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Palmprint Identification Based on DWT, DCT and QPCA

K. P. Shashikala, K. B. Raja

***Abstract:** An individual can be identified effectively using palmprints. In this paper we propose palmprint identification based on DWT, DCT and QPCA (PIDDQ). Histogram equalization is used on palmprint to enhance contrast of an image. The DWT is applied on Histogram equalized image to generate LL, LH, HL and HH bands. The LL band is converted into DCT coefficients using DCT. QPCA is applied on DCT coefficients to generate features. The test and database palmprint features are compared using Euclidean Distance (ED). It is observed that the proposed method gives better performance compared to existing method.*

***Keywords:** Palmprint Identification, DWT, DCT, QPCA, ED.*

I. INTRODUCTION

Biometric recognition refers to the recognition of an individual based on certain distinguishable physical or behavioral characteristic which are unique to that individual. Biometric identification has gained importance due to high degree of security which is required by any modern organization as well as the day to day life of human beings. In several fields of applications ranging from the ubiquitous banking to the access of sensitive high security zones, establishing the identity of the individual is of paramount importance. Traditional methods of identification such as user names and passwords are not reliable as they can be stolen or forgotten. These systems are vulnerable to the viles of an impostor.

The Biometrics is broadly classified into two categories based on the traits used for identification.

(i) *Behavioral Biometrics*: These traits depend on the behavior and mood of the person and they are not constant throughout life. The common behavioral traits are signature, gait, keystroke, voice etc.

(ii) *Physiological Biometrics*: These traits depend on the physical body parts of a person which are unique and remain constant throughout life. The common physiological biometric traits are fingerprint, face , palm print, iris, retina, DNA etc. Biometric features should satisfy the following characteristics for a valid biometric trait:

(v) Performance: give acceptable accuracy.
(vi) Acceptability: acceptable to people.
(vii) Circumvention: must be foolproof.

A biometric based authentication system has two modules.

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* Correspondence Author (s)
K P Shashikala, Ph.D. Registration Number: PP ECE. 0022, Subject of registration: Development of Efficient Algorithms for Biometric Security System using Palmprint, Rayalseema University, Kurnool, (A.P), India.
K B Raja, Electronics and Communication Department, Bangalore University/ University Visveswaraya College of Engineering (UVCE), Bangalore, India.

(i) Enrollment module: A user's biometric data is acquired using a biometric reader and stored in a database. The stored template is labeled with a user identity (e.g., name, identification number etc.) to facilitate authentication.

(ii) Authentication module: A user biometric data is once again acquired and the system uses this to either identify who the user is, or verify the claimed identity of the user. While identification involves comparing the acquired biometric information against templates corresponding to all users in the database, verification involves comparison with only those templates corresponding to the claimed identity. Thus, identification and verification are two distinct problems having their own inherent complexities. The unique features of biometric traits are extracted either from spatial domain or transform domain.

(a) *Spatial domain techniques* viz., Principal Component Analysis (PCA), Independent Component Analysis (ICA), Singular Value Decomposition (SVD)

(b) *Transform domain techniques* where in the biometric data from spatial domain is converted to transform domain viz., Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Dual Tree Complex Wavelet Transform (DTCWT) etc.

The features of the test palm image are compared with the data base images in matching section to authenticate a person using (i) Euclidean Distance (ED),(ii) Hamming Distance (HD),(iii) Support Vector Machine (SVM), (iv) Random Forest (RF), (v) Neural Networks (NN) etc.

The performance of the biometric system can be improved by fusion. The three possible levels of fusion are: (a) Fusion at the feature extraction level, (b) Fusion at the matching scores level and (c) Fusion at the decision level.

The possible feature fusion techniques are:

(i) Multiple set of features extracted using different techniques from one biometric trait are fused to obtain the final feature vector.

(ii) Single feature set from two or more biometric traits and fuse to generate final feature set.

(iii) Fusion of Multiple feature sets from each biometric trait and final fusion of the fused feature sets.

The reliability of biometric systems can be improved by multimodal biometric systems. Multimodal biometric systems are those which utilize more than one physiological or behavioral characteristic which are captured by multiple sensors. Multimodal systems also provide anti-spoofing measures by making it difficult for an intruder to spoof multiple biometric traits simultaneously.

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The performance of a biometric system can be measured by reporting its False Accept Rate (FAR) and False Reject Rate (FRR) at various thresholds

Palmprint recognition negates the flaws of all the other non-invasive methods thereby providing a reliable, socially acceptable, accurate, convenient and economical recognition system. The palm of person is not smooth but has a pattern. This pattern is formed by the raised portions of the skin known as ridges. Palmprint is based on ridges, principal lines and wrinkles on the surface of the palm. Among other biometric techniques, palm recognition is one of the most promising approaches due to its high reliability for personal identification. Palmprint has the characters of uniqueness, reliability and security. Palm print recognition system basically has 3 stages namely preprocessing, feature extraction and matching. In preprocessing there are 3 steps – palm localization, palm normalization and image enhancement. Palm print has multiple features which can be extracted by conventional methods giving better authentication. Feature extraction may consist of the pixel values of principle lines, ridges, valleys and wrinkles in spatial domain or transform of the palm image such as FFT, DFT, DWT etc, or a fusion of different features. Matching is done by the conventional methods viz., ED, HD, SVM, etc.

Motivation: Reliable Automatic personal identification has become a necessity in public places where security is of prime concern. The traditional methods of identification such as Passwords, Pins, ID cards, smart cards, credit and debit cards are susceptible to getting lost, impersonation, frauds etc, also it is difficult to manage many different cards and passwords. A biometric identification can be used for all transactions at all places such as malls, airports, banks etc. Voter ID, driving licenses, Medical insurance, Ration Cards, Employee Pension and Provident fund can also be accessed biometrically. Each person's entire data can be archived and made available. The motivation of the paper is the detailed study; analysis and improvement over existing palm print biometric systems.

Contribution: In this paper PIDDQ algorithm is proposed. The multispectral poly U palmprints are preprocessed by applying, DWT and DCT. The features are extracted using QPCA and Matching is done by ED.

Organization: The paper is organized into following sections. Section 2 is an overview of related work. The proposed model is described in section 3. Section 4 discusses the algorithms used. Performance analysis is discussed in section 5 and Conclusion is given in section 6.

II. LITRATURE SURVEY

Victor S Viera and Joao Marquez Salomao [1] used Gaussian filter for principle line extraction. Debauchies wavelet transform is applied four times to get features. A classifier is used to group each person's palmprint. A final matrix consisting of all the coefficients are then used to train the neural network which is used to identify the class to which the palmprint belongs. Zhenhua Guo et al., [2] proposed a hyper spectral palmprint imaging system which is used for best feature band selection. 2D PCA is used for feature extraction to select the correct feature bands. Jifeng Dai and Jie Zhou [3] proposed an algorithm for high resolution palmprints required for forensic applications. The algorithm takes multiple features such as orientation, principle lines, minutiae and density of lines. Identification is done by multiple fusions of methods such as weighted sum, SVM and Neyman Pearson rule. Naidu Swathi et al., [4] proposed a palmprint identification system which uses the textural information for palm features by means of wavelets. The wavelet transforms used are bi-orthonormal, simlet and discrete mayer and a combination of all the three. Matching is done by Euclidean distance. Abdallah Meroumia et al., [5] used 1D Log Gabor filter for feature extraction. The phase feature is obtained quantized and encoded. Hamming distance is used for feature matching.Murat Aykut and Murat Ekinci [6] presented palmprint identification using Gabor wavelets and KFD method for feature extraction and mapped using Euclidean distance. Patprapa Tunkien et al., [7] used three principle lines as features. Eight Shape histograms of eight directions translate the principle lines into eight directions then classified into K-nearest neighbor. Cosine similarity is used for matching. Ningbo Zhu et al., [8] proposed a multi-biometric system combining the feature level and matching score level fusion. Two biometric features are combined by PCA and further the matching scores are combined for final identification. Yong Jiang Chin et al., [9] use finger and palm feature fusion. By means of random tiling and a user defined key, random features are obtained and then discretized based on equal probability. Xing penxu and Zhenhua Gao [10] proposed palmprint identification based on multispectral images which are down sampled by DWT and represented by Quaternion matrix further the features are extracted by PCA. Matching is done by Euclidean distance. Luleng et al., [11] described palm hashing scheme where in the Gabor filtered palm features are randomized by a pseudo random number and quantized. Matching is done by measuring the difference in number of bits by hamming distance. Liu Yu-qin et al., [12] proposed feature extraction by ICA using wavelet transform. Nearest neighbor classifier is used for matching. Zohaib Khan et al., [13] used Non Sub sampled Contour let transform for feature extraction then convolved with a bandpass filter and directionally decomposed and encoded into a contour code for matching. Vivek Kanhangad et al., [14] used the 3D palm image to correct the pose of the 3D and 2D images. Feature extraction of 3D and 2D palm images is obtained and fused for matching. Trebelsi et al., [15] acquired the iris features by fractal analysis and palmprint features by Local Binary Pattern (LBP). Fusion of the average of scores is used for matching. Meraoumia et al., [16] proposed feature extraction of palmprint and finger knuckle print. Fusion is in the matching score level by phase correlation function. Yanquing Zhang et al., [17] applied the laplacian transform to palm and middle finger images which are fused together and the feature extraction is done by PCA. Matching is done by Nearest Neighbor Classifier. Jiewu and Zhangding Qiu [18] extracted course palm features. Fine features extracted are the grey scale values based on entropy .These are then mapped as a matrix and used for identification. Yanquing Zhang et al., [19] automatically adjusted the intensity of the palmprint by gamma modification.

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The feature extraction is by Gabor filter and Euclidean distance is used for matching features. Better performance is observed when image intensity is adjusted towards darker side.

Xiang Quiang Wu et al., [20] represented the palm features as an orientation code and differential code. The orientation code defines the orientation of each pixel. Fusion of these two features is used for matching. Shuang Xu et al., [21] used Gabor wavelet for feature extraction and represent as a matrix by B2DPCA and further reduced by PCA. Runbin Cai and Dewen Hu [22] fused the visible and infrared images of palmprints. This is then decomposed by DTCWT. The entropy of the fused image and the source image is used for identification. K B Nagasundara and D S Guru [23] propose a multi algorithm based feature extraction. Features are extracted using both Haar wavelet and Zernike moments. The fused features are then indexed using KD-Tree, which results in faster identification. Ashutosh Kumar and Ranjan Parekh [24] classify each palm into eigen vectors. Then they are represented into small dimensions for fast computation. Euclidean distance is used as classifier. Xiang Peng Xu et al.,[25] extract QPCA features and QDWT features and final distance is computed by weighted fusion of QPCA Euclidean distance and QDWT Euclidean distance. K.Vaidehi, et al., [26] apply DWT DB4 and then DCT for feature extraction. The dimension of DCT is reduced by PCA. SVM is used as classifier. Linlin Shen et al., [27] propose an embedded palmprint recognition system. The palmprint image is convolved with Gabor Wavelet. The binary pattern is then used to find the relation of the central pixel with the neighbours.DSP processor OMAP 3530 and ARM processor is used for implementation.

III. PROPOSED MODEL

In this section the definitions of performance analysis and proposed model are discussed.

A. Definitions

a) False Accept Rate or False Match Rate (FAR or FMR)

It is the probability that the system incorrectly matches the test palmprint to a person not in the database. It measures the percentage of test palmprints incorrectly accepted. It is the ratio of number of person accepted incorrectly to the total number of persons out of database, given as in the Equation 1.

$$FAR = \frac{Number\ of\ persons\ accepted\ incorrectly}{Total\ number\ of\ persons\ out\ of\ database} \quad \ldots \qquad (1)$$

b) False Rejection Rate or False Non-Match Rate (FRR or FNMR)

The probability that the system fails to detects a match between the test palmprint and matching template in the database. It measures the percentage of valid test palmprints rejected. It is the ratio of number of persons rejected to the total number of persons in database, as in Equation 2.

$$FRR = \frac{Number\ of\ persons\ rejected}{Total\ number\ of\ persons\ in\ database} \quad \ldots\ldots\ldots \qquad (2)$$

c) Equal Error Rate or Cross over Error Rate (EER or CER)

The rates at which both accept and reject errors are equal. The value of the EER can be obtained from the FRR and FAR values with threshold graph. The EER is the way to compute the accuracy of devices. The lowest EER is most accurate.

d) Correct Recognition Ratio or True Success Rate (CRR or TSR)

It is the rate at which the system recognizes all the persons in the database to particular individuals correctly. CRR is defined as the ratio of number of persons correctly matched in the database to the total no of persons in the database is given in the Equation 3.

$$CRR = \frac{Number\ of\ persons\ correctly\ matched}{Total\ persons\ in\ the\ database} \quad \ldots\ldots\ldots \qquad (3)$$

B. Proposed Palm Recognition Model (PIDDQ):

The human body can be identified using palmprint identification with transform domain and spatial domain techniques as shown in Fig 1.

a) Palmprint Database:

The POLY-U multispectral Palmprint database is used to test the proposed algorithm. There are twelve palm images of 500 persons in all the four illuminations of NIR, Red, Blue and Green. Eleven images of each person of each illumination is used to create data base. The remaining one image is used for testing, ie 500 images of each illumination.

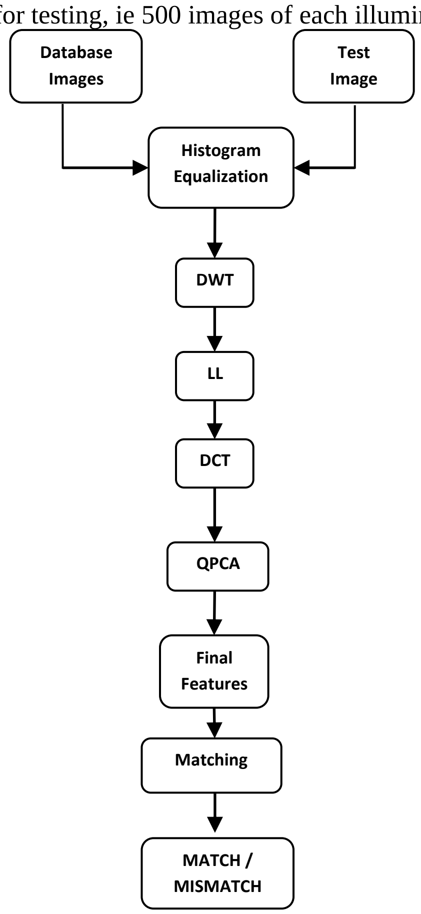

Fig1. Proposed palm recognition model

b) Histogram Equalization

The Database and Test images are histogram equalized. This is done to make the image illumination invariant.

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The histogram equalization technique is a grey level transform which varies the contrast adaptively in the image. The intensities of the grey level pixels are distributed in such a way that the areas of low contrast are enhanced to higher contrast levels and vice versa enhancing the image clarity. The original palmprint image and its histogram equalized image are shown in Fig 2; the principal lines of palmprint are clearly visible in the histogram equalized image.

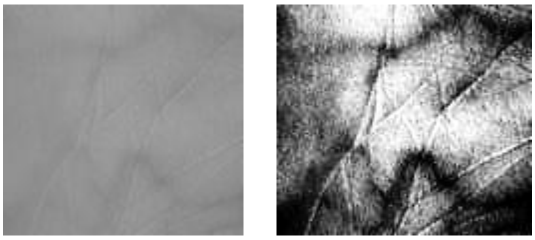
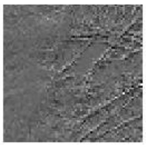


Fig 2. Original and Histogram equalized image.

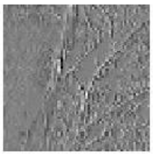
c) Discrete wavelet transform

Two dimensional Discrete Wavelet Transform (2D-DWT) is applied to the histogram equalized image. A DWT is a wavelet transform for which the wavelets are discretely sampled. The DWT of a signal is calculated by passing it through a series of low and high pass filters to obtain four sub bands viz., one approximation band and three detailed bands belonging to low frequency and high frequency components respectively. The four sub bands of DWT such as approximation band, horizontal band, vertical band and diagonal bands are shown in Fig 3. The significant information of palmprint is present in the approximation band compared to other three high frequency component bands.

Approximation coefficients



Horizontal coefficients



Vertical coefficients

Diagonal coefficients

Fig 3. DWT on the equalized ROI palmprint sample

The Haar wavelet

In the proposed method Haar wavelet is used as we observed that the performance results are better as compared to other wavelet families.The Haar wavelet is almost a step function as given by equation 4.The approximation band (LL) is considered for further analysis.The following expressions define the Haar wavelet.

$\Psi(x)=1$, if $x\epsilon[0,0.5]$

$\Psi(x)=-1$, if $x\epsilon[0.5,1]$

$\Psi(x)=0$, if $x\epsilon[0,1]$

$\Phi(x)=1$, if $x\epsilon[0,1]$

$\Phi(x)=0$, if $x\epsilon[0,1]$ ………………………….(4)

d) Discrete Cosine Transform

A Discrete Cosine Transform (DCT) expresses a finite sequence of many data points in terms of a sum of cosine functions oscillating at different frequencies. The DCT and DCT-II are often used in signal and image processing, especially for lossy data compression, because it has a strong energy compaction property. Most of the signal information tends to be concentrated in a few low-frequency components of the DCT. The two-dimensional DCT of M-by-N matrix A is given in equation 5 and 6.

$$B_{pq}=\alpha_p\,\boldsymbol{\alpha}_q\sum_{M=0}^{M-1}\sum_{N=0}^{N-1}A_{mn}\cos\frac{\pi(2m+1)p}{2m}\cos\frac{\pi(2n+1)q}{2N} \quad \text{….. 5.}$$

$$0\leq q<N-1$$
$$0\leq q<N-1$$

$$\alpha_P = \begin{cases}1/\sqrt{M}, & p=0\\ \sqrt{2/M}, & 1\leq p\leq M-1\end{cases} \qquad \alpha_q=\begin{cases}1/\sqrt{N}, & q=0\\ \sqrt{2/N}, & 1\leq q\leq N-1\end{cases} \quad \text{………..6.}$$

Where *M* and *N* are the rows and columns of *A*. DCT is applied on the approximation band of DWT image to derive DCT coefficients as shown in Fig 4.

(a) LL Band of DWT

(b) DCT image

Fig 4. Transform Domain Palmprint Images

e) *Quaternion Principle Analysis (QPCA):*

Quaternion technique and Principle Component Analyses (PCA) are together used to obtain the palmprint features. QPCA is the combination of quaternion technique and PCA.

Generation of Quaternion Matrix

Quaternion is a multi scale analysis tool which is shift invariant. Quaternion matrix can be used for processing color and multispectral images. The four spectral images of a palm print pertaining to NIR, red green and blue are used for getting a quaternion matrix Q(x,y).The elements of each image I(x, y), R(x, y), G(x,y) and B(x,y) as shown in Figure 5.

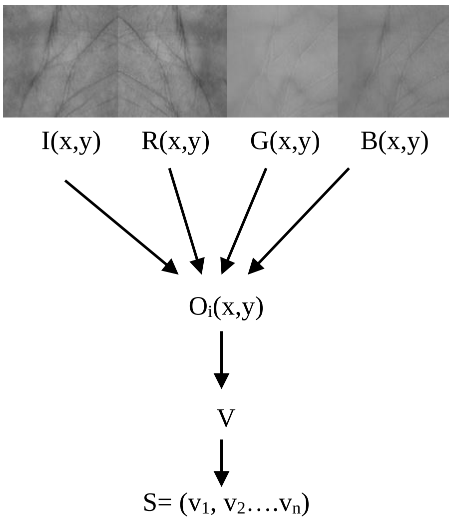


Fig 5. Generation of quaternion sample matrix

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The sum of the four elements of the four spectral images is the quaternion matrix Q(x, y) which is obtained as according to [10].

$$Q(x,y)=I(x,y)+R(x,y)i+G(x,y)j+b(x, y)k \quad \ldots\ldots(7)$$

Where i, j, k are the imaginary parts, *n* such quaternion matrices Q1, Q2, …. Qn are thus obtained. From each quaternion matrix we construct a column quaternion vector of size *m*. Thus we obtain quaternion vectors V1, V2 …. Vn. From this we obtain the sample matrix S_{mxn}

$$S_{m\,x\,n} = V1, V2,\ldots,Vn \quad \ldots\ldots\ldots \quad (8)$$

Where *m* is the number of pixels and *n* is the number of images.

Principal Component Analysis (PCA)

PCA is the process of obtaining the Eigen vectors and Eigen values of a given image. The ROI of each palmprint is of size 40x40 i.e. 1600 pixels. The palmprint ROI's are arranged in column wise to derive a matrix *I* of size 1600 x Number of images. Compute mean of each row of I to obtain mean matrix *m* of size 1600x1. Zero mean matrix *z* of *I* is derived by subtracting each element of *I* from the corresponding mean. Compute the covariance *c* of matrix *z* and Eigen vectors using Equation (9).

$$c * V = V * \lambda \ldots\ldots \quad (9)$$

Where λ is the Eigen value and V is the Eigen vector. PCA coefficients are obtained by multiplying z and *V*.

f) Matching

The matching metric that is used to compare two templates is the weighted Euclidean distance. This metric is heavily used especially when the two templates consists of integer values and is given in equation (10).

$$d1(p,q) = \sqrt{\frac{1}{M}\sum_{i=1}^{M}(p_i - q_i)^2} \ldots\ldots\ldots\ldots\ldots(10)$$

Where, M is the dimension of feature vector. P_i is the i^{th} component of database feature vector. q_i is the i^{th} component of test feature vector.

IV. ALGORITHM

Problem Definition: Given Palm images to verify the authentication of a person using fusion of (DWT), DCT and (QPCA) features. The objectives of the proposed model are:

(i) To increase the Correct Recognition Rate (CRR).

(ii) To reduce the False Rejection Rate (FRR).

(iii)To reduce the False Acceptance Rate (FAR).

(iv) To reduce Equal Error Rate (EER).

The proposed algorithm of palm recognition system is given in the Table 1, to authenticate a person based on fusion of Discrete Wavelet Transform (DWT), DCT and Quaternion Principal Component Analysis (QPCA).

Table 1: Algorithm of PIDDQ

Input: palm Image.

Output: Match /Mismatch of a person.

Read NIR ROI palm image from Poly U database.

Apply histogram equalization.

Apply Haar DWT.

Apply DCT on LL band image .

Above four steps are repeated for remaining Red, Green and Blue images.

Construct the quaternion sample matrix for required number of persons.

Final feature vector is extracted by applying PCA to the matrix obtained in step6.

The Euclidian distance is used to compare test features with database features for matching.

V. RESULTS AND PERFORMANCE ANALYSIS

The Poly U database is used to test the performance analysis; each person in the Poly U database contains 12 image sample images under 4 categories; NIR, Red, Green and Blue. For example fig 6 shows the first person's all palm sample images under one (NIR) category. The first 11 samples are used to create database and last twelfth image is used as test image.

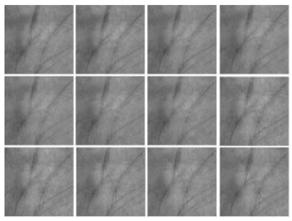

Fig 6. Sample palm ROI images of First Person under Blue category

The database is created by considering 400 persons from Poly-U MS palm database. The first 11 palm images of each person under all 4 categories are considered for the database creation.ie, totally 4400 palm images are present in the database of 400 persons. Twelfth palm image of each person is considered for testing, which is equal to a total of 500 test palm images. The FRR and CRR are computed with 4400 palm database images and the 500 test palm images.

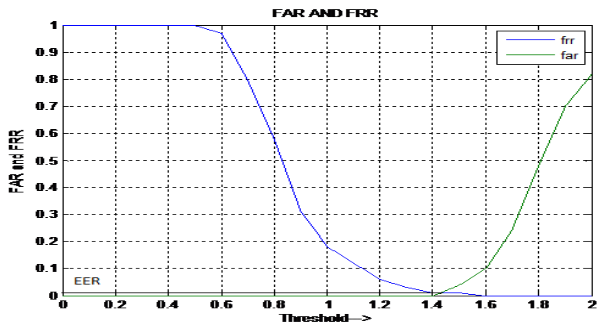

Fig 7: FRR and FAR v/s Threshold.

The remaining i.e., 401th person to 500th are considered for the calculation of FAR. Totally 100 persons out of the database are considered for the computation FAR.

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The Figure 7 shows the graph drawn for FRR and FAR v/s Threshold. From the graph it can be inferred that FAR and FRR intersect at the point of given threshold value. The intersection of the FAR and FRR curve gives EER.

Table 2: Output values for different thresholds.

Threshold	CRR	FRR	FAR
0.0	0.0000	1.0000	0.0000
0.2	0.0000	1.0000	0.0000
0.4	0.0000	1.0000	0.0000
0.6	3.0000	0.9700	0.0000
0.8	40.000	0.6000	0.0000
1.0	82.000	0.1800	0.0000
1.2	94.000	0.0600	0.0000
1.4	99.000	0.0001	0.0000
1.6	100.00	0.0000	0.0012
1.8	100.00	0.0000	0.2400
2.0	100.00	0.0000	0.4100

The values of CRR, FRR and FAR with different thresholds are tabulated in Table 2. It is seen that as the threshold value increases CRR and FAR increases whereas FRR Decreases with increase in threshold value. The values of FAR and FRR are almost zero for threshold value of 1.5.The correct recognition rate is 100% at a threshold value of 1.6.

The CRR values for existing multispectral palmprint recognition using Quaternion Principle Analysis (MPRQ) [10] and proposed PIDDQ is compared in Table 3.It is observed that the CRR value is better in the case of proposed algorithm compared to the existing method.

Table: 3 Comparison of CRR for existing and proposed methods

MODEL	CRR (%)
Existing MPRQ Model[10]	98
Proposed PIDDQ Model	99

VI. CONCLUSION

In this paper PIDDQ algorithm is proposed to identify a person. The poly U palmprint database is used for performance analysis. The histogram equalization is applied on each image to distribute intensity values uniformly. The Haar wavelet is used on the histogram equalized image to generate low frequency band i.e. approximation band and high frequency bands viz., vertical, horizontal and diagonal bands. The DCT is applied on approximation band to generate DCT coefficients. The final features are obtained by applying QPCA on DCT. The test features are compared with the features of each image in the data base using ED. It is observed that the recognition rate is better in the case of the proposed algorithm as compared to the existing algorithm.

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K P Shashikala is an Assistant Professor, Dept. of Electronics and Communication Engineering, Dayananda Sagar College of Engineering, Visveswaraya Technical University, Bangalore. She obtained her B.E. Degree from MSRIT Bangalore and MTech in Digital Communication from BMSCE Bangalore, Currently pursuing Ph.D. under the guidance of Dr. K B Raja. She has published a paper in the international journal IJESR, "Performance evaluation of Palmprint Identification Using Multimatching Techniques" and presented a paper in the IEEE Conference ICIIP held in Shimla, India. Her interests include Image Processing, Biometrics, Communication and Embedded Systems.

K B Raja is an Assistant Professor, Dept. of Electronics and Communication Engineering, University Visveswaraya college of Engineering, Bangalore University, Bangalore. He obtained his BE and ME in Electronics and Communication Engineering from University Visveswaraya College of Engineering, Bangalore. He was awarded Ph.D. in Computer Science and Engineering from Bangalore University. He has over 65 research publications in refereed International Journals and Conference Proceedings. His research interests include Image Processing, Biometrics, VLSI Signal Processing, computer networks.

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