Rotation and Translation Invariant Person Identification System using Palmprints

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ABSTRACT

Security is a major concern in many facets of life today. During the last decade, Forensic Science in India has also taken a big leap. Recent introduction of the said biometrics facilities in Forensic Laboratories is now ready to take the forensics to the doorsteps of common man. A decade ago, a new branch of biometric technology, palmprint authentication, was proposed whereby lines and points are extracted from palms for personal identification. In this paper, we consider the palmprint as a piece of texture imprint and apply texture-based feature extraction techniques to palmprint authentication. In order to make the proposed algorithm rotation and translation invariant, the ROI of the imprint has been cropped from the captured palmprint image, prior to feature extraction. A 2-D Gabor filter is used to extract the important features for obtaining the textural information. Features of the query palmprint image have been compared in terms of the Euclidian distance with the templates in the database. The experimental results illustrate the effectiveness of the proposed method for criminal identification based on the palmprints found at the crime scene. The results and conclusions match the standard of forensic laboratories.an efficient algorithm using Haarclassifiers like features for real time face detection is devised then motion analysis techniques are used to locate the user's eye by detecting eye blinks. The eye is tracked in real time using correlation with an open eye template. If the user's depth changes significantly or rapid head movement occurs, the system is automatically reinitialized. The principle of the proposed system is based on the real time eye blink detection for warning the driver of drowsiness or in attention to prevent traffic accidents. The facial images of driver are taken by a camera with frame rate of 30fps. An algorithm isproposed todetermine the level of fatigue by measuring the eye blink duration and tracking of the eyes, and warn the driver accordingly. The system is also able to detect when the eyes cannot be found. These experiments on four drivers/subjects yielded an overall blink detection accuracy of 87.01% and overall drowsiness detection accuracy of 81.14%.

Keywords

Biometrics, palmprint, Gabor transform, feature extraction, Euclidean distance, personal identification.

1. INTRODUCTION

Personal Identification using biometrics refers to the application of principles and methods of science and medicine to biometric traits of a human. Biometric impressions on the floor, mat, mud, papers, utensils, weapons, etc. are the most common clues found at the place of crime. It can be categorized into two major groups: Physical and Behavioral. Some of the physical biometric evidences include palmprint, fingerprint, footprint, ear, face, iris, DNA, odor, hair, blood etc. Behavioral characteristics include gait, signature, voice, keystroke, etc. These evidences found at the place of crime with great regularity; hence studied by police and crime laboratory personnel. These impressions carry substantial information and are useful in linking the crime scenes and trap the criminals. In these cases it is possible to work back from suspect, using impressions from the central database available at regional Police Stations to see if a match can be found at the crime scene and thereby providing corroborative evidence. When the crime place is examined by the Crime Offices, biometric evidence impressions can be collected by way of either using photography, gel, electrostatic lifting or by making a cast when the impression is on soil. Imprints of the persons having legitimate access are then eliminated and the Crime Offices can be quite confident to say that left over imprints belong to the offenders.

Recently, due to advancement in Computer-based systems and the scanners, Automated System for Personal identification based on hand geometry has become popular. The first commercial system, called Identimat, which measured the shape of the hand and the length of fingers, was developed in the 1970s. At the same time, fingerprint-based automatic checking systems were widely used in law enforcement. Because of the rapid development of hardware, including computation speed and capture devices, iris, retina, face, voice, signature and DNA have joined the biometric family.

Fingerprint identification has drawn considerable attention over the last 25 years. However, some people do not have clear fingerprints because of their physical work or problematic skin. Iris and retina recognition provide very high accuracy but suffer from high costs of input devices or intrusion into users. Recently, many researchers have focused on face and voice verification systems; nevertheless, their performance is still far from satisfactory [1]. The accuracy and uniqueness of 3-D hand geometry are still open questions [1-3].

Palmprint is concerned with the inner surface of the hand. It is defined as the prints on a palm, which are mainly composed of the palm lines and ridges. A palmprint, as a relatively new biometric feature, has several advantages compared with other currently available features [4]: palmprints contain more information than fingerprints, so they are more distinctive; palmprint capture devices are much cheaper than iris devices; palmprints contain additional distinctive features such as principal lines and wrinkles, which can be extracted from low-resolution images; and last, by combining all of the features of a palm, such as palm geometry, ridge and valley features, and principal lines and wrinkles, it is possible to build a highly accurate biometrics system. Given these advantages, in recent years, palmprints have been investigated extensively in automated personal authentication.

The most promising application for palmprints is in security as it is possible to obtain unique feature from a palm for person identification because the print patterns are not duplicated in other people, even in monozygotic twins. More importantly, the details of these patterns are permanent. The rich structures of the palmprint offer plenty of useful information for recognition. Compared with the other physical characteristics, palmprint authentication has several advantages like low-resolution imaging, low intrusiveness, stable line features and high user acceptance. Palmprint recognition distinguishes between palms based on the lines, texture and points features in palmprint images.

Thus, human palmprint recognition has become an active area of research over the last decade.

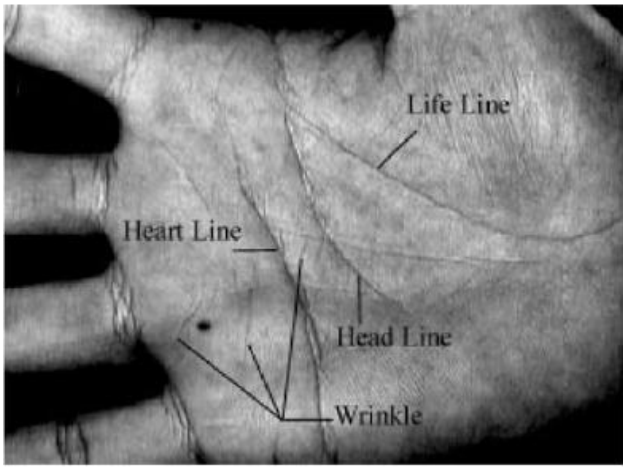


Fig. 1 (a) Example of on-line palmprint image

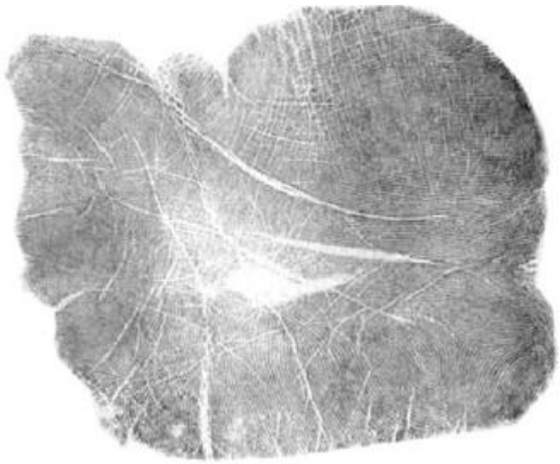


Fig. 1 (b) Example of off-line palmprint image

Palmprint authentication can be divided into two categories, on-line and off-line. Figure 1 show an on-line palmprint image and an off-line palmprint image, respectively. Research on off-line palmprint authentication has been the main focus in the past few years [5-8], where all palmprint samples are inked on paper, then transmitted into a computer through a digital scanner. Due to the relative high-resolution off-line palmprint images (up to 500 dpi), some techniques applied to fingerprint images could be useful for off-line palmprint authentication, where lines, datum points and singular points can be extracted [5,6]. Duta et al. [8] extracted some points (called "feature points") on palm-lines from oIinepalmprint images for verification. For on-line palmprint authentication, the samples are directly obtained by a palmprint scanner [9]. Recently, a CCD based palmprint capture device has been developed by Wai Kin Kong et al [10]. They have used Gabor transform to investigate the features of palmprints. Zhang et al. [11] used 2-D Gabor filters to extract the texture features from low-resolution palmprint images and employed these features to implement a highly accurate online palmprint recognition system. Han et al. [12] used Sobel and morphological operations to extract line-like features from palmprints. Kumar et al. [13] integrated line-like features and hand geometric features for personal verification. Wangli Yang et al [14] used a two-stage Neural Network Classifier for palmprint identification. W. Li et al [15] used Fourier Transform for palmprint identification. Many other researchers have developed palmprint verification systems done using various techniques [16-20].

All of these palmprint authentication methods require that the input palmprint should be matched against a large number of palmprints in a database, which is very time consuming. To reduce the search time and computational complexity, it is desirable to classify palmprints into several categories such that the input palmprint need be matched only with the palmprints in its corresponding category, which is a subset of palmprints in the database. Palmprint classification is a coarse-level matching of palmprint. Shu et al. [21] used the orientation property of the ridges on palms to classify oIine high-resolution palmprints into six categories. This classification method is unsuitable for low-resolution palmprints because it is impossible to obtain the orientation of the ridges from low-resolution images. X Wu et al [22] classified palmprints with the help of most visible and stable features, i.e. the principal lines (heart line, head line and life line).

It is evident that on-line identification is more important for Criminal identification based on the palmprint images found at the crime scene, as a real-time application, so that it draws our attention to investigate. The objective of this paper is to propose a palmprint based criminal identification method. The palmprints of all the citizens can be stored as image templates in the database. But it requires large storage space, also it will require more time for matching. Thus, in order to make the system time and space efficient, important features of these palmprints have been computed using Gabor transform and these features can be stored as the templates in the central database at central crime investigation bureau. When a query imprint is found at the location of crime scene, the features of these imprints have been computed and matched with that of the imprint database in order to find a suitable match, for criminal investigation.

2. BLOCK DIAGRAM OF PROPOSED SYSTEM

The proposed palmprint verification system shown in Figure 2 contains five modules, palmprint acquisition (from crime scene), preprocessing, feature extraction, matching and storage. A palmprint image is captured by palmprint scanner which is then converted into a digital imprint. This imprint is transmitted to a computer for further processing. In pre-processing a co-ordinate system is set up on basis of the boundaries of fingers so as to extract a central part called as ROI of a palmprint for feature extraction. Then apply a 2-D Gabor filter to extract textural information from the central part. These textural features are then compared with the features stored in the database as the templates of imprints during the enrolment phase. A distance measure is used to find the close match between the palmprint found at the crime location and the template imprints stored in the database.

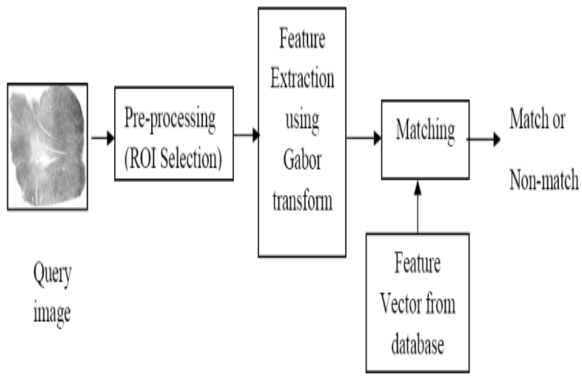


Fig. 2 Block diagram of proposed palmprint identification system

The proposed criminal identification system operates in two modes, enrolment and identification. In the enrolment mode, the police have to provide several palmprint samples of the persons staying in that area under their jurisdiction to the system. The samples captured by palmprint scanner are passed through pre-processing and feature extraction to produce the templates stored in the database. In the identification mode, the police or the investigating officer provide the palmprint images found at the crime scene as the query imprint to the system. These query palmprints passes through pre-processing and feature extraction. The extracted features are compared with templates in the database in order to find the correct match or the probable matches for further investigation.

In this paper, a textural feature extraction method for palmprint images is proposed that can be used for criminal identification based on the pamprint evidences found at the crime scene. The remaining part of this paper is organized as follows: preprocessing steps for selection of ROI are mentioned in Section 3. Palmprint feature extraction by texture analysis is explained in Section 4. Experimental results and discussions are given in Section 5 followed by conclusions and references.

3. ROI - SELECTION

In order to make the proposed algorithm rotation and translation invariant, it is necessary to obtain a ROI imprint from the captured palmprint image from crime scene, prior to extract the important features. Five major steps of palmprint image pre-processing to extract the ROI are as follows and illustrated in Figure 3:

Step 1: Convolve the original imprint with a low-pass filter. Convert this convolved imprint into a binary, as shown in Figure 3(b) by using a threshold value. This transformation can be represented as,

$$B(x,y) = \begin{cases} 1, & if O(x,y) * L(x,y) \geq T \\ 0, & if O(x,y) * L(x,y) < T \end{cases} \quad [1]$$

where, B(x,y) and O(x,y) are the binary image and the original image, respectively;

L(x,y) is a lowpass filter, such as Gaussian, and

"*" represents an operator of convolution.

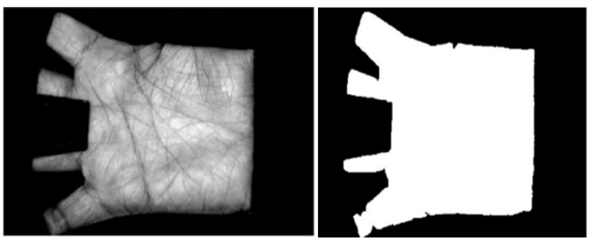
Step 2: Extract the boundaries of the holes, (Fixj, Fiyj) for i=1,2 between fingers using a boundary-tracking algorithm. The start points (Sxi, Syi) and end points, (Exi, Eyi) of the holes are then marked in the process (see Figure 3(c)).

Step 3: Compute the center of gravity, (Cxi,Cyi), of each hole with the following equations:

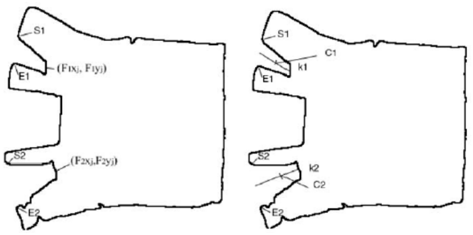
$$C_{x_i} = \frac{\sum_{j=1}^{M(i)} F_i x_j}{M(i)}, \quad C_{y_i} = \frac{\sum_{j=1}^{M(i)} F_i y_j}{M(i)} \quad [2]$$

where, M(i) represents the number of boundary points in the ith hole.

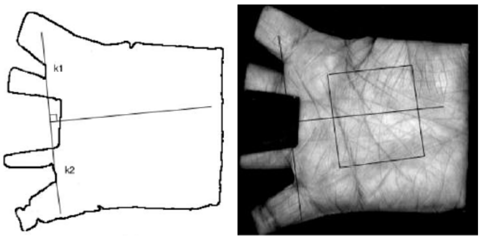
Then construct a line that passes through (Cxi, Cyi) and the midpoint of (Sxi, Syi) and (Exi, Eyi).



(a) (b)



(c) (d)



(e) (f)

Fig. 3 Steps illustrating pre-processing: (a) original image, (b) binary image, (c) boundary tracking, (d) key points (k1 and k3) detecting, (e) the coordinate system and (f) The central part of a palmprint.of proposed palmprint identification system

The line equation is defined as,

$$y = x\frac{(Cy_i - My_i)}{(Cx_i - Mx_i)} + \frac{(My_i Cx_i - Mx_i Cy_i)}{(Cx_i - Mx_i)} \quad [3]$$

where, (Mxi, Myi) is the midpoint of (Sxi, Syi) and (Exi, Eyi).

Based on these lines, two key points k1 and k2 can easily be detected (see Figure 3(d)).

Step 4: Line up k1 and k2 to get the Y-axis of the palmprint coordinate system and make a line through their mid point which is perpendicular to the Y-axis, to determine the origin of the coordinate system (see Figure 3(e)). This coordinate system can align different palmprint images.

Step 5: Extract a sub-image with the fixed size on the basis of coordinate system, which is located at the certain part of the palmprint for feature extraction (see Figure 3(f)).

4. FEATURE EXTRACTION USING GABOR TRANSFORM

Gabor filters have been used extensively in image processing, texture analysis for their excellent properties: optimal joint spatial / spatial-frequency localization. The family of 2-D Gabor filters was originally presented by Daugman [23] as a framework for understanding the orientation-selective and spatial–frequency selective receptive field properties of neurons in the Brains' visual cortex, and then was further mathematically elaborated in [24].

The palmprint image has been viewed as a texture image. The textural features in a palmprint could be extracted by properly selecting the frequency, bandwidth and orientation of Gabor filter. It helps in extracting the local and global texture features of palmprint images. In spatial domain Gabor filter is represented by a Gaussian modulated sinusoid. An even symmetric Gabor filter in a spatial domain has a form of

$$G_{\theta,f}(x,y) = \exp\left\{-\frac{1}{2}\left[\frac{x'^2}{\delta_x^2} + \frac{y'^2}{\delta_y^2}\right]\right\}\cos(2\pi f x') \quad [4]$$

where,

f is the frequency of the sinusoidal plane at an angle θ with x-axis,

δ_x and δ_y are standard deviations of Gaussian envelope along x and y axes respectively,

$$x' = x\sin\theta + y\cos\theta,$$

$$y' = x\cos\theta - y\sin\theta.$$

The textural information in each block of a palmprint image is determined by setting the parameters f, θ, δ_x and δ_y. The values of f, δ_x and δ_y are selected empirically. The bandwidth of the Gabor filters is determined by δ_x and δ_y. The higher values of δ_x and δ_y are more robust to noise, but will not capture edge information at fine level i.e. is more likely to smooth the image to the extent that the ridge and furrow details in the palmprint are lost. Smaller values of δ_x and δ_y are less robust to noise, but capture edge information verywell. Thus selection of values of δ_x and δ_y involves a tread-off. Similarly if f is too large, spurious ridges may be created in the filtered image, whereas if f is too small, nearby ridges may be merged into one.

The general form of a 2D Gabor filter is defined by (4) and typical 2-D Gabor filter response with different orientations is as shown in Figure 4 and its 3-D view is shown in Figure 5.

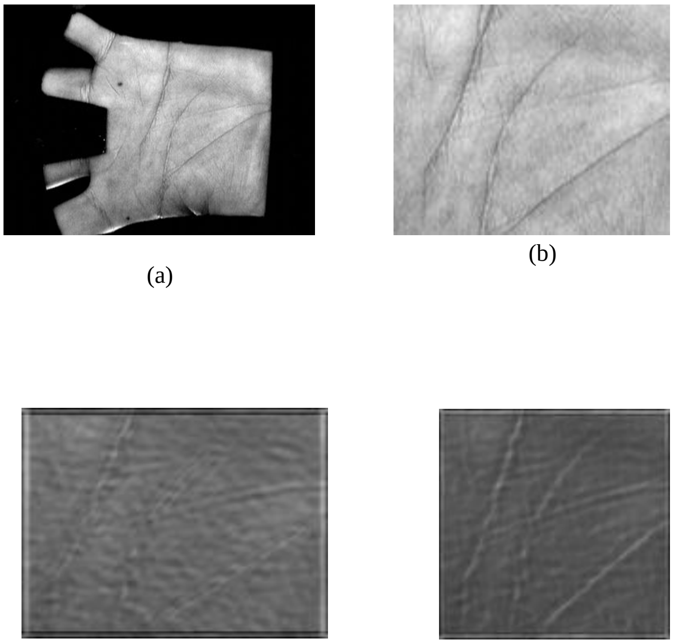
In the proposed algorithm, the filter frequency f is set to the reciprocal of the inter-ridge distance since most local ridge structures of palmprints come with well-defined local frequency and orientations. The average inter ridge distance is approximately 10 pixels in a 500 dpi palmprint image. Thus, inthe proposed algorithm, the values of δ_x and δ_y were empirically determined and both were set to 4.0 and the filter frequency f is set to 0.1.

Thus, by applying properly tuned Gabor filters to a palmprint image, the true ridge and furrow structures can be significantly emphasized. These emphasized ridges and furrow structures constitute an efficient representation of a palmprint image. The extracted ROI palmprint image $E(x,y)$ is decomposed into eight component images corresponding eight different values of $\theta_k = (0^0, 22.5^0, 45^0, 67.5^0, 90^0, 112.5^0, 135^0 \textit{ and } 157.5^0)$ with respect to the x-axis. In order to achieve this, the palmprint image $E(x,y)$ is convolved with each of the eight Gabor filters to produce eight component images. Convolution with an $0°$ oriented filter accentuates ridges parallel to the x-axis, and it smoothes ridges that are not parallel to the x-axis. Filters tuned to other directionswork in a similar way. The even Gabor feature, at sampling point (X,Y) can be calculated by convolving $E(x,y)$ with (4), which is expressed as given in (5) and the results are illustrated in Figure 5.

$$G(X,Y,\theta_k,f,\delta_x,\delta_y) = \left| \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} E(X+x, Y+y) \times g(x,y,f,\theta_k,\delta_x,\delta_y) \right| \quad [5]$$

where, $E(.,.)$ denotes a ROI of palmprint image $O(x,y)$ of size $M \times N$, having 256 gray-levels.

According to the experimental results, the eight component images capture most of the ridge directionality information present in a palmprint image and thus form a valid representation. It is illustrated by reconstructing a palmprint image by adding together all the eight filtered images. The reconstructed image is similar to the original image but the ridges have been enhanced. Filtered, and reconstructed images from four and eight filters for the palmprint are shown in Figure 7 and Figure 8 respectively.



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

Fig. 7(a) Original image (b) ROI of palmprint image (c) Reconstructed image using four Gabor filters (d) Reconstructed image using eight Gabor filters

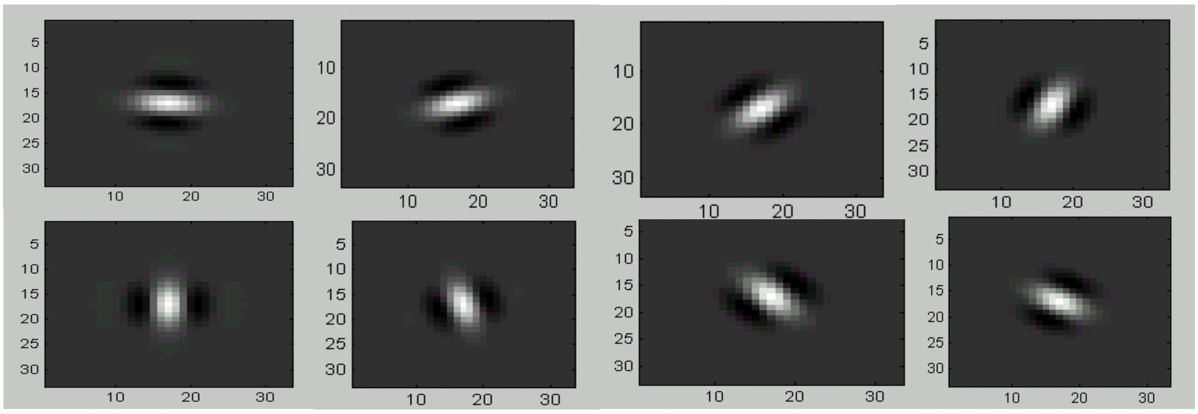


Fig. 4 Block A 2-D Gabor filter plot in eight orientations (0^0, 22.5^0, 45^0, 67.5^0, 90^0, 112.5^0, 135^0, and 157.5^0).

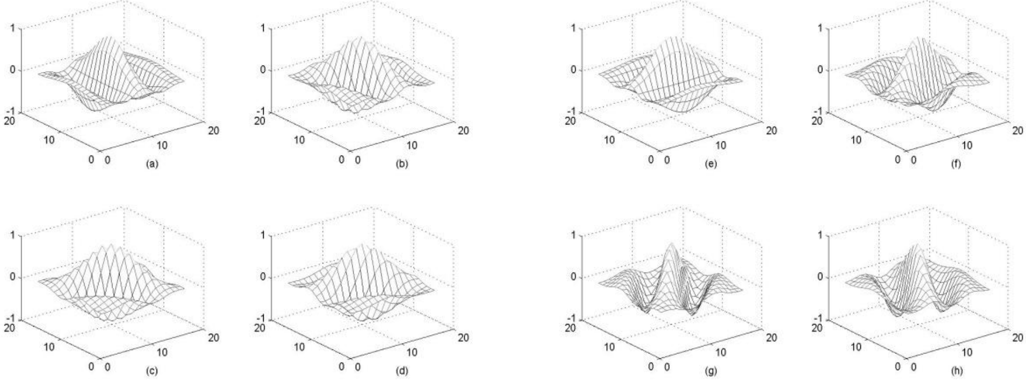


Fig. 5 A 3-D Gabor filter plot in eight orientations (00, 22.50, 450, 67.50, 900, 112.50, 1350, and 157.50).

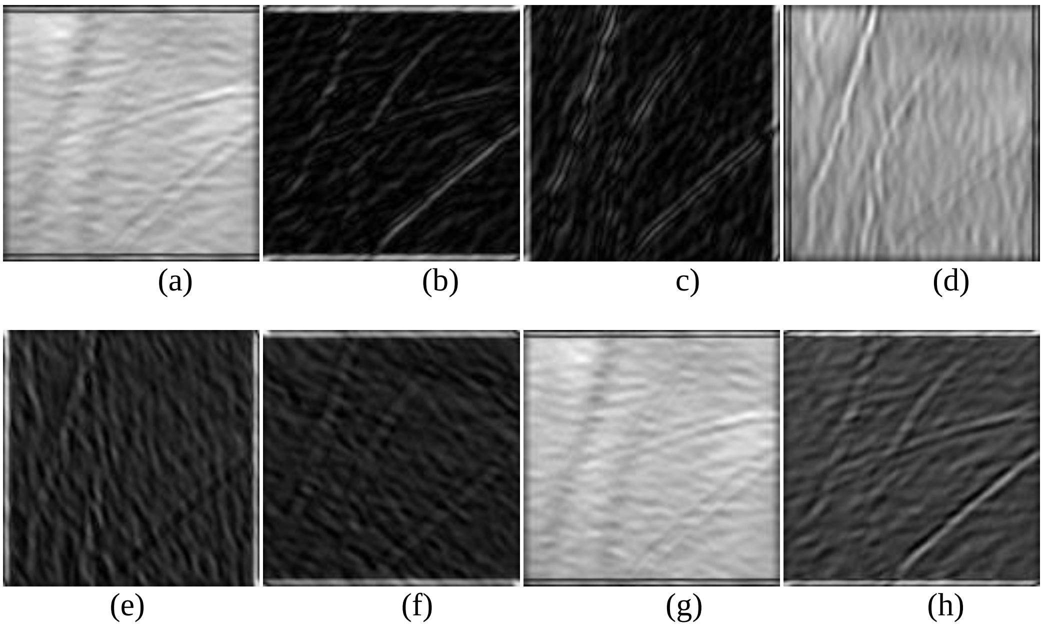
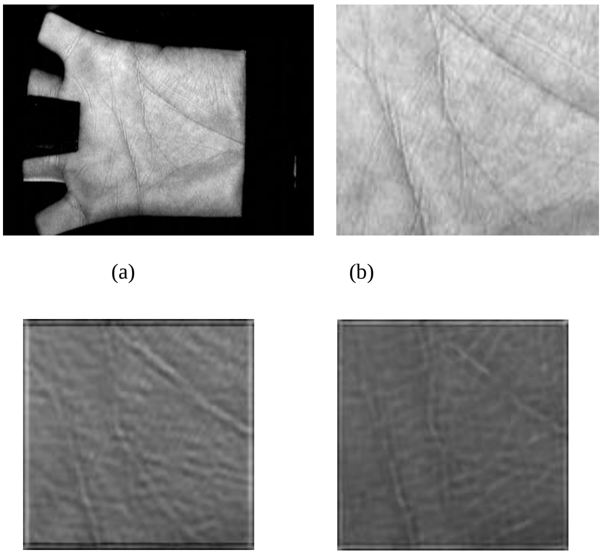


Figure 6. (a)-(h)Gabor features of palmprint image for $\theta_k \in (0^0, 22.5^0, 45^0, 67.5^0, 90^0, 112.5^0, 135^0 \textit{ and } 157.5^0)$

As local features represent the palmprint texture information in better sense, the Gabor filtered palmprint image is then divided into distinct non-overlapping blocks of size 16 x 16 pixels. The size of a block is chosen such that sufficient information must appear in it. This results into 8 blocks in each row and 16 blocks in each column of the square grid. The total number of square blocks over the image is therefore 128. The average variance of the pixel intensities in each block across all Gabor filtered images is used as feature map.



(a) (b)

(C) (D)

Fig. 8. (a) Original image (b) ROI of palmprint image (c) Reconstructed image using four Gabor filters (d) Reconstructed image using eight Gabor filters

The average variance of a filter response for shoeprint textural information in a local neighborhood is defined as,

$$\Re_\theta = \left\{ \sigma_\theta^2(\mathrm{i},\mathrm{j}) \right\} \quad [6]$$

where,

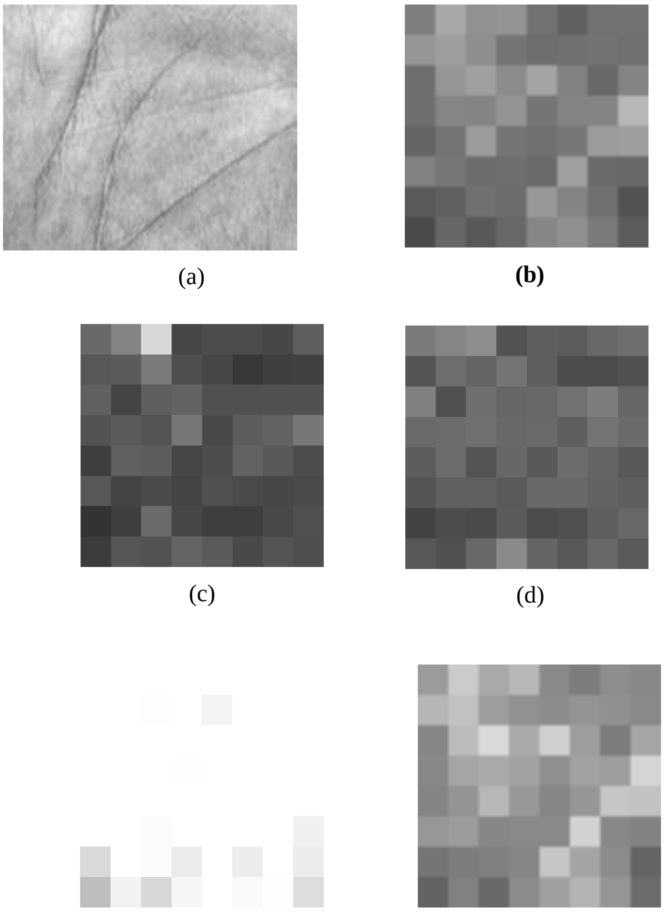
$$\sigma_\theta^2(i,j) = \frac{1}{i \times j} \sum_{i,j} (pixel\,\mathrm{int}\,ensity - mean)^2 ,$$

$\theta \in \left\{ \theta_1, \theta_2, \theta_3, \theta_4, \theta_5 \right\}$: five dominant orientations containing higher energy

$i = 1,2,...8$ and $j = 1,2,...16.$

Thus, a five-dimensional feature map corresponding to the five filtered images for each palmprint image is obtained. Five dominant variance feature map for two different palmprint images are shown in Figure 9 and Figure 10. It can be clearly noticed that two different palmprints posses dissimilar textural features. This feature map has been used to represent and

match a query palmprint image.



(a) **(b)**

(c) (d)

(e) (f)

Fig. 9 (a) A typical example of palmprint Image and (b)-(f) Five dominant variance features at

$$\theta = \left\{ 22.5^0, 45^0, 67.5^0, 135^0, 157.5^0 \right\}.$$

To generate the Gabor filter-based palmprint feature vector from the palmprint image the said procedure is carried out for every palmprint image and stored in the database. When a query palmprint image found at the crime scene is to be identified from the database, the Gabor feature vector of query palmprint image is computed by the same way. The query and template palmprint Gabor feature vector are then matched and the matching score is found using Euclidian distance (7) between this query imprint features and all the imprints in the database. Thus a close match is found. The average absolute deviation of each sector of the five filtered images defines the components of the feature vector.

The Euclidian distance between trainee and query shoeprint image is computed by

$$d = \sum_{u=1}^{m} \sum_{v=1}^{n} \left(\Re_\theta(u,v) - \Re_\theta^{'}(u,v) \right)^2 \quad [7]$$

where, $\Re_\theta(u,v)$ and $\Re_\theta^{'}(u,v)$ are the feature vectors of trainee and query shoeprint images respectively.

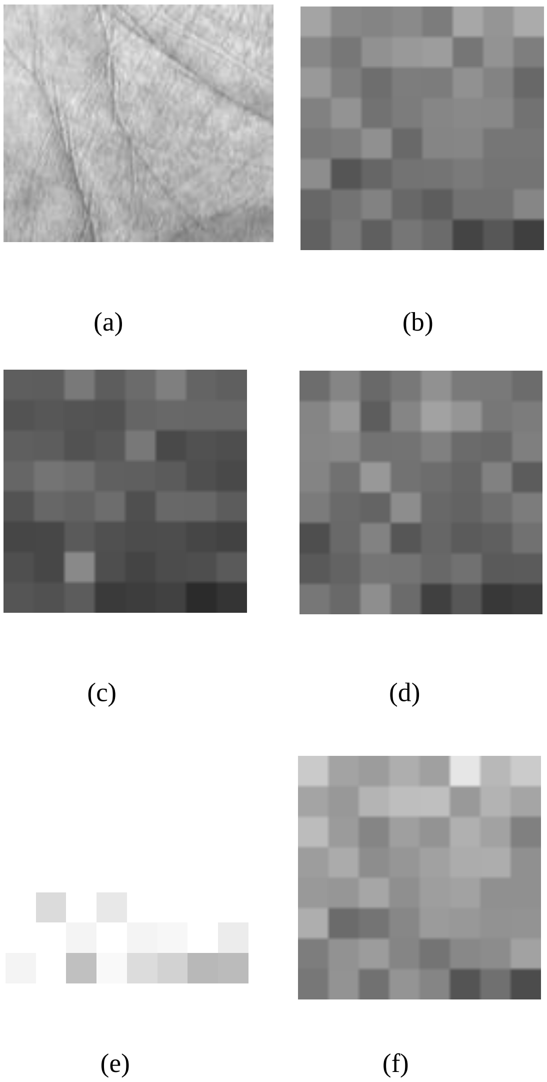


Fig. 10 (a) A typical example of palmprint Image and (b)-(f) Five dominant variance features at $\theta = \{22.5^0, 45^0, 67.5^0, 135^0, 157.5^0\}$.

5. IMPLEMENTED ALGORITHM

The proposed algorithms have been implemented and tested on Pentium-IV processor with 2.6 GHz, 512 MB RAM under MATLAB environment. The performance of the total system have been tested using the standard database used by many researchers for experimentation of palmprint recognition system and easily available on the internet, a well-known database known as PolyU. The PolyUpalmprint is a standard Database (file size 429MB) contains 7752 grayscale images corresponding to 386 different palms in BMP image format. Around twenty samples from each of these palms were collected in two sessions, where around 10 samples were captured in the first session and the second session, respectively. The average interval between the first and the second collection was two months. The layout of palm images are as follows: fingers are on the left side, wrist on the right, thumb is up and little finger down for right hand and thumb down, little finger up for the left hand. The resolution of those images is 384 x 284 with 256 grayscales.

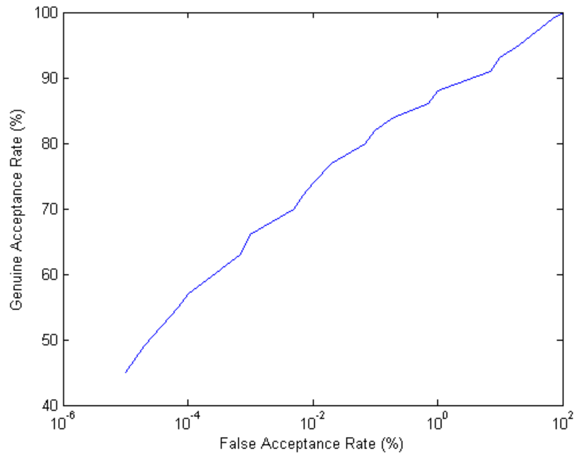


Fig. 11 Region of Convergence (ROC) curve

To evaluate the performance of the proposed algorithm Gabor filter based features have been computed. Each of the image in the database is matched with all other palmprint images in the same database. A matching is counted as correct match if two palmprint images are collected from the same palm, otherwise it is an incorrect matching. The performance of various thets is presented by Receiver Operating Characteristic(ROC0 curves, which are a plot of genuine acceptance rate against false acceptance rate for all possible operating points (see Figure 11).

6. CONCLUSION

This paper reports a novel method for palmprint based criminal identification using 2D Gabor transform based local and global textural features. The proposesd method is invariant to rotation and translation variation of the palmprint images. The proposed palmprint identification system achieves good performance in terms of speed and accuracy.

Combining the proposed palmprint coding scheme with other texture feature measurements such as texture energy for coarse level classification to achieve higher performance; and on some noisy images with cuts and bruises on the hand to test the performance of the system will be the further part of investigation.

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