المعياري وعدة قيم للخصائص المختارة سابقاً. في المرحلة الاخيرة تتم عملية المطابقة من خلال قياس مسافةEuclidean بين الصورة المدخلة وقاعدة البيانات وتحديد اقل قيمة كأقرب نتيجة بعد حساب مستوى حد العتبة يتم تحديد التطابق او عدم التطابق . وكانت النتائج CRR لليد اليمنى واليسرى ٩٤.٤٩% و قيمة CRR للرسغ الايمن والايسر ٩٢.٣٣%.

الكلمات المفتاحية : اوردة الرسغ ، اوردة اليد ، التعريف ، التمييز و مرشح كابور