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Contactless Hand Based Multimodal Biometrics Identification System

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Abstract

Biometrics is an emerging technology that is used to identify people by their physical and/or behavioural characteristics and, so, it inherently requires that the person to be identified is physically present at the point of identification. A new approach for multimodal based personal identification using hand images is presented. This paper attempts to improve the performance of hand based verification system by integrating palm print, hand geometry and knuckle print features from user's hand. Unlike other multimodal biometric systems, the users do not have to undergo the inconvenience of using two different sensors since the palm print, hand geometry and Knuckle Print features can be acquired from the same image, at the same time. Individual matching scores are then combined using a new dynamic fusion approach. The experimental results showed the effectiveness of the system in terms of equal error rate.

Keywords: Hough Transform, Gabor Filter, Sobel Edge Detector, KNN Classifier.

Introduction

Hand based biometric systems, are amongst the highest in terms of user acceptability for biometric traits. the human hand also contains a wide variety of features —e.g., shape, texture, and principal palm lines—that can be used by biometric systems. These features of the human hand are relatively stable and the hand image from which they are extracted can be acquired relatively easily.

The physical characteristics of an individual that can be used in biometric identification/verification systems are fingerprint, hand geometry, palm print face, iris, retina and ear The behavioral characteristics are signature, lip movement, speech, keystroke dynamics, gesture, and gait. Biometric systems based on a single biometric characteristic are referred to as unimodal systems. They are usually more cost-efficient than multimodal biometric systems. However, a single physical or behavioral characteristic of an individual can sometimes fail to be sufficient for identification. Unimodal biometric systems has many disadvantages regarding performance and accuracy. For this reason, multimodal biometric systems —i.e., systems that integrate more than one biometric characteristic—are being developed to provide an acceptable performance and to increase robustness to fraudulent technologies. With this methodology, the probability of accepting an imposter is greatly reduced.

Although systems based on fingerprints and eye features have, so far at least, achieved the best matching performance, the human hand also contains a wide variety of features —e.g., shape, texture, and principal palm lines—that can be used by biometric systems. These features of the human hand are relatively stable and the hand image from which they are extracted can be acquired relatively easily. Furthermore, it has been reported that identification systems based on hand features are the most acceptable to users.

The contactless system offers many advantages over contact systems. It is an ideal technology to be used in public as it resolves any psychological resistance the users may develop for touching the same sensors again in public places. Currently, most of the biometric systems utilize scanner, CCD camera or CMOS Camera as the input sensor. Users must touch the sensor for their hand images to be acquired. In public areas, like the hospital especially, the sanitary issue is of utmost importance. Besides, latent palm prints which remain on the surface could be copied for illegitimate uses. Further, the surface will get contaminated easily especially in dirty, and outdoor environments. Therefore, there is a pressing need for a biometric technology which is flexible enough to capture the users' hand images without having the users to touch the platform of the sensor.

Hence, we propose a contactless multi modal Hand based biometrics which includes Palm print, Hand Geometry and knuckle print. Features are extracted for all the biometrics and matching is performed. Finally a fusion scheme is applied to combine the matching score of all the three biometrics.Finally a decision for identifying a person is made based on the Matching score.

In this paper we propose Palm print based personal identification system. The identification process can be divided into following phases: capturing the image; pre processing; normalizing the palm by the method of Hough Transform based Rectangular edge detection; extracting the features by Gabor filter; matching by K^{th} Nearest Neighbourhood Classifier; and, finally, a decision. The other two biometrics will be added to the Palm print biometric in future to achieve higher performance.

The rest of this paper is organized as follows: The proposed palm print recognition scheme is presented in section 2. The feature extraction module using Gabor filter is exposed in section 3. The matching module and decision is presented in section 4. The obtained results are evaluated and commented in section 5. We conclude the paper, by stating the conclusions and perspectives, in the last section.

Related Work: Among different biometrics, in security applications with a scope of collecting digital identity, the palm-prints are recently getting more attention among researchers[1,2] Palm-print recognition is a complicated visual task even for humans. The primary difficulty arises from the fact that different palm-print images of a particular person may vary largely, while those of different persons may not necessarily vary significantly. Moreover, some aspects of palm-prints, such as variations in illumination, position, and scale, make the recognition task more complicated[3]. Palm-print recognition methods are based on extracting unique major and minor line structures that remain stable throughout the life time.

In this regard, generally, either line-based or texture-based feature extraction algorithms are employed . In the line based schemes, generally, different edge detection methods are used to extract palm lines (principal lines, wrinkles, ridges, etc.)[4, 5]. The extracted edges, either directly or being represented in other formats, are used for template matching. In cases where more than one person possesses similar principal lines, line based algorithms may result in ambiguous identification. In order to overcome this limitation, the texture-based feature extraction schemes can be used, where the variations existing in either the different blocks of images or the features extracted from those blocks are computed[6,7]. In this regard, generally, principal component analysis (PCA) or linear discriminant analysis (LDA) is employed directly on the palm-print image data or some popular transforms, such as Fourier and discrete cosine transforms (DCT), are used for extracting features from the image data. Given the extracted features, various classifiers, such as decision-based neural networks and Euclidean distance based classifier, are employed for palm-print recognition. Despite many relatively successful attempts to implement face or palm-print recognition system, a single approach, which combines accuracy, robustness, and low computational burden, is yet to be developed.

Methodology

Figure.1 shows the block-diagram of the proposed biometric identification system based on the features at the matching-score level. In the image-acquisition phase, a hand image is taken using a low-cost scanner. The spatial resolution of images is 256 gray levels. Feature Extraction stage includes extraction of principal lines and wrinkles in the palm. The matching between the verified ROI and registered one in database is performed using Euclidean distance. Finally a decision is made based on the matching score.

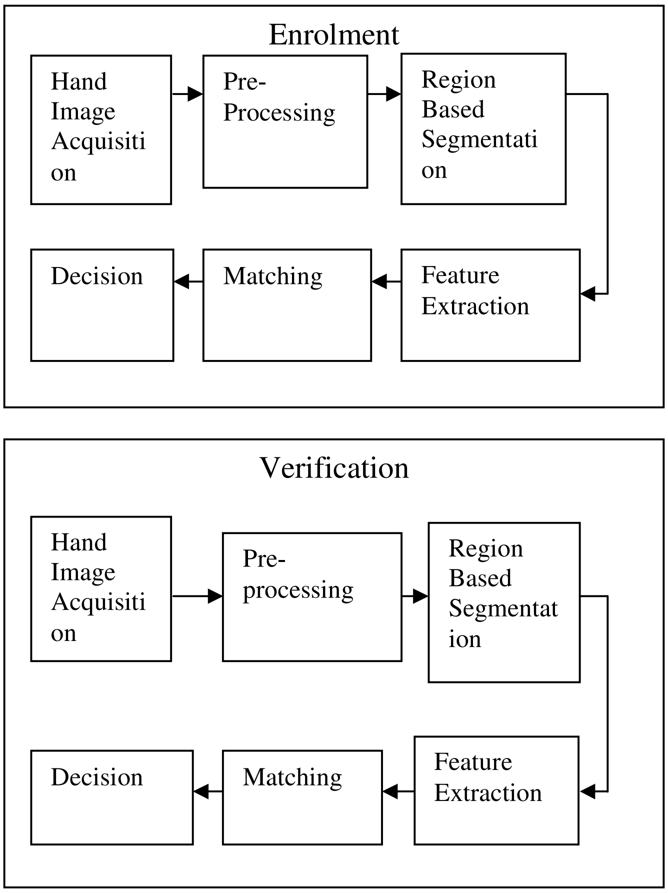

Figure-1
Block Diagram of the Proposed System

IIT Delhi Touch less Hand database are used as input hand image in this paper .These hand images are collected in an indoor environment and employ circular florescent illumination around the camera lens. The image resolution is 800 * 600 pixels.

Figure-2
Sample Hand Images

Segmentation: Before extracting the features of the palm, the region of interest of the Palm is extracted. The finger valleys (depression points present between fingers) are chosen to fix a co-ordinate system with respect to which the palm image can be extracted. Once the co-ordinate axes are fixed, extracting the palm is relatively straight forward. The most common approach is to extract a square region of fixed size from a palm. One of the ways to extract a palm is to extract a square sub-image of fixed size taken at a fixed distance from the axis. Hough Transform based Rectangular edge detection is used for extracting the region of Interest of the palm.

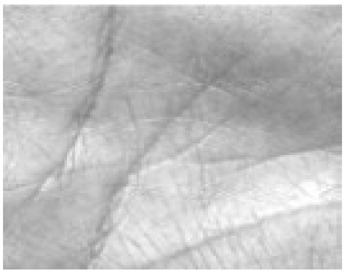

Figure-3
Extracted Region of Interest of the Palm

Feature Extraction: Palm region consists of principle lines, wrinkles and ridges on the surface of the palm. These line structures are stable and remain unchanged throughout the life of an individual. Feature Extraction involves extraction of these principal lines and wrinkles.

Use of Gabor Filter for feature Extraction: Gabor filter was originally introduced by Dennis Gabor. Daugman extended the Gabor filter to two dimensions. Two dimensional Gabor filters are used to model the spatial summation properties (of the receptive fields) of simple cells in the visual cortex. They are widely used in image processing, computer vision, neuroscience and psychophysics.

A two dimensional Gabor filter is used to extract the texture-based features of the palm.

A Gabor filter samples the frequency space of an image providing information about oriented, band-pass statistical textures. Each Gabor filter has a Gaussian profile in the frequency domain of an image. The Gaussian has a centre frequency, (u,v), two spatial extent parameters (σ_x, σ_y) and the filter is rotated through an angle of θ degrees about the origin. In the spatial domain the filter is a Gaussian modulated sine wave grating.

Typically, a large bank of filters is employed for texture analysis tasks. Since every filter generally involves a two-dimensional inverse fourier transform, this can be very computationally expensive.

A 2D Gabor filter oriented at an angle θ is given by

$$G_{(\sigma,\theta)} = \frac{1}{2\pi\sigma_{x}\,\sigma_{y}} \exp\left[-0.5\left(\frac{x_\theta^2}{\sigma_x^2} + \frac{y_\theta^2}{\sigma_y^2}\right) Cos\,(\frac{2\pi}{\lambda} * x_\theta + \varphi)\right.$$

Where:

$$x_\theta = xCos\,\theta + ySin\,\theta$$

$$y_\theta = -xsin\,\theta + yCos\,\theta$$

Where: λ – Wavelength, θ – Orientation, φ- Phase Offset, σ - Standard Deviation.

Statistical Features: Gabor filter output is also used for extracting some of the following statistical features like Mean, Standard deviation, Median and mode.

Mean: The arithmetic mean is the average of a set of values.

$$\mu = \frac{1}{n}\sum x_i$$

Variance: Variance is a measure of dispersion. It tells us about the scatter of values around the mean. It is defined as the mean squared deviation from the mean, and symbolized by a small sigma squared.

$$\sigma^2 = (x_i - \mu)^2$$

Standard Deviation: The standard deviation is the square root of the variance and is symbolized by a small Greek sigma.

$$\sigma = \sqrt{\sigma^2}$$

Median: If values are listed in order from highest to lowest (or lowest to highest) and find the middle-most score, then it is called as median.

Mode: The mode is the most frequently occurring value.

Matching: Euclidean distance metric is used for matching. In Cartesian coordinates, if p=(p_1,p_2 p_3,....p_n) and q=(q_1,q_2,q_3.....q_n) are two points in Euclidean-n space, then the distance from p to q or from q to p is given by

$$d_{p,q} = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots .(q_n - p_n)^2}$$

Finally a decision is made according to the matching score .The output of Euclidean distance is considered as the matching score. If the matching score is zero, then the two feature matrices are equal which means that both the palm prints are one and the same. Otherwise the two feature matrices are unequal which implies that the palm prints differ. Thus the person is identified based on the matching score.

K-Nearest Neighbor Classifier (KNN) is used for the classification of palm print. K-Nearest neighbor algorithm is a method for classifying objects based on closed training samples in the feature space K-Nearest Neighbors (KNN) classification divides data into a test set and a training set. For each row of the test set, the K nearest (in Euclidean distance) training set objects are found, and the classification is determined by majority vote with ties broken at random. If there are ties for the K^{th} nearest vector, all candidates are included in the vote.

Results and Discussion

The simulation of Palm print is carried out using MATLAB Simulation Software.

Hand Image after Edge Detection: Sobel Edge Detector is used for edge detection.

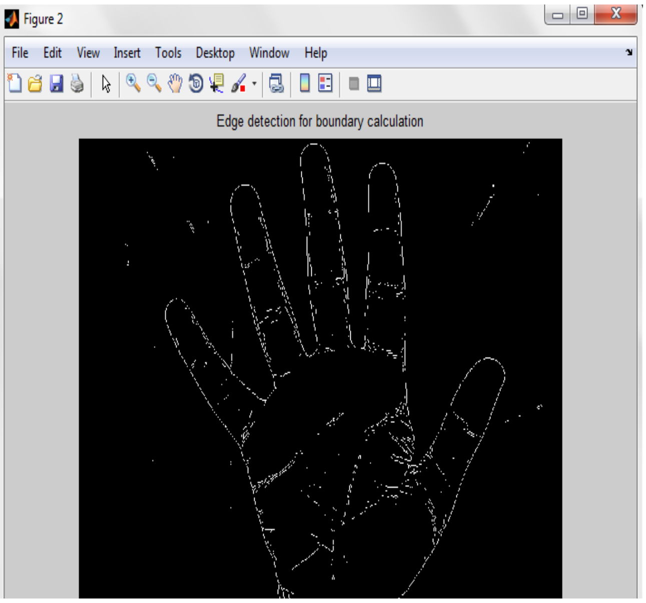

Figure-4
Hand Image after Edge Detection

Extracted Palm Image: The palm is extracted from the input hand image using Hough Transform based Rectangular edge detection.

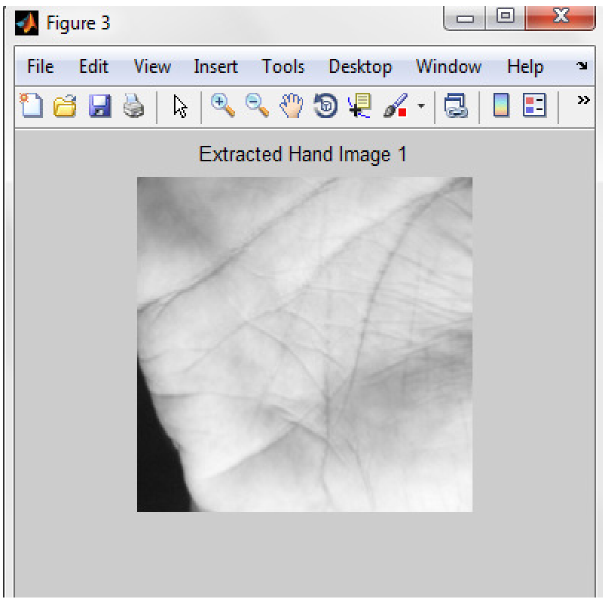

Figure-5
Extracted Hand Image 1

Gabor Filtered Image: The Gabor filtered palm image is obtained by convolving Gabor filter function with the extracted palm image.

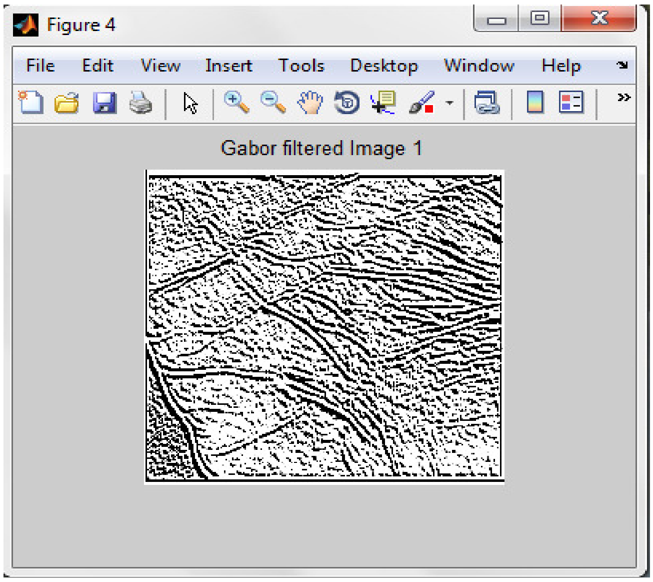

Figure-6
Gabor Filtered Palm Image

Performance Analysis: The performance of the Palm print Recognition system is analyzed through ROC curve. The performance analysis is shown in figure 7.

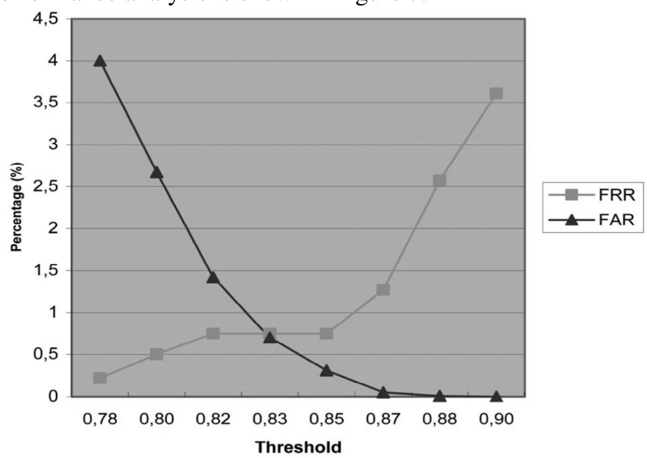

Figure-7
The Dependence of FAR and FRR on the threshold

Conclusion

We have developed a prototype of a biometric identification system based on palm print features. This paper presents an innovative touch-less Palm print biometric system. The proposed method offers several advantages like flexibility and user-friendliness. Experimental results show that the proposed system is able to produce promising result. Apart from that, another valuable advantage is that the proposed system could perform very fast in real-time application. In future, we extend the work by adding additional biometric features namely Hand Geometry and Knuckle print and improve the performance.

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