Wavelet Based Palmprint Authentication System

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Abstract – **Palmprint based personal verification has quickly entered the biometric family due to its ease of acquisition, high user acceptance and reliability. This paper proposes a palm print based identification system using the textural information, employing different wavelet transforms. The transforms employed have been analyzed for their individual as well as combined performances at feature level. The wavelets used for the analysis are Biorthogonal, Symlet and Discrete Meyer. The analysis of these wavelets is carried out on 500 images, acquired through indigenously made image acquisition system. 500 palmprint obtained from 50 users with 10 samples each have been collected over a period of six months and have been evaluated for the performance of the proposed system. The experimental results obtained from the data have demonstrated the feasibility of the proposed system by exhibiting Genuine Acceptance Rate, GAR of 97.12%.**

Index Terms –**Wavelets, Normalized energy, Euclidean distance, Palmprint, Texture Analysis.**

I. INTRODUCTION

Biometrics based personal identification is getting wide acceptance in the networked society, replacing passwords and keys due to its reliability, uniqueness and the ever increasing demand of security. Common modalities being used are fingerprint and face but for face authentication people are still working with the problem of pose and illumination invariance where as fingerprint does not have a good psychological effect on the user because of its wide use in crime investigations. If any biometric modality is to succeed in the future it should have the traits like uniqueness, accuracy, richness, ease of acquisition, reliability and above all user acceptance. Palm print based personal identification is a new biometric modality which is getting wide acceptance and has all the necessary traits to make it a part of our daily life. This paper investigates the use of palm print for personal identification using combination of different wavelets. Palmprint not only has the unique information available as on the fingerprint but has far more amount of details in terms of principal lines, wrinkles and creases. Moreover it can easily be combined with hand shape biometric so as to form a highly accurate and reliable biometric based personal identification system.

Palmprint based personal verification has become an increasingly active research topic over the years. The Palmprint is rich in information and has been analyzed for discriminating features like principal lines [1], [2], appearance based [3], [4], [5], [6], [7], [8] and texture based [9], [10], [11], [12], [13], [14], [15]. The results reported in [10], [11] , [14] and [15] where wavelet transform has been used for feature extraction has motivated us to investigate the effectiveness of using combination of multiple wavelets for the textural analysis of palmprint.

II. ALGORITHM DEVELOPMENT

The approach followed for the development of a palmprint based authentication setup is depicted in the Fig. 1.

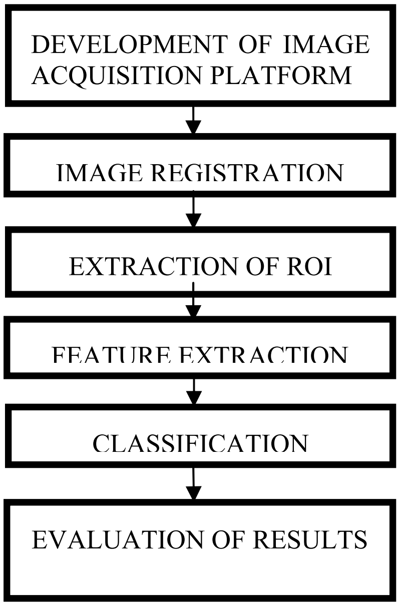

Fig 1 –Algorithm Development.

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III. DEVELOPMENT OF IMAGE ACQUISITION PLATFORM

There are two types of systems available for capturing the palmprint of individuals i.e., scanners and the pegged systems [16], [17]. Scanners are hygienically not safe whereas the pegged systems cause considerable inconvenience to the user. Hence both of these systems suffer from low user acceptability. The attributes of ease of acquisition and hygienic safety are of paramount importance for any biometric modality. The proposed image acquisition setup satisfies the mentioned criteria by proposing a contactless, peg free system, Figure 2. It is an enclosed black box, simple in architecture and employs ring source light for uniform illumination. Two plates are kept inside the image acquisition setup. The upper plate holds the camera and the light source while the bottom plate is used to place individual's hand. The distance between these two plates is kept constant to avoid any mismatch due to scale invariance. The distance between the two plates after empirical testing is kept at 14 inches. The palmprint images have been collected from 50 individuals with 10 images each making a total dataset of 500 images. The dataset contains all images of males with age distribution between 22 to 56 years, with a high percentage between 22 to 25 years. A low resolution of 72 dpi has been used employing SONY DSC W-35 CYBER SHOT for palmprint images acquisition.

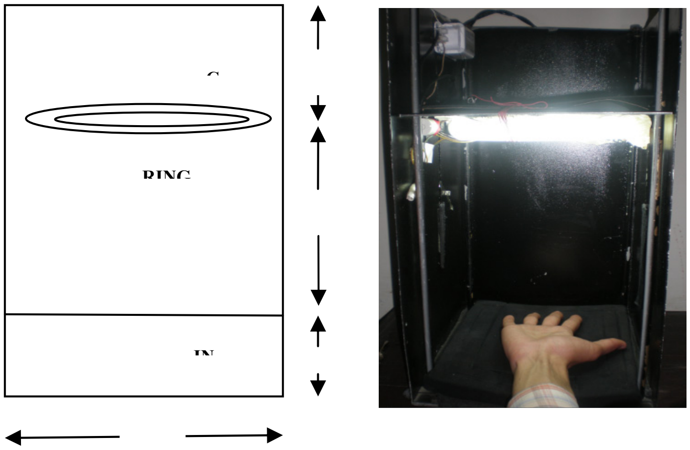

Fig 2 – Front view of Image Acquisition device.

1. *USER TRAINING*

The user was requested to place his hand maximally flat on the imaging surface and keep his fingers apart. A line was drawn on the imaging surface and the user was asked to place his middle finger in line with it. One important observation made using these constraints was that they does not cause any inconvenience to the user though they require the user to be a bit cautious. The middle finger if kept aligned with a certain reference line facilitates rotational and translational invariance.

IV. IMAGE REGISTRATION

Our image registration approach follows the technique proposed in "[13]", and is summarized as follows: The acquired color (RGB) parameters of palmprint are changed to HSI parameters. The hue value of skin is same so it was safely neglected along with the less discriminating saturation value. The palmprint has been analyzed for its texture using the gray level or intensity values, I among the HSI values. Gray level images retain all the useful discriminating information required for personal identification, along with considerable reduction in processing time. The color images are changed to gray level images using the following equation:

$$I = (0.2989 \times R) + (0.5870 \times G) + (0.1140 \times B\ ) \quad (1)$$

The gray level images are normalized and thresholded to get a binary image. Hysteresis thresholding has been adopted due to its effectiveness in varying illumination conditions and undesirable background noise.

Although the user training ensures optimal and standard acquisition of palmprint, a rotational alignment is incorporated in our proposed approach to cater inadvertent rotations. The longest line in a palm passes through the middle finger, and any rotation is considered with reference to this line. The second order moment helps analysing the elongation or eccentricity of any binary shape. By finding the Eigen values and eigenvectors, we can determine the eccentricity of the shape by analyzing the ratio of the Eigen values. We can determine the direction of elongation by using the direction of the eigenvector with corresponding highest Eigen value. The parameters of the best fitting ellipse have been extracted using second order statistical moments on the binarized palmprint corresponding to the longest line. Consequently, the offset (theta) between the normal axis and the longest line passing through the middle finger is calculated. The theta is calculated using the following equation:

$$\theta = \left[\frac{1}{2}\tan^{-1}\left[\frac{2c}{a-b}\right]\right] \quad (2)$$

where a, b and c are the second order normalized moments of the pixels and are calculated using the following equations:

$$a = \frac{\sum_{((x,y)\in P)}\{(y-v)^2.P(x,y)\}}{\sum_{((x,y)\in P)}P(x,y)} \quad (3)$$

$$b = \frac{\sum_{((x,y)\in P)}\{(x-u)^2.P(x,y)\}}{\sum_{((x,y)\in P)}P(x,y)} \quad (4)$$

$$c = \frac{\sum_{((x,y)\in P)}\{(x-u).(y-v).P(x,y)\}}{\sum_{((x,y)\in P)}P(x,y)} \quad (5)$$

After determination of theta, we rotated the palmprint accordingly for vertical alignment using the Affine transform. After the vertical alignment of the palmprint, morphological operation of dilation is applied to remove holes in the binary image. The image is complemented and finally distance transform is used with the chessboard metric to calculate the centre of palmprint, Figure 3.

Fig 3 – Center of Palm calculation through Distance Transform.

The distance transforms evaluates the pixels which have a value of zero for their nearest non-zero neighbours and the maximum distance obtained from the distance transform is estimated to be the centre of palmprint. The mathematical equation for the chessboard metric is defined as

$$max[\| x1 - x2 \|, \| y1 - y2 \|] \qquad (6)$$

A fixed square region of 256 x 256 pixels is cropped around the calculated center of palmprint.

V. FEATURE EXTRACTION AND CLASSIFICATION

We obtained ten images of each individual of which five were used for training and the rest of them were used for validation. The obtained registered palmprint image has been analysed for its texture using different symmetrical wavelet families namely biorthogonal 3.9, symmelt 8 and demeyer 5. The palmprint region 256x256 has been decomposed into three scales for each wavelet type, Figure 4.

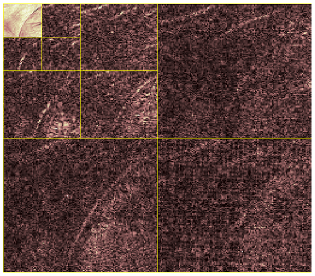

Fig 4 – Three level decomposition of Palm Using Wavelet Transform.

This resulted in ten directional details for each wavelet. We neglected the approximation level and then normalized energy is calculated for each block. Texture analysis in Palmprint is adversely affected by the variations in illumination, [6], [18]. The problem has been addressed by computing normalized energy of the decomposition blocks so as to minimize feature variance due to non-uniform illumination. The energy computed from each block for the three wavelet types is concatenated to form a feature vector of length 27 for an individual palmprint. The normalized energy of the ROI image block B associated with subband a is defined as

$$E_a = \sum_{u,v\epsilon B} |f_a(u,v)| \qquad (7)$$

Where the normalize energy is given as

$$E = \frac{E_a}{\sum_{a=1}^{a=n} E_a} \qquad (8)$$

where ‘n’ equals the total number of blocks present in the image. Matching is performed by calculating the Euclidean Distance between the input feature vector and template feature vector. Euclidean distance between two vectors is calculated by squaring the difference between corresponding elements. For p(x,y) and q(s,t) the Euclidean distance between p and q is defined as:

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{\frac{1}{2}} \qquad (9)$$

A detailed analysis of results revealed that rotation of the palmprint caused considerable blur in the vertical aligned images due to interpolation, Figure 5.

Fig 5 – Image degradation due to rotation.

An intelligent solution to this problem is devised by rotating the axis of region instead of the palm, Figure 6.

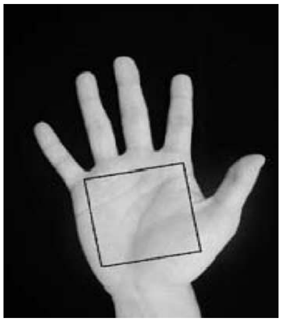

Fig 6 – Rotating the axis of region instead of the palm.

A reverse transformation is computed from the Affine transform, as follows:

$$Xnew = Xcos(\theta) - Ysin(\theta) \quad (10)$$

$$Ynew = Xsin(\theta) + Ycos(\theta) \quad (11)$$

Using the above equations, a rotation invariant region of interest is cropped from the palmprint. The approximation or interpolation error still exists but the results show improved performance and accuracy. The selected wavelets have been analyzed for their individual performance by formulating similar energy based feature vectors of length 27, using 9 levels decomposition. The results for Biorthogonal 3.9 wavelet are shown in Figures 7, 8 and 9.

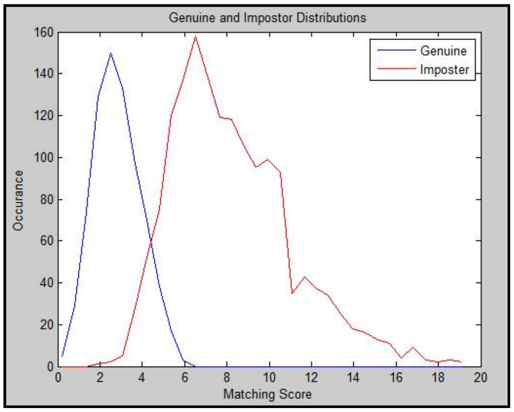

Fig 7 – Genuine and Imposter distribution for bior3.9 wavelet.

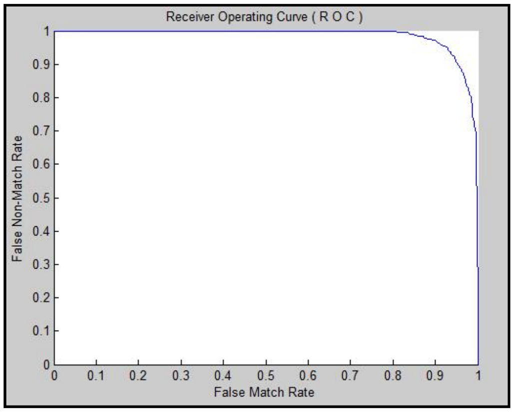

Fig 8 – ROC curve for bior3.9 wavelet.

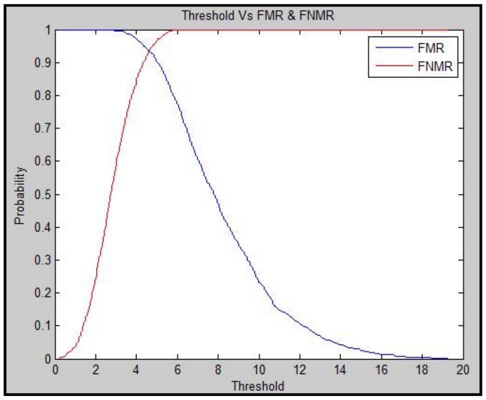

Fig 9 – Threshold Vs FMR and FNMR for bior3.9 wavelet.

The results for Symlet 8 wavelet are shown in Figure 10, 11 and 12.

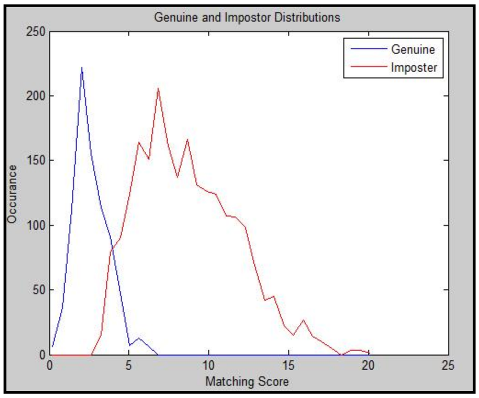

Fig 10 – Genuine and Imposter distribution for sym8 wavelet.

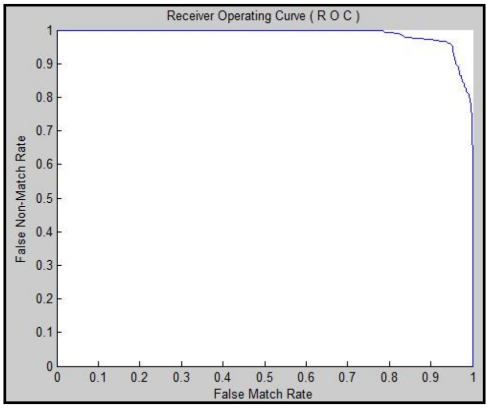

Fig 11 – ROC curve for sym8 wavelet.

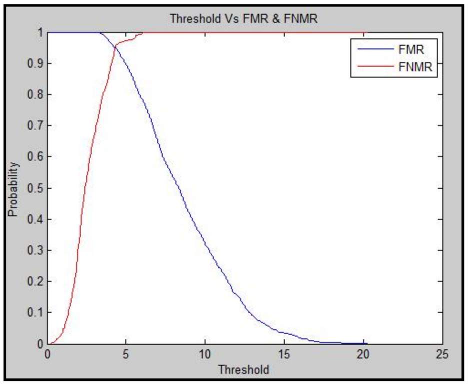

Fig 12 – Threshold Vs FMR and FNMR for sym8 wavelet.

The results for Discrete Meyer wavelet are shown in Figure 13, 14 and 15.

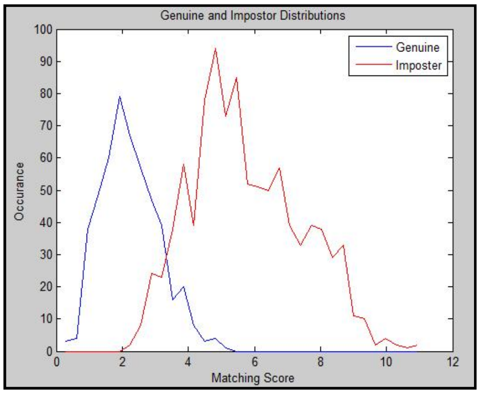

Fig 13 – Genuine and Imposter distribution for meyer wavelet.

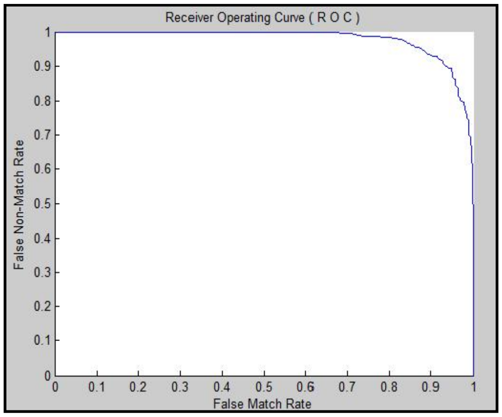

Fig 14 – ROC curve for meyer wavelet.

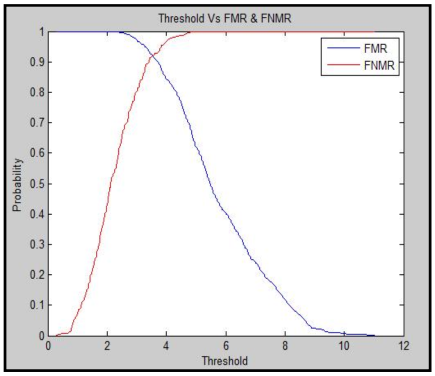

Fig 15 – Threshold Vs FMR and FNMR for meyer wavelet.

TABLE I – COMPARISON OF WAVELET PERFORMANCE

Wavelet	EER (%)	Decidability Index	GAR (%)
Bior3.9	4.6238	2.5090	76.23
Sym8	4.3265	2.6179	84.45
Dmeyer	4.5379	2.6357	71.1
Wavelet Combination	4.0702	2.9681	97.12

Table-1 summarizes the EER and Decidability Index for the different wavelets for their individual performance. Here the results of symlet have been found to be the best as compared to the other two wavelet types. Moreover the genuine acceptance rate of symlet is also higher than the other two but still it does not satisfy the requirement of any acceptable biometric system. In the next stage, the performance of proposed algorithm is tested for multiple wavelets combination. Here GAR of 97.12 % was achieved. The decidability index was 2.9681 whereas the EER was 4.0702, Table 1. The results for wavelet combination are shown in Figure 16, 17 and 18. Thus by using the combination of multiple wavelets we have achieved significant improvement in the system performance.

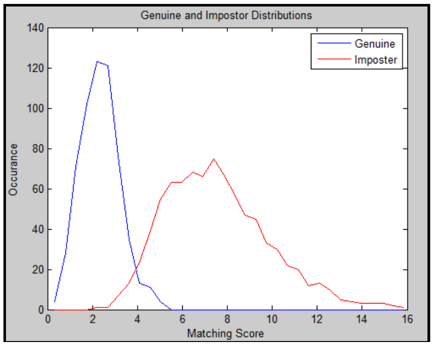

Fig 16 – Genuine and Imposter distribution for wavelets combination.

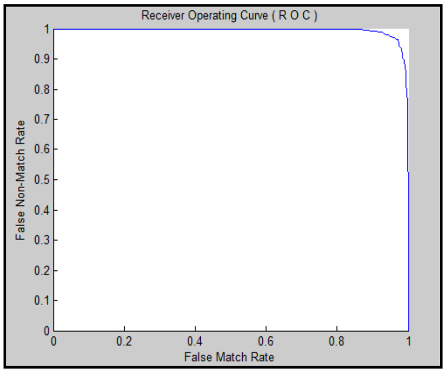

Fig 17 – ROC curve for wavelets combination.

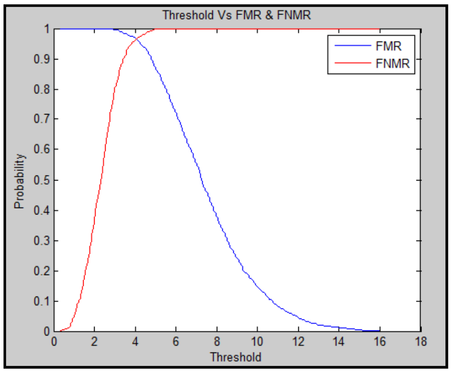

Fig 18 – Threshold Vs FMR and FNMR for wavelets combination.

1. *Speed*

The registration of an individual takes about 20.5 seconds whereas the identification takes about 22.5 seconds on a 1.5 GB RAM 1.67 GHz Intel Core Duo processor with Windows Vista operating system. The speed may be increased by using more advanced processors with real time operating system. Moreover, in the present scenario we believe that accuracy and precision are the main concerns over computational efficiency.

VI. CONCLUSION

This paper investigates combination of multiple wavelets at feature level for palmprint based authentication system using an indigenously developed peg-free image acquisition platform. The results depict the superiority of combined wavelets over individual wavelet feature for the palmprint authentication, using coarse level information. The paper also presented a new approach for rotation invariance, which proved its effectiveness by enhancing genuine acceptance rate.

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