RESEARCH PAPER

International Journal of Recent Trends in Engineering, Vol 1, No. 1, May 2009

BRIOP: Blood Relation Identification Using Offline Palmprints

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Abstract— **Biometrics is an automated approach of measuring and analysing physical and behavioural characteristics for identity verification. Palmprint is one of the utilitarian traits of biometrics. There are scads of work done in the area of palmprint technology. But, to the best of our knowledge no work has been done to trace the family members of a particular person using offline palmprints. This can be utilised when a new criminal comes under the custody of law, his investigation might need the information of the family members who are already indulged in criminal activities. In this paper, the above application is implemented by extracting texture features from the offline palmprint and then classifying them into desired family and non-family clusters. Moreover, this approach, called BRIOP, has also been compared with prior works related to classification and clustering of data. The accuracy of the used approach is discussed using FAR and FRR graphs.**

Index Terms— **Biometrics, Offline Palmprint, Texture Analysis, Wavelet Analysis, K-means, family, BRIOP, criminal.**

I. INTRODUCTION

Biometrics, through its statistical matching of physiological characteristics, to an efficient database can provide for greater security and more accurate authentication practices. Biometric continues to grow in importance as government security forces now opt to rely less on documents or passwords to authenticate individuals. The various traits used in biometric system are fingerprints, handprints, iris, signature, face, etc. Palmprint identification is one of the developing technologies of biometric authentication.

As described in [13], there are certain important considerations in choosing the right biometric technology. Accuracy and complexity of the analysis are the two cardinal elements which help in deciding the technology to be employed and its associated cost.

In present times, fingerprint is the most widely used trait of biometrics. Some of the problems posed by its use for identification purposes are mentioned below:

1) The utilisation of fingerprints, which are minute in detail, actually requires very high resolution image, complex imagery setup and increased system memory requirements. This complexity of fingerprint technology can be reduced by the use of palmprint technology.
2) Moreover, capturing clear fingerprint images is problematic and the process often needs to be repeated to secure an indelible image of an individual's identity. This lack of accuracy can be compensated by the use of palmprints.

Thus, the need and importance of palmprints as a simple and highly accurate tool for biometric recognition systems increases manifold. Palmprints provide more potential for identification because they include fingerprints, hand geometry, texture and also the ability of thermal readings.

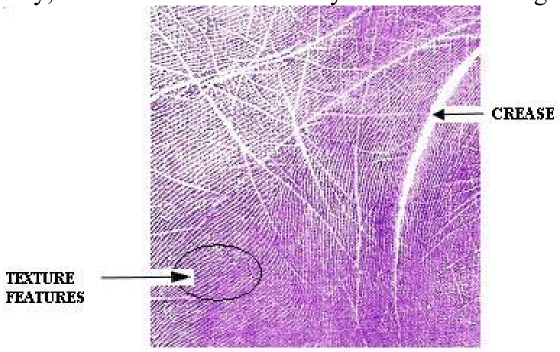


Fig. 1 Image of Offline palmprint showing texture features and crease

Since the precision of feature extraction is heavily dependent on the image quality, image enhancement is an indispensible module in offline palmprint system as compared to online palmprint[4]. Palmprint feature extraction methods are mainly based on geometrical parameters[9], lines topology[7][11], texture features[1], crease[11], Wavelet and Fourier transforms[1][8][10] etc.

In this paper, we have devised an approach (BRIOP) to classify palmprints into family and non-family clusters with respect to a particular person. This can be utilised for tracing the family members of a criminal, who are already indulged in criminal activities. This approach is implemented by extracting texture features of offline palmprints. These texture features are shown in fig. 1. After extraction, the palmprints are classified into desired family and non-family clusters.

For the effectuation of the proposed approach, rest of the paper is organised as follows: Section II comprises of the prior work which have been done so far. Section III explains our motivation to come over to this approach and our contribution in it. Section IV contains the terms and notations used throughout the paper. Section V proposes system design for this framework. Section VI conducts some experiments and produces the desired result. Section VII draws out the conclusion for our approach and finally Section VIII discusses the future work to be done.

II. PRIOR WORK

The prior work done in image pre-processing stage mainly focuses on extraction of central image from the whole palmprint image with the help of gaps between the fingers[6][12]. Work has also been performed to reduce the noise in the image by filling the image with non-overlapped disks taking the disk of the maximum radius[5].

A significant amount of work has been done in feature extraction stage. In 2001, Chen et al. [11] extracted all the creases in a palmprint based on which a rotation and translation invariant matching algorithm was devised. In 2007, Zheng et al. [3] performed a series of experiments and provided enhanced and smoothened palmprint images which contributed in locating special areas on offline palmprints[4]. Also, Wang et al. [7] proposed a fuzzy approach to recognize one of the special structures (mi-structure) in the palmprints. Various texture features were also extracted using multi-resolution method through wavelet transform[1][8].

Clustering of palmprints is an area which has attracted very few researchers. The work done for classification of palmprints includes isodata clustering and RB K-means classification[1][2]. These methods take any random centroid and then make clusters by successive iterations.

III. MOTIVATION AND CONTRIBUTION

The severity of terror attacks has been increasing significantly day after day. More and more people are getting involved in criminal activities and hence identification of these criminals is becoming a menace for the defence authorities.

Criminal psychology is hereditary is an irrefutable fact[14]. Much information about the criminals, their characteristics and psychology can be discovered if we are able to identify their family line. The palmprints of the criminals can be matched with the existing database of palmprints to extract out their family or blood relations who are already indulged in the criminal activities. Up till now no such technology has been developed for identification of family palmprints.

Our research work is an endeavour to study a particular palmprint and identify such palmprints which would characterize its family clusters. This is done by extracting texture feature vectors and classifying palmprints into clusters according to their family associations. This brings forth the family relations of criminals and caters to our objective. The detailed working of the above approach has been presented in the subsequent sections.

IV. TERMINOLOGY USED

The various terms and notations used are as follows:

1) f' – Normalised texture feature vector.
2) f_{min} –The minimum value of the normalised vector f'.
3) f_{max} – The maximum value of the normalised vector f'.
4) *Test Hand* – It is the hand under consideration of which family members are to be found out.
5) *Sample hand* – It is the hand taken as a sample which does not belong to the family of the test hand.
6) *Database hand* – It is hand in the database from where the family hands are to be sought.
7) *n* – It is the number of palms in the database.
8) *FAR* – Also known as False Accept Ratio. This gives the number of false samples which have been accepted. It is defined as:

$$FAR = \frac{\text{Number of accepted imposter claims}}{\text{Total number of genuine accesses}}.$$

9) *FRR* – Also known as False Reject Ratio. This gives the total number of true cases which have been rejected. It is defined as:

$$FRR = \frac{\text{Number of rejected genuine claims}}{\text{Total number of genuine accesses}}.$$

V. BRIOP SYSTEM FLOW

Fig. 2 shows the flow of operations to be performed in our BRIOP framework.

Fig. 2 Flow Diagram of BRIOP framework

These are discussed as follows:

A. Image Pre-processing

The hand images are pre-processed to obtain the *region of interest (ROI)* or palmprint image. Image pre-processing stage involves hand image segmentation, key point determination and palmprint extraction from the hand image so obtained[6].

The various steps involved are:

Step1: *Binary the image.*

Binary the hand image. Then by applying suitable threshold value the hand image is severed from the entire page area.

Step2: *Application of Boundary Tracking Algorithm.*

Using Boundary Tracking Algorithm three key points k1, k2 and k3 are detected to find the local minima of distance between centre and the boundary pixels.

Step3: *Alignment of palmprint image.*

With the help of the key points calculated above the new coordinate system is devised as in [12] and the palmprint is aligned along the vertical direction.

Step4: *Extraction of central part sub-image*

Once the coordinate system is decided, a square sub-image of the central part of the palmprint is extracted. The side of square image should be 70% of the width of the palm.

B. ***Feature Extraction***

According to the fact that the basic features of a palmprint, including principal lines, wrinkles and ridges, have different resolutions, we analyse palmprints using a multi-resolution method and define novel palmprint features, called wavelet energy feature (WEF) and wavelet variance feature (WVF), based on Wavelet transform. These extracted feature vectors reflect the wavelet texture distribution of palmprint in different directions at different scales[1].

The palmprint image A_0 is decomposed by second level Wavelet transform using Daubechies Wavelet. The decomposed vectors H_k, V_k, D_k (k=1,2) obtained are the horizontal, vertical and diagonal detail parts of the k_{th} level decomposition, respectively as shown in fig. 3.

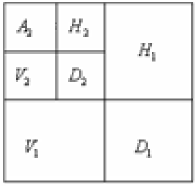


Fig. 3 Second level wavelet transform

The two static texture features described above (energy and variance) are defined as follows:

Energy:

$$E_{i,d} = \sum_{j=1}^{m} \sum_{k=1}^{n} (g_i^d(j,k))^2 \qquad (1)$$

Variance:

$$V_{i,d} = \sum_{j=1}^{m} \sum_{k=1}^{n} (g_i^d(j,k) - M_{i,d})^2 \qquad (2)$$

Where d=0, 1, 2, 3 corresponding to the Wavelet sub-image in the low resolution of original image and image details in horizontal, vertical and diagonal directions at different scales.

$M_{i,d}$ is the gray mean,

$$M_{i,d} = \sum_{j=1}^{m} \sum_{k=1}^{n} \left| g_i^d(j,k) \right| \qquad (3)$$

After i-level decomposition, the feature vector can be defined as:

$$f' = [f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8]$$

$$= (1/i) * [\sum_{k=1}^{i} E_{k,0}, \sum_{k=1}^{i} E_{k,1}, \sum_{k=1}^{i} E_{k,2}, \sum_{k=1}^{i} E_{k,3},$$

$$\sum_{k=1}^{i} V_{k,0}, \sum_{k=1}^{i} V_{k,1}, \sum_{k=1}^{i} V_{k,2}, \sum_{k=1}^{i} V_{k,3}] \qquad (4)$$

Where, i is total wavelet decomposition level. $E_{k,d}$, $V_{k,d}$ are energy and variance feature vectors respectively of wavelet sub-images in different directions d(d = 0, 1, 2, 3) at the k_{th} level wavelet decomposition (k from 1 to i).

Finally, the vector f is normalised as follow:

$$f'' = [f_1', f_2', f_3', f_4', f_5', f_6', f_7', f_8']$$

$$f_i' = (f_i - f_{min}) / (f_{max} - f_{min}) \qquad (5)$$

where f_i(i = 1,2,...,8) is one of the elements in vector f'.

f_i' should lie in the range [0,1]. This normalised vector f_i' is called the wavelet texture feature.

C. ***Clustering***

Clustering is the classification of objects into groups (called *clusters*) so that the objects belonging to the same cluster are more similar to each other than the objects from different clusters. Often similarity is a function of the distance between the vectors of these objects.

K-means clustering is an algorithm to classify or to group objects based on attributes/features into K number of groups, where K is a positive integer number. The grouping is done by minimising the square root of the sum of squares of distances between data and the corresponding cluster centroid. Thus it is a very simple approach to classify the data.

Our BRIOP approach applies this simple K-means clustering algorithm to obtain the desired clusters of family and non-family members.

Algorithm 1: Application of K-means

```
Input –  Centroid[1] ← F_TH
         Centroid[2] ← F_SH
         F_DH
Output – Match[number of palmprints][2]
```

```
For all i
    For c = 1 to 2
        For k = 1 to 8
            R[i][k] ← F_DH[i] – centroid[c]
            Sq[i][k] ← R[i][k] * R[i][k]
            Sum[i] ← Sum[i] + Sq[i][k]
        End for
        Sqrt[i][c] ← √ Sum[i]
    End for
End for

For all i
  Min[i] ← minimum(Sqrt[i][1], Sqrt[i][2])
  Match[i] ← 0
  For c = 1 to 2
      If ( Min[i] = sqrt[i][c]) then
          Match[i][c] = 1
      End if
  End for
End for
```

In simple K-means algorithm, generally random centroids are taken and then the above algorithm is repeated many a times until a certain condition is reached. In each iteration, new centroids are chosen and the algorithm is repeated as shown in fig. 4. This repetitive iteration leads to the formation of clusters irrespective of the properties of centroids chosen initially.

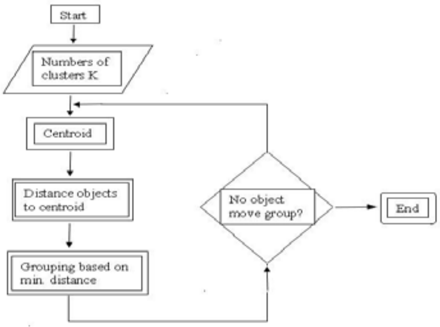


Fig. 4 Flow Diagram of K-means Algorithm

Whereas, our approach, called BRIOP, says that the centroid defines the property of a cluster. So, selection of a new centroid in each and every iteration of the algorithm causes the cluster property to deviate from the centroid chosen initially. Hence, our approach performs only one iteration of the algorithm and take one centroid as the test palm and other centroid as the sample palm which is the non-family palm. Therefore, two clusters are formed where the first cluster consists of the family members and the second cluster comprises of the non-family members.

VI. EXPERIMENTATION AND RESULT

The palmprint database used in the experiment is obtained from the people of different ages, occupation and families so that the database is diversified. It consists of 700 images collected from 350 individuals including 30 families. The images were scanned at the resolution of 500 dpi and 256 gray scales. Image pre-processing and feature extraction were carried out in MATLAB 7.0.1. Clustering was performed in MS Visual C++.

Second level wavelet transform carried out in feature extraction method gives horizontal, vertical and diagonal detail vectors as shown in fig. 5.

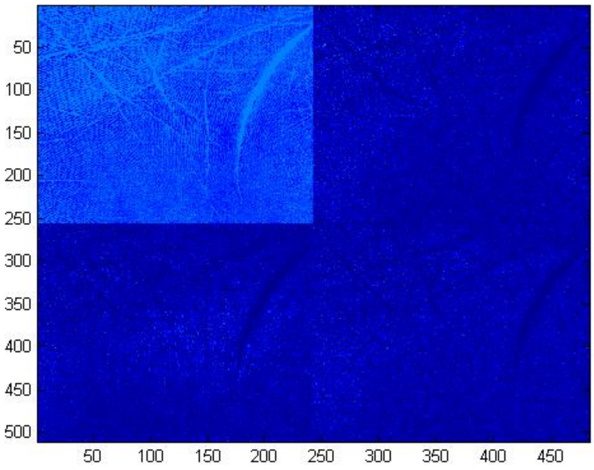
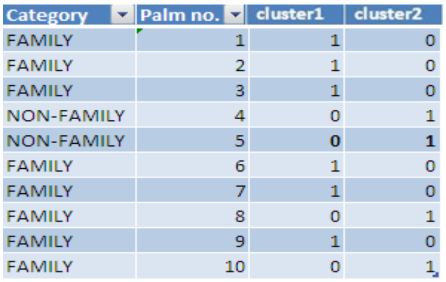


Fig. 5 Example showing second level wavelet transform

The feature vectors extracted are stored in an array of dimension eight. The texture feature vectors for 10 palmprints, which include mixture of family and non-family members, obtained are shown in fig. 6. The first four indices give the energy vectors while the last four indices give the variance vectors of the original, horizontal, vertical and diagonal details of the image.

After extracting the feature vectors, one iteration clustering is performed taking two centroids, one test palm and the other sample non-family palm. The two clusters obtained after application of k-means algorithm are shown in fig. 7. Here the palmprints 1 and 5 are taken as the centroids where palmprint 1 is the test palm and palmprint 5 is the sample non-family palm.



Category	Palm no.	cluster1	cluster2
FAMILY	1	1	0
FAMILY	2	1	0
FAMILY	3	1	0
NON-FAMILY	4	0	1
NON-FAMILY	5	**0**	**1**
FAMILY	6	1	0
FAMILY	7	1	0
FAMILY	8	0	1
FAMILY	9	1	0
FAMILY	10	0	1

Fig. 7 Cluster Table
cluster1 – family, cluster2 – non-family

The accuracy of the above approach comes out to be 80%. Its FAR (False Accept Ratio) and FRR (False Reject Ratio) graph is as shown in fig. 8.

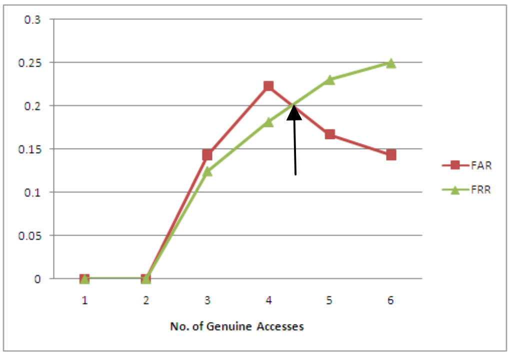


Fig. 8 Graph showing FAR and FRR vs. number of samples

The graph shows how the false accept ratio and the false reject ratio varies with the number of database samples. The point marked with arrow indicates the critical point and the value at this point gives the Equal Error Rate (EER) which comes out to be 20%.

Low critical value will be taken when we wish to secure the inclusion of all possible family palmprints in the family cluster. But the associated disadvantage in this case is that some palmprints not belonging to the family would also be included in the family cluster.

On the other hand, selecting high critical values will not allow any non-family palmprint to be included in the family cluster, but some family palmprints will also fail to be admitted in the family cluster.

The relation between FAR and FRR is as shown:

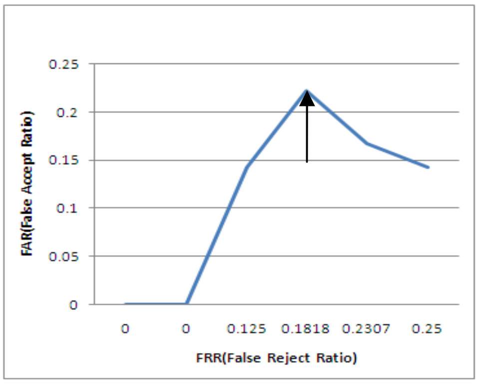
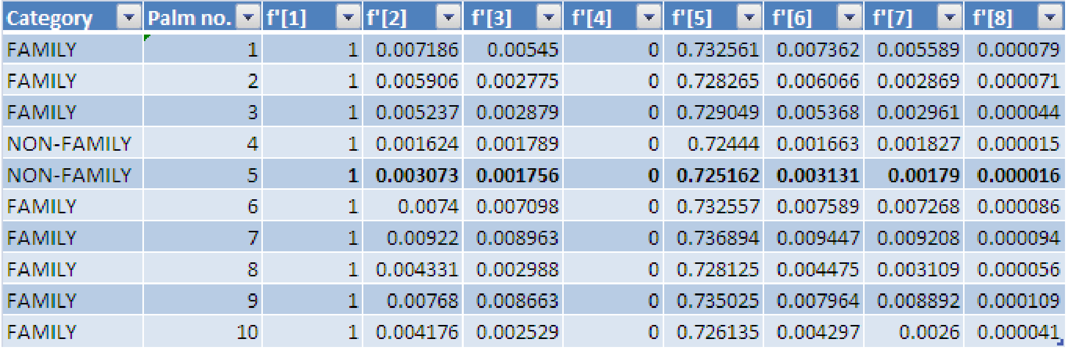


Fig. 9 Graph showing FAR vs. FRR



Category	Palm no.	f'[1]	f'[2]	f'[3]	f'[4]	f'[5]	f'[6]	f'[7]	f'[8]
FAMILY	1	1	0.007186	0.00545	0	0.732561	0.007362	0.005589	0.000079
FAMILY	2	1	0.005906	0.002775	0	0.728265	0.006066	0.002869	0.000071
FAMILY	3	1	0.005237	0.002879	0	0.729049	0.005368	0.002961	0.000044
NON-FAMILY	4	1	0.001624	0.001789	0	0.72444	0.001663	0.001827	0.000015
NON-FAMILY	**5**	**1**	**0.003073**	**0.001756**	**0**	**0.725162**	**0.003131**	**0.00179**	**0.000016**
FAMILY	6	1	0.0074	0.007098	0	0.732557	0.007589	0.007268	0.000086
FAMILY	7	1	0.00922	0.008963	0	0.736894	0.009447	0.009208	0.000094
FAMILY	8	1	0.004331	0.002988	0	0.728125	0.004475	0.003109	0.000056
FAMILY	9	1	0.00768	0.008663	0	0.735025	0.007964	0.008892	0.000109
FAMILY	10	1	0.004176	0.002529	0	0.726135	0.004297	0.0026	0.000041

Fig. 6 Second level wavelet transform

The point marked in the graph of fig. 9 indicates that after this point the FAR-FRR graph comes to its normal hyperbolic state. This point indicates that the approach works quite efficiently and accurately with at least 20 database palmprints. After this point, FAR varies inversely with FRR. Hence, the graph is in concordance with our motive.

VII. CONCLUSION

This paper implements an efficient and crucial application of offline palmprints using wavelet transform and k-means algorithm. The BRIOP approach mainly comprised of three stages. The first stage included image acquisition and image pre-processing in which a palmprint image was segmented out of the hand image taking care of the hand orientation. The second stage consisted of feature extraction where energy and variance feature vectors were extracted using wavelet transform. And at last clustering was performed, classifying each database palm as family or non-family palm.

The study of FAR and FRR graph concludes that for the purpose of identification of criminal blood relations, the critical value should be taken low. This is done so as not even one of the criminal family member is left out from investigation. But, this may lead to investigation of some non-family members which does not hold much importance for this grand motive.

The results quantifies that our approach can trace family members with dependable efficiency and accuracy. This can also successfully be used in criminal investigation for identifying their blood relations.

VIII. FUTURE WORK

In future, feature extraction will be analysed with different wavelets to improve the accuracy of the BRIOP algorithm. Also a similar approach with footprints will be analysed. Also it will be studied for taking offline palmprints with different colours.

Also, the critical values will be decided for various other purposes like identification of mutilated bodies in case of serious blasts, etc.

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