International Journal of Computer Applications (0975 – 8887)
Volume 144 – No.3, June 2016

Feature Level Fusion of Multispectral Palmprint

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ABSTRACT
Palmprint identification is one of the evolving technologies for personal authentication. Multispectral palmprint over the years have been widely used for authentication and security. This paper investigates the use of hybrid of Gabor filter and information sets for multispectral palmprint feature extraction. The Gabor feature vector has high dimensionality and it increases the time complexity of the identification. To overcome this we have extracted the information set based features from the Gabor features. Till now the hybrid of Gabor filter and information set based features has not been implemented. The rigorous experimental results ascertain that these features outperform the state-of-art features for multispectral palmprint. After this feature level fusion is performed, this converts two or more feature vectors into one feature vector and thus increases accuracy. Then in classification process individual's palmprint is compared with the enrolled user's palmprint in database by using K-nearest neighbor classifier. The performance of K-nearest neighbor classifier is compared with the SVM classifier. Accuracy of SVM classifier is more than the K-nearest neighbor classifier.

Keywords
Biometrics, Fusion, Gabor filter, Information sets, Multispectral palmprint.

1. INTRODUCTION
In the recent years, palmprint as an authentication system for securing assets and infrastructure has grown widely. The reason behind same is that this technique of authentication is cost effective, user friendly, highly accurate and reliable as compared to other biometric techniques. Except these advantages one most important thing about palmprint is that it has principal lines, ridges and wrinkles which makes feature extraction more easy and accurate. No two people have same palmprint, not even twins. As compared to other biometrics techniques palmprint have larger surface area and discerning feature such as principal lines, ridges and wrinkles making it useful in biometric security.

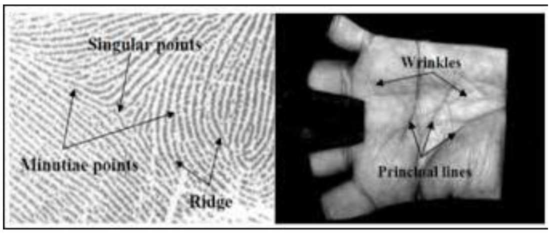


Figure1. Image of Palm

The motive of this research is to provide surety that only authenticated person can access the resources. Like Face, Iris, Fingerprint, vein pattern, hand geometry, ear recognition, Retina scans, Palmprint is also considered as 'physiological' biometrics whereas Voice-scan, Signature-scan, keystroke-scan comes under 'behavioral' biometrics. Fusion is a very effective way to increase the accuracy of features. After fusion the resulting features is more accurate and robust than the individually extracted feature. Fusion may combine two or more color bands but accuracy depends on the choice of band used for fusion. Biometric system can be unibiometric or multibiometric. Unibiometric systems are those systems which make use of only one biometric attribute. While multibiometric modal uses multiple biometric attributes. Unibiometric has some limitations like non-universality, circumvention, lack of individuality. Multispectral imaging overcomes these limitations very well. In electromagnetic spectrum to capture image data at specific wavelength multispectral imaging is used. Multispectral uses either all the visible bands or infrared or combination of both.

As highly accurate and robust palmprint authentication system with anti-spoofing features is in demand, so that the use of multispectral palmprint is increasing day by day. Multispectral palmprint means images of palmprint are captured in different spectral bands. Each band has specific features that provide more accurate features as a result.

The rest part of the paper is organized as follows: Section 2 describes motivation and related work. Section 3 details Literature Survey. Section 4 describes proposed system work which includes feature extraction by using Gabor filter (Section 4.1) and information sets (Section 4.2) and fusion of multispectral bands. Section 5 summarizes the experimental results. Section 6 summarizes conclusion and Section 7 highlights the references.

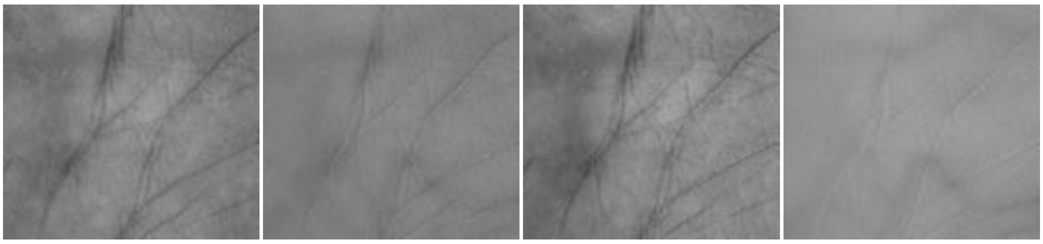
2. MOTIVATION
Palm has much larger area and distinctive features as compare to other biometrics. This makes it more suitable for the process of identification. Gabor filter is used for the texture feature extraction of an image. The Gabor feature vector has very high dimension which increases the complexity of classifier. To overcome this we are using information sets which not only help in dimension reduction but also address the uncertainty in the gray levels.

3. LITERATURE REVIEW
Palm print authentication system has gained lot of attention of researchers because of its high accuracy and anti-spoofing characteristics. An automated palmprint recognition system proposed by Connie et al [1] uses principal component Analysis (PCA), Fischer Discriminant Analysis (FDA) and Independent Component Analysis (ICA) for the feature extraction. Palm print Recognition System by Kour et al [2] analyzed CASIA palmprint database, Poly U palmprint database and IITD palmprint database. Mrs. Maheswari. M et al [3] have done a survey on multispectral biometric images in which they studied various types of multispectral biometrics attributes. They have found that multispectral image provides better result for identification. Mamta et al [4] use Local Principal Independent Component (LPIC) which is extension of PCA. They use different features such as Effective

information (EI), Energy feature (EF), Sigmoid feature (SF) and Multi Quadratic feature (MQD) for feature extraction. Harshad et al [5] makes use of Contourlet Transform (CT) for feature extraction of multispectral palmprint. CT is a very effective multiresolution and multidirectional transform which is useful in collecting palm features. Bhokare et al [6] explain various image fusion methods like Wavelet Transform, Curvelet Transform, Principle Component Analysis (PCA) Intensity-hue-saturation (IHS), Laplacian Pyramid, Brovey Transform, Gradient Pyramid, Filter-Subtract-Decimation (FSD), Contrast Pyramid, and Linear Superposition in detail. For multispectral palmprints, Zhang et al [7] conclude that features extracted from red bands are superior to blue, green and NIR bands. The score level fusion is also performed to achieve high accuracy with anti-spoofing capability. Sale et al [8] calculated quality metrics SSIM, MI, QI, Edge based parameter etc after applying PCA for palmprint. Nan Luo et al [9] have proposed a novel method for multispectral palmprint recognition by using feature level fusion technique that gives better results than image level fusion, and comparable results with matching score level fusion. Pan et al [10] uses Gabor filter for calculation of local invariant features and they used KNN (K- Nearest Neighbor) method for classification. Authors in [11] applied sigmoid function at the output of Gabor filter for better performance. They make histogram features from positive and negative real parts of output. Xingpeng Xu et al [12] present quaternion model for multispectral biometrics system. DWT and PCA are used for features extraction of multispectral palmprint. Shashikala et al [13] presented palmprint identification system in which features are extracted by using QPCA and Euclidean Distance is used for matching. Jayshri P. Patil et al [14] proposed palmprint identification methods for palmprint image acquisition, pre-processing fusion, feature extraction and feature matching. Authors in [15] proposed a scanner-based authentication system by using the palmprint features. Enrolment and verification are two stages of authentication system. To find the similarity in the verification stage they use template-matching and the back propagation neural network. To increase the accuracy Amel Bouchemha et al [16] have proposed the fusion of palmprint and palm vein features. They have proposed a approach which is based on statistical study and energy distribution analysis of Finite Ridgelet transform coefficients They have also tested the performance of three classifiers: K nearest neighbor (KNN), Support Vector Machine (SVM) and `One-Against-One' multi-class SVM (OAO-SVM) with RBF kernel using 6-folders cross-validation.

4. PROPOSED SYSTEM WORK

Palmprint as a biometric authentication system is widely used for Identification and verification of security access applications. So to increase accuracy and anti-spoofing capability multispectral palmprint with fusion technique is used. For optimization of the performance some palm recognition systems segment the palm into smaller areas, while others scan the entire palm. We have used a large multispectral palmprint database from Poly U, Hongkong. The palmprint images are captured under Blue, Green, Red, and near-infrared (NIR).



(a) (b) (c) (d)

Figure 2 (a) Green (b) Red (c) Blue (d) NIR

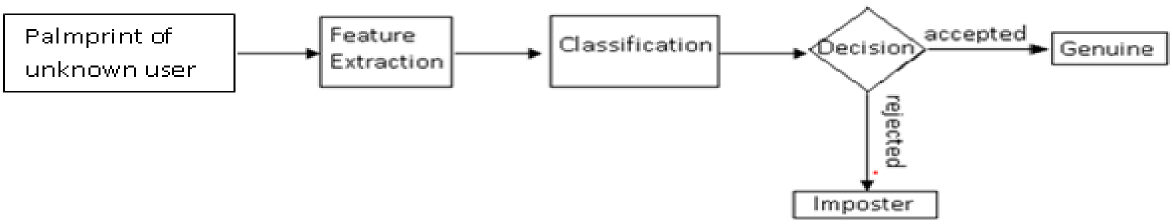


Figure 3 Flow-chart for authentication of individual band

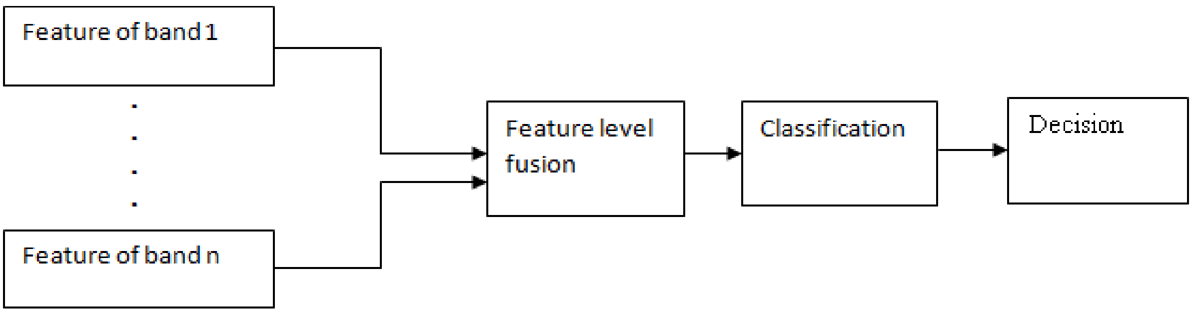


Figure 4: Verification of multispectral Palmprint

4.1 Feature Extraction By Using Gabor Filter

Gabor filter is a band pass filter, widely used in image processing. Impulse response of Gabor filter is a harmonic function multiplied by a Gaussian function is used for feature extraction. The phase, frequency, size and orientation of the output image are selected by the Gabor filter. The output image is decided by the various parameters of the Gabor filter which plays an important role in decision making. Gabor filter removes noise, improves contrast and detects known pattern. Real and imaginary part of Gabor filter represents orthogonal directions. 2-D Gabor filter is a complex sinusoidal modulated Gaussian function [11] with response as given below:

In spatial domain

$$g(x, y; \lambda, \phi, \sigma_x, \sigma_y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\{-\frac{1}{2}[\frac{R_1^2}{\sigma_x^2} + \frac{R_2^2}{\sigma_y^2}]\} * \exp[i . \frac{2\pi R_1}{\lambda}], \quad (1)$$

Where

R_1 = x cos ϕ+ ysin ϕ

R_2 = - xsin ϕ+ ycos ϕ

In spatial-frequency domain

$$G(u, v; \lambda, \phi, \sigma_x, \sigma_y) = C \exp\{-2\pi^2(\sigma_x^2(F_1 - \frac{1}{\lambda})^2 + \sigma_y^2(F_2)^2)\}, \quad (2)$$

Where

F_1= ucos ϕ+ vsin ϕ and

F_2= -usin ϕ + v cos ϕ'

C is constant

In our paper, Features of palmprint are extracted by using Gabor filter. Output of Gabor filter is very high in dimension, hence using more space. So, we are using hybrid of Gabor filter and information sets which overcome the disadvantages of Gabor filter to achieve better performance. Till now no one has implemented the hybrid of both Gabor filter and information sets for feature extraction.

4.2 Feature extraction by using Information sets

Information sets nowadays is attracting attention of researchers [4]. Information sets is developed to expand the scope of the fuzzy sets. In fuzzy set, each element is a pair constituting information source value and membership function. Membership function is core of related operations in many fuzzy set theories, but information value is hardly investigated. To overcome this and include information values to derive uncertainty of an image, Information Sets are used. Information set is nothing but product of Information values and membership function. The base of information sets being the product of property (Information values) and degree of belonging (membership function) of an image gets derived from Shannon entropy function. [4]

$$H = \sum p(-\log p) = \sum p \log p^{-1} \quad (3)$$

Where p is probability and log p is logarithmic gain.

log p can be replaced with exponential gain as

$$H = \sum p e^{(1-p)} \quad (4)$$

A generalized exponential gain with cubic polynomial of p in the exponential function is as follows.

$$H = \sum_{i=1}^{n}\sum_{j=1}^{n} p_{ij}\ e^{-(ap_{ij}^3 + bp_{ij}^2 + cp_{ij} + d)} \quad (5)$$

To quantify the uncertainty both the elements of fuzzy set (information source value and membership function) are required. Issue here is that this entropy is based on probabilities forcing the sum to be 1 and if information source values are used as probabilities the result is small leading to overall entropy to be also small. So instead of using information source value, we normalize information source value by global maximum and replace P by these values $I_{ij} = I_{ij}/Ig_{max}$

Now in Hanmandu and Das entropy functions if we take:

$$P = I_y; \quad a = 0; \quad b = \frac{1}{2f_{h(ref)}^2}; \quad c = -\frac{2I_{(ref)}}{2f_{h(ref)}^2}; \quad d = \frac{I_{(ref)}^2}{2f_{h(ref)}^2}$$

This converts exponential function to:

$$\mu_{ij}^g = e^{-\left[\frac{|I_{ij} - I_{ref}|}{\sqrt{2}f_h}\right]^2} \quad (6)$$

Here μ_{ij}^g is the Gaussian Function and fuzzifier f_h^2 is defined as:

$$f_{h(ref)}^2 = \frac{\sum_{i=1}^{w}\sum_{j=1}^{w}(I_{ref} - I_{ij})^4}{\sum_{i=1}^{w}\sum_{j=1}^{w}(I_{ref} - I_{ij})^2} \quad (7)$$

And I_{ref} is the reference to gray level in the image which can be maximum or averaged for normalized information source value.

So now the Hanmandu and Das equation can be written as:

$$H_g = \sum\sum I_{ij}\,\mu_{ij}^g \quad (8)$$

Here H_g is the information set and its element $I_{ij}\,\mu_{ij}$ represents information source value. For each different value ofμ, we can acquire different information forms.

The information sets are based on non overlapping window which are formed by granularization of the palm image. In our paper Effective Information and simple information set features are derived for extraction of information from palm and then feature level fusion is done to get the reduced number of features. K-NN is used for the classification of these features

Let I be an image of palm which is divided into non-overlapping windows by information set where each window represents one feature as shown in figure.

Simple information set: For simple information set we are using Gaussian membership function as described in eq. (5). In the kth window information source value is calculated by using formula as given below.

$$S.I = \sum_{i=1}^{n}\sum_{j=1}^{n} \mu_{ij}\, I_{ij} \quad (9)$$

Effective Information (EI): In the kth window, information source value is calculated using the centroid method from the information values.

$$\overline{I_k} = \frac{\sum_i\sum_j \mu_{ij}^g I_{ij}}{\sum_i\sum_j \mu_{ij}^g} \quad (10)$$

Here also we are using Gaussian membership function $\mu_{ij}^g = e^{-(\frac{|I_{ij} - I_{ref}|}{\sqrt{2}f_h}^2)}$

Figure 5 describes the feature extraction of multispectral palmprint. Here we apply Gabor filter for texture analysis and then we divide the image into non overlapping windows. Then we apply the information set based features as described in Eq. (9) and Eq. (10). For each window we get one feature. After obtaining features from all windows we concatenate them to form a single feature vector.

Here the features acquired from different bands of multispectral palmprint are concatenated. Feature level fusion means combining feature vectors of different multispectral bands into single feature vector and then classifies it. In our research we have used fused different bands at the feature level.

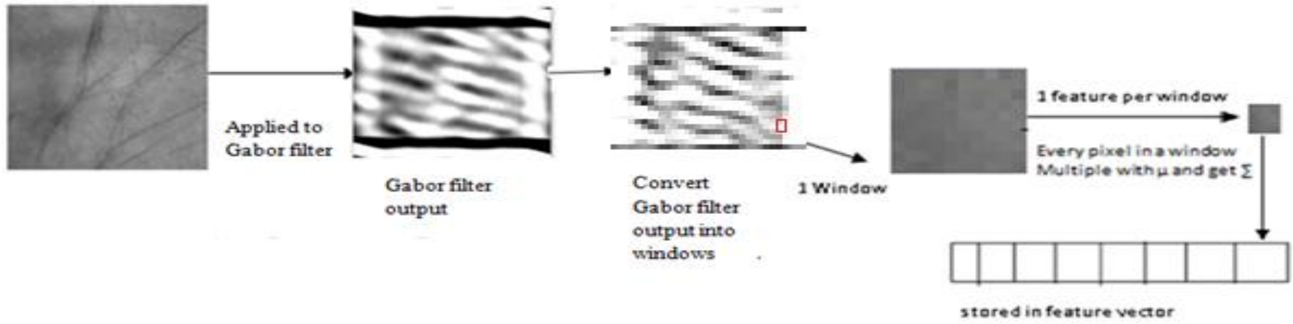


Figure 5. Extraction of feature vector from Palmprint

5. EXPERIMENTAL RESULT

We have done experiment based on multispectral palmprint which is developed in Poly U, Hongkong. Multispectral palmprint were created under blue, green, red and NIR illuminations. For each spectral band, there are 250 users and each user provided images of both left and right hand palm. So for each spectral band of the palmprint, we have 500 (=250*2) classes and we have taken 6 image samples for the training and 6 images for the test. There are total 500*6(3000) genuine scores and 500*499*6(1497000) impostor scores for each spectral band of the palmprint. These scores are then compared with the threshold (varying with a step size of 0.001) and then error rates FAR and FRR are calculated. Plot of GAR vs. FAR which is Receiver Operating Characteristic (ROC) curve determines the performance of this authentication system. GAR is genuine acceptance rate which decides the accuracy of a system. GAR= 1- FRR, where FRR is false rejection rate. FRR and FAR is calculated corresponding to threshold value. When the value of genuine becomes greater than the threshold value then FRR situation comes into picture. When the value of imposter becomes less than the threshold value then FAR situation comes into picture. If the value of FAR is zero no imposter will accepted as a genuine. If the value of FRR is zero no genuine will rejected as an imposter.

Fig. 6 shows the ROC plots of individual bands of multispectral palmprints using effective information based features for different window sizes. For all bands, the best GAR is obtained with the window size of 11*11.

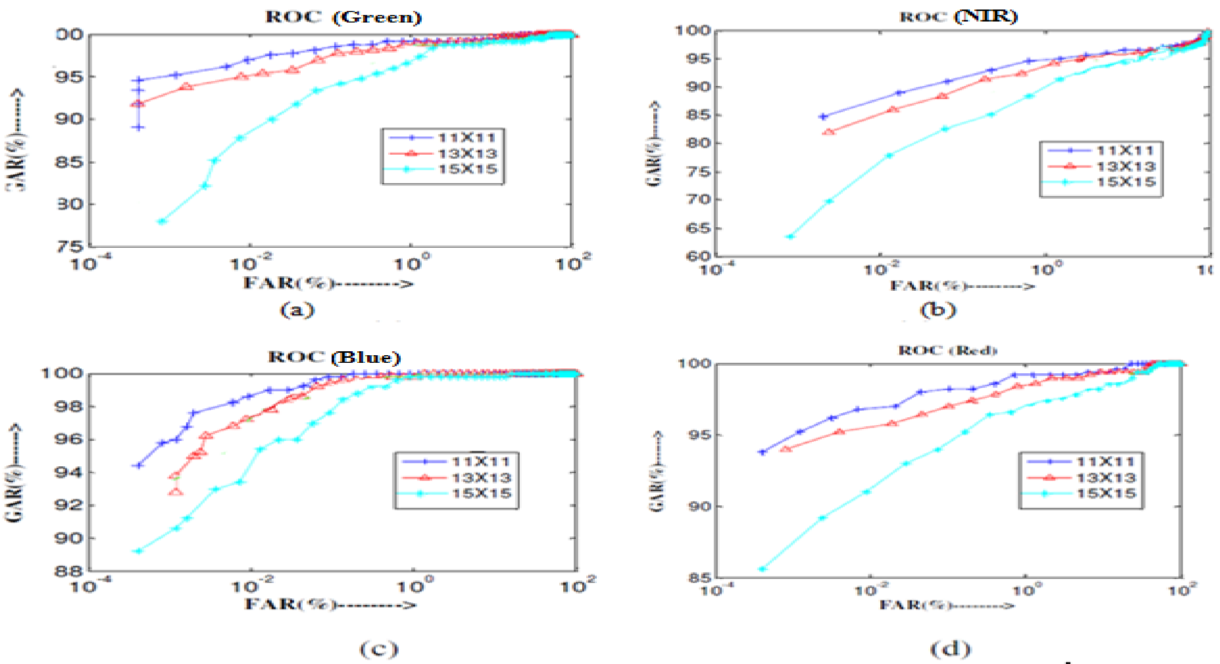


Figure 6: ROCs of (a) Green (b) NIR (c) Blue (d) Red bands of palmprint using effective information features for different window sizes

Table below shows the accuracy of multispectral bands for different window size. In this paper we are using K- Nearest Neighbor and SVM classifier for the classification. The performance (in terms of accuracy) of both the classifier is compared. If the person is authenticated, system accepts that person otherwise reject them.

Table1. Recognition Accuracy of individual spectral bands by using Simple Information set based features before Fusion

Window size / Band	11*11	13*13	15*15
Blue	99.53	99.33	99.13
Green	99.04	98.97	98.67
Red	98.86	98.53	97.13
NIR	97.07	96.20	95.73

Table2. Recognition accuracy of different combinations of multispectral bands by using simple Information features

Window size / Band	11*11	13*13	15*15
Green-Red	99.08	99.02	98.89
Blue-NIR	99.69	99.06	98.87
Blue-Green	99.89	99.74	99.58
Blue-Red	99.64	99.27	98.93
Green-NIR	98.87	98.37	97.79
Red-NIR	98.29	97.38	96.64

Table3. Individual spectral band's recognition accuracy by using effective information before Fusion

Window size / Band	11*11	13*13	15*15
Blue	99.47	99.13	98.03
Green	98.91	97.57	95.13
Red	97.46	96.06	95.03
NIR	92.02	90.17	85.33

Table4. Individual spectral band's recognition accuracy by using effective information after Fusion

Window size / Band	11*11	13*13	15*15
Green-Red	98.97	98.85	98.29
Blue-NIR	99.57	99.00	98.64
Blue-Green	99.67	99.37	99.34
Blue-Red	99.27	99.04	98.68
Green-NIR	98.66	98.03	97.61
Red-NIR	97.89	96.96	96.33

When we have compared the performance of K-NN and SVM classifiers on the multispectral palmprint it is found that the accuracy of SVM classifier is high as shown below.

Table5. Performance comparison of K-NN and SVM classifiers (in terms of accuracy (%))

Spectral Bands	K-NN	SVM
Blue	99.53	99.97
Green	99.04	99.54
Red	98.86	99.26
NIR	97.07	99.01

6. CONCLUSION

This paper presented an authentication system based on multispectral palmprint in which to overcome the problem of large dimensionality of the feature vector extracted from Gabor filter, Information sets are used. Features extracted from simple information sets are more accurate than the effective information. Fusion is implemented at the feature level for the authentication. Blue has highest accuracy as compared to green, red and NIR band. Fusion is carried out on the features extracted from combination of Gabor filter and information sets. When we compare the accuracy of individual band with the fused bands, accuracy of fused band is high. SVM classifier gives better results than K-NN. This implementation has carried out on database developed at Hongkong, Poly U.

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