



## Palm Vein Recognition Based on Centerline

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### Abstract

The palm vein recognition is one of the biometric systems that use for identification and verification processes since each person have unique characteristics for the veins. In this paper we can improvement palm vein recognition system have been made. The system based on centerline extraction of veins, and employs the concept of Difference-of Gaussian (DoG) Function to construct features vector. The tests results on our database showed that the identification rate is 100 % with the minimum error rate was 0.333.

**Keywords:** Biometric System, Palm Vein Recognition, Centreline Extraction, DoG Function.

### تميز اوردة راحة اليد اعتماداً على الخط الوسطي

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### الخلاصة

تميز اوردة راحة اليد هي واحدة من النظم البيولوجية التي تستخدم لعمليات التحديد والتحقق من الهوية حيث ان كل شخص له خصائص فريدة من نوعها لأوردته. في هذا البحث نحاول ان نحسن نظام التعرف على اوردة راحة اليد. هذا النظام يعتمد على استخراج الخط الوسطي من العروق، وتوظيف دالة الفرق الضبابي (Difference of Gaussian)) لأنشاء ناقلات الخصائص المميزة (feature vectors) . و تظهر النتائج التجريبية على قاعدة البيانات أن معدل التمييز هو 100% مع اقل معدل خطأ 0.333.

### Introduction

In contemporary societies, technological development plays an important and active role in the lives of people where he facilitated life dramatically, On the other hand fraud, security threats and theft of personal data develops in parallel; so it is very important to save data and secure them completely far away from manipulation and misuse and theft through a password, ID cards and personal identification numbers (PINS). But it remains impersonation is, theft and duplication impedes data security, this conflict has led to the development of Biometrics systems and used to secure personal data [1, 2].

Palm vein is a kind of biometric technologies that used for authentication that announced by Fujitsu Laboratories Limited 2002 as a method to identify the person's identity. Each person has unique

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characteristics for the veins is physical can be used for verification [3]. The near Infrared light (NIR) is most suitable to acquire the Palm vein samples [1].

Comparing with the other biometric techniques, palm vein is less costly, difficult to fake or change because it's unique internal information from a human's body, and easy to acquisition [4].

#### Related works

Many researchers showed their interest about palm vein recognition systems some of the published works related to the objectives of this paper are given in the following :

1. Tang in 2012 presented an approach for hand-dorsa vein recognition based on multi-level keypoint detection approach. This system composed by Harris-Laplace and Hessian-Laplace detectors in order to find enough keypoints; and then apply SIFT based local matching to associates these keypoints between hand vein of the same person [5].

2. Manikanda in 2013 proposed an approach for authentication system using palm vein. This system based on wavelet transform since the distribution of energy feature for all veins can reflected by wavelet energy. The feature vector is constructed by calculate the energy of approximation sub band. The Euclidean distance is used for measuring the similarity between energy features [6] .

3. Asmaa in 2014 presented a personal palm vein recognition system based on spatial energy distribution of wavelet sub-bands, after pre-processing image, apply discrete Haar wavelet (DHW) and compute the average energy distribution for each sub-band, the feature vector established by concatenated these sub-bands [1] .

4. Bharathi in 2015 proposed an approach for hand vein recognition based on multi-modal biometric: finger vein, palm vein and dorsal vein of the hand the features are extracted using both of scale-invariant feature transform (SIFT) and Shearlet transform, these features are matched and fused using maximum likelihood ratio technique for recognition process, the databases of finger vein, palm vein and dorsal vein are used to tested performance of this system [7].

5. Prasathkumar in 2016 proposed an approach to extract features from the dorsal hand vein pattern. After pre-processing and skeletonization, the key features ( $r$  and  $\theta$ ) were extracted from skeleton of vein by using Hough transform, and then apply K-nearest neighbor for matching task [8].

#### Proposed System

The overall system includes two major phases to identify persons by biometric system depending on his/her physical and/or behavioral traits, namely: (1) enrollment stage (2) recognition stage. During enrollment phase the image is process and extracted its features to generate template that storage in database along with the person's identity, this template was used for future comparisons in order to identify a specific authentication user. While in the recognition phase the image is process and extracted its features to generate template and comparison with corresponding reference samples that stored in database in order to determine the person identity, There are two types of identity management functionalities, namely, verification and identification. Figure-1 shows the diagram of propose system, which it contains three steps: (1) pre-processing, (ii) feature extraction, and (iii) matching process.

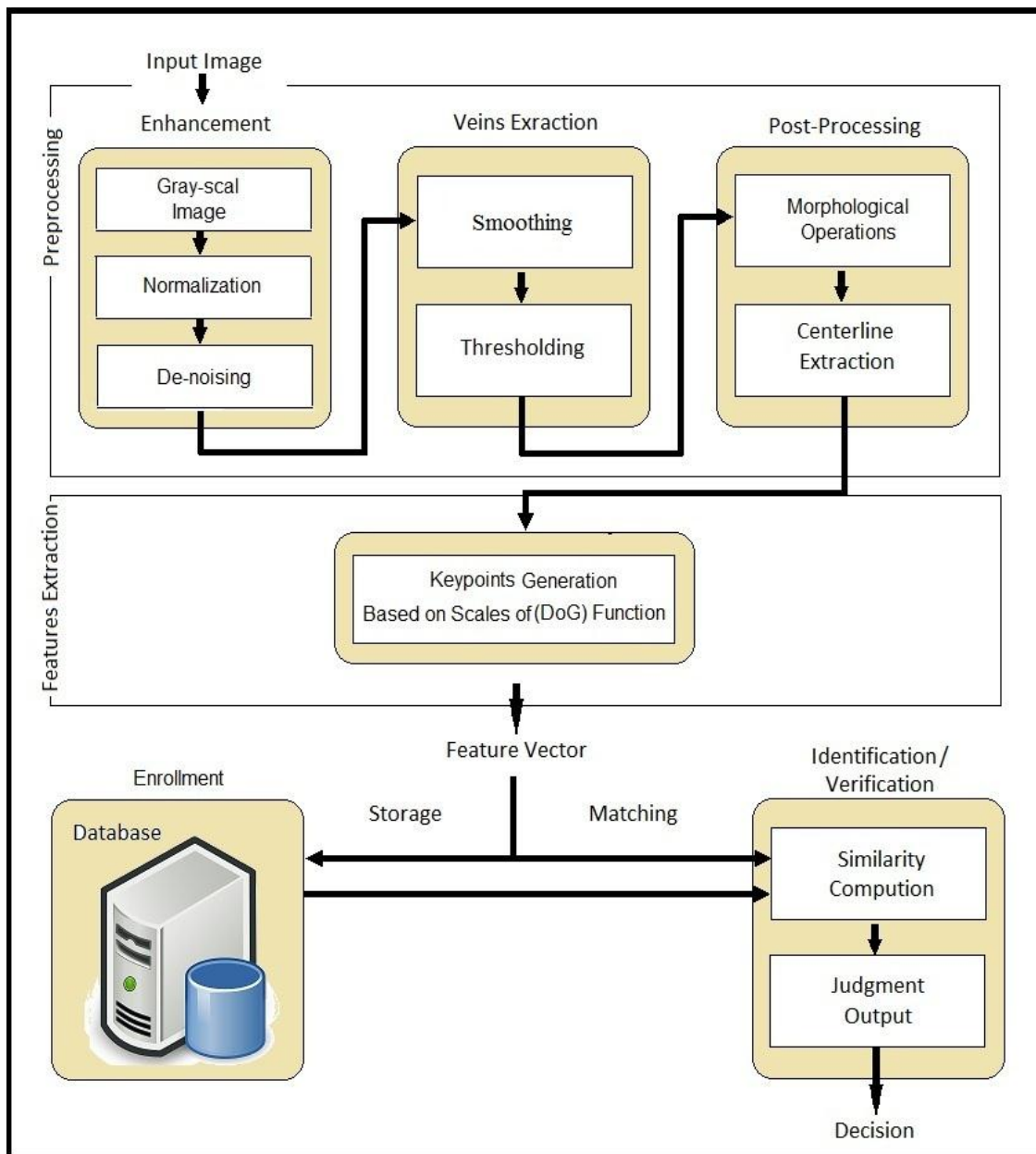


Figure 1- The Diagram of Propose System.

**1. Pre-processing:**

The need for pre-processing is due of problems that may appear during image acquisition (e.g. rotation, Illumination etc.). For this work the pre-processing is down using the following steps:

**1.1 Image Enhancement**

The aim of this stage is to enhance the wanted vein pattern and reduce the unwanted information in order to extract common features. This is done by: (i) converting a raw image into a gray intensity image. (ii) Adjusting the contrast of grayscale image, by stretching the contrast of the image using the following equation:

$$Stretch(I(r, c)) = \left[ \frac{I(r, c) - I(r, c)_{MIN}}{I(r, c)_{MAX} - I(r, c)_{MIN}} \right] [MAX - MIN] + MIN \dots \dots \dots (1)$$

Where  $I(r, c)_{MAX}$  and  $I(r, c)_{MIN}$  refer to the highest and the lowest gray level values in the gray image, MAX and MIN refer to the greatest and smallest gray level values. (iii) De-noise image using median filter which it replace the statistical median of its (3x3) neighborhoods.

**1.2 Vein Segmentation**

The aim of this step is to segment a vein of an image based on its pixels values by setting pixels values to 1 for vein and 0 for background and produces a binary image which is performed by: (i)

blurring image using mean filter, this is by replacing the center pixel value in the output image  $\hat{g}(x, y)$  with the mean value of a  $(N \times M)$  neighbouring pixels of  $g_i(x, y)$  as shown in equation (2):

$$\hat{g}(x, y) = \frac{1}{N \times M} \sum_{i=1}^{N \times M} g_i \dots \dots \dots (2)$$

In this work create a window size  $(N \times M)$  is  $11 \times 11$  pixels. (ii) Thresholding image to extraction the vein with binary image (1 for vein and 0 for background) this implemented by subtracting the grey intensity image  $g$  from the blurring image  $\hat{g}$ , as shown in equation (3):

$$h(x, y) = \begin{cases} 1 & \text{if } ((\hat{g}(x, y) - g(x, y)) + \alpha) < 0 \\ 0 & \text{otherwise} \end{cases} \dots \dots \dots (3)$$

Where  $h$  is a threshold image,  $(x, y)$  are coordinates and  $\alpha$  is constant value, through the experiments when  $\alpha = 0.015$  gets more acceptable and close to the original image.

**1.3 Post Processing**

Some of post processing operations should be applied for retaining object with an image, which can be use morphological operations, cleaning operation in order to remove the undesired pixels, for example fewer than 50 pixels in this work. Also, closing operation to remove holes (spaces) those appear on the vein region. Figure-2 illustrations each step of pre-processing phase.

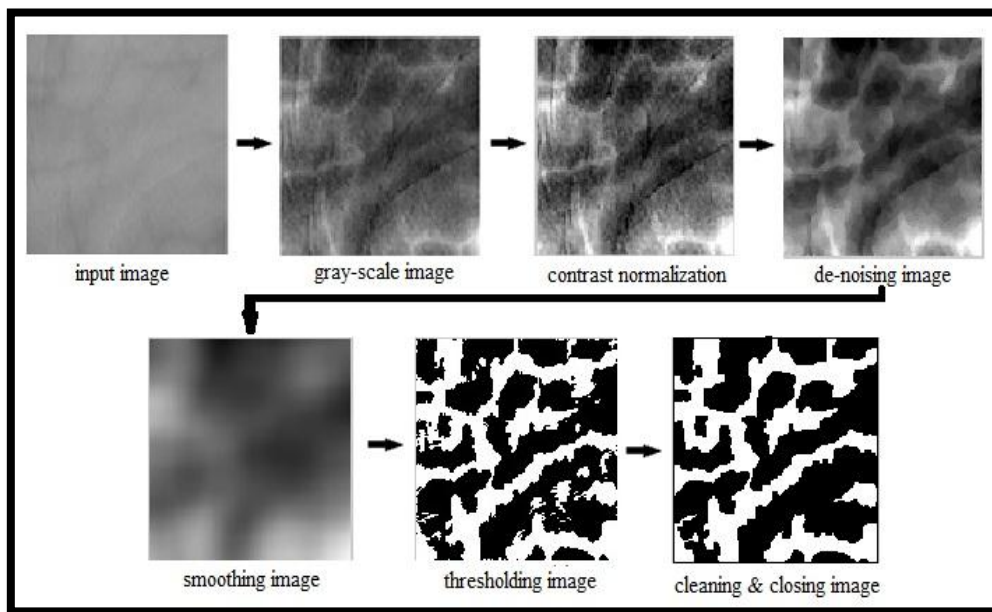


Figure 2- pre-processing steps

**1.4 Centerline Extraction**

Image of vein resulting from the previous pre-processing operations showing the vein’s width varying from one location to another, it is may due to the pre-processing operations, therefore, the centerline extraction is an important step to get more accurate results and better understood and handled for vein’s shape, where it can be reconstructed original shape of veins from their centerlines and it's reduces the processing time.

In this paper, the vein centerline was extracted as the following sub-steps: (i) compute the distance form boundary (DFB) (ii) applies equations (4) to find most of central points (iii) put these central points on the (DFB) image (iv) link all of central points with each other based on pixel value as illustrate in algorithm (1).

$$L(x, y) = \begin{cases} 1 & \text{if } im(x + 1, y) > im(x, y) < im(x - 1, y) \\ 1 & \text{if } im(x, y + 1) > im(x, y) < im(x, y - 1) \\ 0 & \text{otherwise} \end{cases} \dots \dots \dots (4)$$

Where  $L$  is a binary image and  $im$  is the vein grayscale image after applying (DFB). The thinning morphological operation is used after subtracting DFB image from resulting image to get a centerline. Figure-3 shows steps of centerline extraction task.

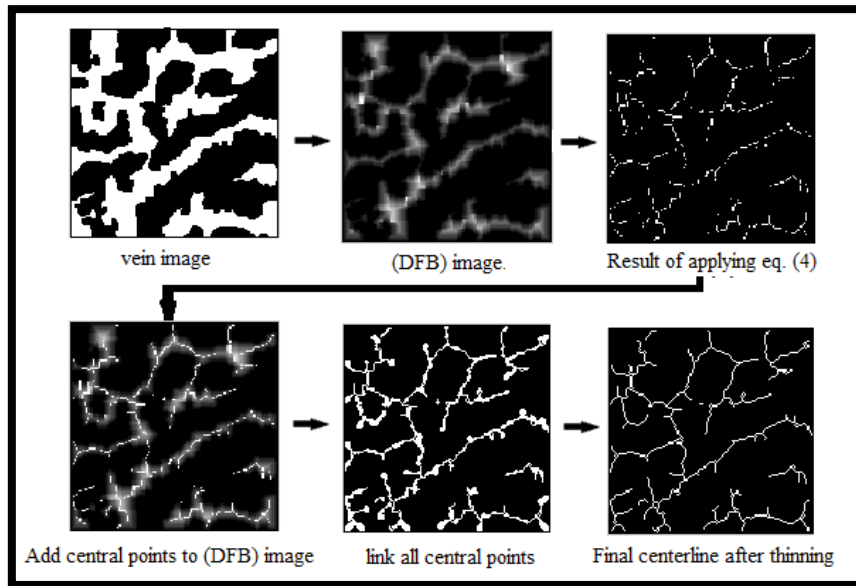


Figure 3- Centerline Extraction steps

#### Algorithm 1- Link Central Points

**Input:** C //central points on the DFB image  
 x and y // row and colom of input image  
 SR=[] // matrix of pixels neighbour locations  
 Rang=[] // matrix of 5 pixels neighbour values

**Output:** link central points

#### Begin:

```

For s (1 ≤ s ≤ to no. iterations) // 5 iterations for this work
  For m, n (1 ≤ m ≤ x, 1 ≤ n ≤ y)
    If C(m, n) > 1
      Set Max= the max pixel value of neighbouring window
      If Max > 1
        For k=1 to 8 // neighbours window
          If Max = C(SR(k))
            Case k=1
              Rang = [C (SR(3)) C(SR(5)) C(SR(6)) C(SR(7)) C(SR(8))]
              Set mx= max (Rang)
              If mx>0
                For k2=1 to 5
                  Find the location of maximum pixel value of (Rang) to set it as 1
                End For
              Case k=2
                Rang = [C (SR(6)) C(SR(7)) C(SR(8)) C(SR(4)) C(SR(5))]
                Set mx=max(Rang)
                If mx>0
                  For k2=1 to 5
                    Find the location of maximum pixel value of (Rang) to set it as 1
                  End For
              Case k=3
                Rang = [C (SR(4)) C(SR(7)) C(SR(6)) C(SR(8)) C(SR(1))]
                Set mx=max(Rang)
                If mx>0
                  For k2=1:5
                    Find the location of maximum pixel value of (Rang) to set it as 1
                  End For
          End If
        End For
      End If
    End If
  End For
End For

```

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Case k=4
Rang = [C (SR(8)) C(SR(4)) C(SR(1)) C(SR(2)) C(SR(7))]
Set mx=max(Rang)
If mx>0
For k2=1:5
Find the location of maximum pixel value of (Rang) to set it as 1
End For
Case k=5
Rang = [C (SR(1)) C(SR(4)) C(SR(6)) C(SR(2)) C(SR(7))]
Set mx=max(Rang)
If mx>0
For k2=1:5
Find the location of maximum pixel value of (Rang) to set it as 1
End For
Case k=6
Rang = [C (SR(2)) C(SR(5)) C(SR(3)) C(SR(8)) C(SR(1))]
Set mx=max(Rang)
If mx>0
For k2=1:5
Find the location of maximum pixel value of (Rang) to set it as 1
End For
Case k=7
Rang = [C (SR(1)) C(SR(2)) C(SR(6)) C(SR(4)) C(SR(5))]
Set mx=max(Rang)
If mx>0
For k2=1:5
Find the location of maximum pixel value of (Rang) to set it as 1
End For
Case k=8
Rang = [C (SR(1)) C(SR(2)) C(SR(4)) C(SR(6)) C(SR(3))]
Set mx=max(Rang)
If mx>0
For k2=1:5
Find the location of maximum pixel value of (Rang) to set it as 1
End For
Else If  $0 \leq \max \leq 1$ 
For k=1:8
Find the location of maximum pixel value of 8 neighbours of (SR) to set it as 1
End For
End For
For i, j ( $1 \leq i \leq x, 1 \leq j \leq y$ )
C(i, j) = C(i, j) + cc(i, j)
End For
End For // iterations

```

**End**

## 2. Features Extraction

Feature extraction is a major phase in biometric systems due to its impact on the matching process then on the decision. In this work, a set of features were extracted from centerline of the vein that are representing by keypoints location. The keypoints generation are depending on the difference of Gaussian. The difference of Gaussian (DoG) function is applied in order to detect the scale-space extrema, where at first the image  $I$  is convolved with Gaussian filters  $G$  at different scales  $\sigma$  using equation (5):

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \dots \dots \dots (5)$$

Where L is a convolved image. The Gaussian Blur image G is gotten by using Gaussian blurs equation (6) as below:

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2} \dots \dots \dots (6)$$

Where x, y are the distance from the origin in the axes of horizontal and vertical respectively. A DoG image D (x, y, σ) is given by equation (7):

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma) \dots \dots \dots (7)$$

The keypoint location (x, y) is marked in feature vector if it is the largest or smallest of all 26 neighbors in 3x3 regions as illustrates in Figure -4.

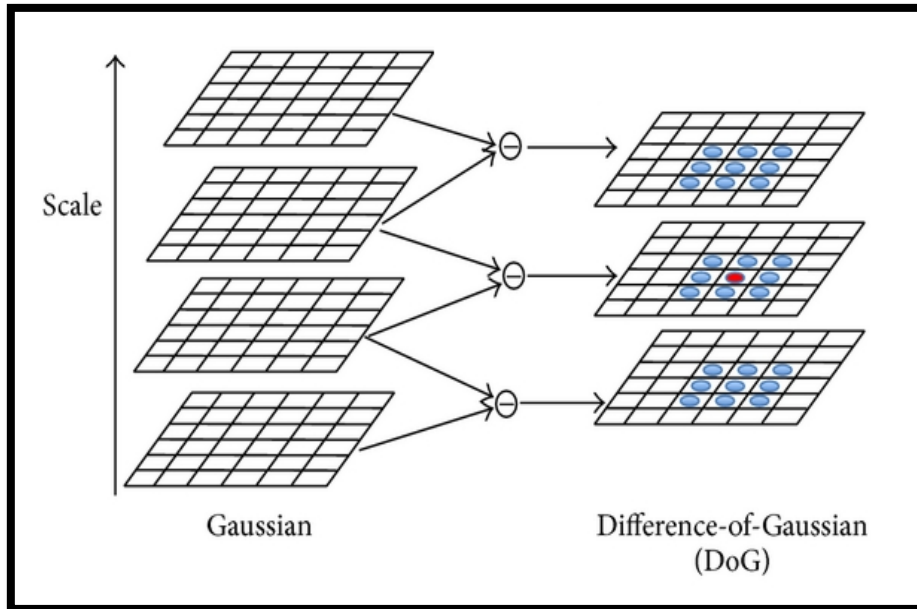


Figure 4- The process of local extrema detection based on (DoG).

**3. Matching Process**

After computing feature vectors and stored in training database, the matching process is take place to calculate the degree of similarity between two vein patterns (i.e. feature vector stored in database with feature vector that input test palm vein image), the absolute difference between two features is used for matching purpose as shown in equation (8), spouse FV is a binary array of n elements:

$$FV[i] = \begin{cases} 1 & \text{If } \text{abs}(x_i - y_j) \leq t \text{ and } \text{abs}(x_{i+1} - y_{j+1}) \leq t \\ 0 & \text{otherwise} \end{cases} \dots \dots \dots (8)$$

Where the parameter ‘t is a predefined value represents distance between two features (distance for tolerance to get more accurate recognition rate) and x, y are feature vectors, the matching ratio between two patterns is obtained using equation (9):

$$\text{matching ratio} = \frac{\sum_{i=1}^n FV[i]}{n} * 100 \% \dots \dots \dots (9)$$

Where n refer to the features in a vector, so that if the matching ratio is greater than threshold value then the two templates are matched.

**Experiment Results**

The performance of this system was tested over the samples of PolyU multi-spectral palm print database [9], the database consists of 6000 images taken from 500 different palms collected from 250 volunteers (195 males and 55 females, ages ranging from 17 to 60 years). These samples were collected through two sessions separated by about 9 days; in each session capture 6 images for each palm. Therefore, 24 images for each volunteer were collected, 12 of them for each of his/her 2 palms.

**1. Recognition (Identification) Results**

The Correct Identification Rate (CIR) parameter is used to evaluate the performance of the identification process, which it is represent the ratio of the correctly classified samples to the total number of tested samples. The behavior of recognition process was affected by many parameters, since the distance between the camera and the light, direction, illumination, and quality are different at

each time. The testes results show that the CIR of our training samples is 100 % when the parameter 't' equals 5 (the distance value 't' between pair of features affected on the recognition performance, where the keypoints cannot be in the same place in the rate of 0 % every time).

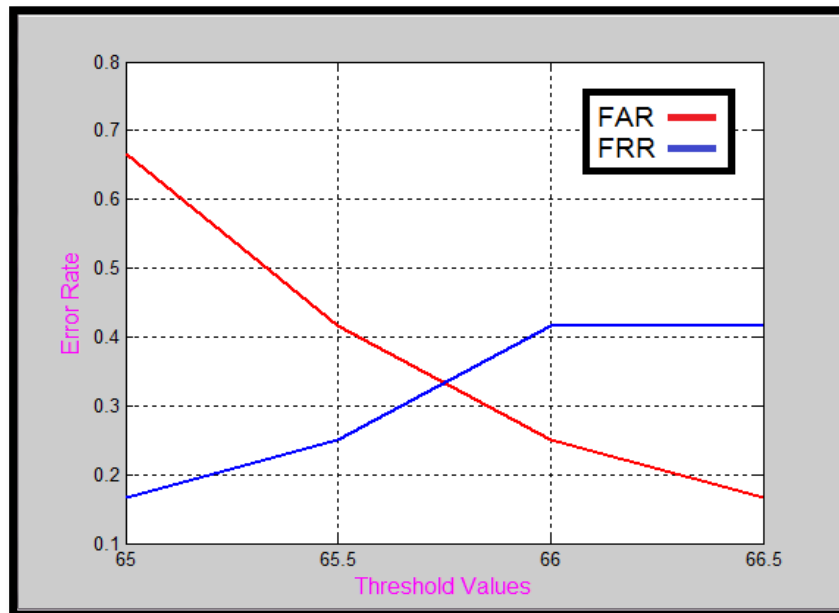
**2. Verification (Authentication) Results**

The parameters Receiver Operating Characteristic (ROC) curve and Equal Error Rate (EER) were used for measuring performance of authentication task. The (ROC) illustrates the curve between FAR and FRR for various threshold values; and the (EER) represent the error rate when the FAR equals the FRR this refer to a lower EER value. The False Acceptance Rate (FAR) (no. unknown persons classified as trained persons/total no. of training dataset) and False Rejection Rate (FRR) (no. of trained persons classified as unknown/ total no. of training dataset) are shown in Table -1 which is list the FAR and FRR at different threshold values.

**Table 1-** FAR and FRR at different threshold values.

Threshold	FAR	FRR
65	0.666	0.166
65.5	0.416	0.25
66	0.25	0.416
66.5	0.166	0.416
67	0.166	0.416

The ROC curve is shown in Figure-5, which is also, illustrates the lower EER equals 0.333 % at the threshold value about 65.75.



**Figure 5-** ROC Curve between FAR and FRR.

We compare the method presented in this paper with the traditional system of palm vein recognition and show the efficiency of our algorithm, Table-2 shows the results of FAR, FRR and correct identification rate for different algorithms.



**Table 2-** Comparison with the different systems results.

Algorithm	FAR	FRR	CIR
Gabor	8.43	37.07	91.09 %
SIFT	4.00	8.57	95.9 %
ICA	1.16	34.27	98.2 %
PCA	4.66	45.67	94.7 %
PCA + LPP	3.38	63.6	95.6 %
Propose Algorithm	0.416	0.25	100 %

### Discussion and Conclusion

An approach of personal recognition system was introduced in this paper. This system based on centerline of palm vein, where the features were extracted from vein's centerline by finding keypoints locations depending on scales of difference-of Gaussian (DoG) function. The experimental results show that the recognition rate was 100 % with 0.333 % error rate which referring high performance in identification and verification tasks. Comparing with other results of palm vein recognition algorithms, this algorithm gets the highest recognition performance.

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