Multi-Feature Level Fusion on Finger Knuckle for Biometric Identification

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Abstract—This paper proposed the use of multi-feature level fusion as a means to improve the performance of Finger Knuckle Print (FKP) verification. DCT, DWT, Gabor filter and ULBP has been used to extract the image local orientation information, and represent the FKP features. Experiments are performed using the FKP database, which consists of 7,920 images. Results indicate that the multi-feature level fusion verification approach outperforms higher performance than using any single feature. The proposed system has a recognition rate of 91%.

Keywords-- Biometric, FKP, Feature Level Fusion, DCT, DWT, Gabor, ULB

I. INTRODUCTION

The necessitate for reliable user authentication techniques has increased in the awaken of keen concerns about security and speedy advancements in networking, communication, and mobility. A broad variety of applications require trustworthy verification schemes to confirm the identity of a person requesting their service. This require reliable user authentication techniques to resolve sensitive concerns about security [1]. Biometrics proves to be a reliable modern standard to ensure automatic recognition of individuals based on their physiological and behavioral features. The Behavioral characteristics refer to the behavior of a person which includes typing rhythm, voice, gait, keystroke, signature etc and the Physiological characteristic refers to the feature or shape of human body which includes finger print, iris, ear pattern, DNA, palm print, face etc [2]. Recently, a latest biometric technology based on finger knuckle print has attracted much consideration in the biometrics research community. The finger rear surface, also known as the dorsum of the hand, can be extremely useful in user identification and has engrossed less attention of researchers[3]. It is reported that the skin pattern on the finger-knuckle is extremely rich in texture due to skin folds and creases, and hence, can be considered as a biometric identifier. Different advantages of using Finger Knuckle Print (FKP) includes rich in skin texture, effortlessly accessibility, contact-less image acquisition, invariant to emotions and further behavioral aspects such as tiredness, constant features and acceptability in the society [4].

Fig. 1 Sample FKP Image
These systems are based on pattern recognition methodology, which follow the acquirement of the biometric data by constructing a biometric feature set, and comparing against a pre-stored template pattern. These are unimodal which rely on the verification of a single source of information for authentication, which have to compete with a variety of problems such as (noise in sensed data, intra-class variations, and inter-class similarities, etc). It is now clear that a single biometric is not sufficient to meet the variety of requirements imposed by numerous large scale authentication systems. Possible solutions to balance for the false classification problem due to intra-class variability and inter-class similarity can be found in the fusion of biometric systems or experts [8] which refers as Multibiometric [5].

The Multibiometric systems can offer considerable improvement in the matching accuracy of a biometric system depending upon the information being combine and the fusion methodology adopted [1] as follows; **Multi sensor**: Several sensors can be used to collect the same biometric. **Multi-modal**: Various biometric modalities can be collected from the same individual, e.g. palmprint and face, which requires different sensors. **Multi-sample**: Multiple readings of the similar biometric are collected during the enrolment and/or recognition phases, e.g. a number of palmprint readings are taken from the same palm. **Multiple algorithms**: Various algorithms for feature extraction and matching are used on the same biometric sample. **Multi-instance**: - which this paper concentrate on means the use of the similar type of raw biometric sample and processing on multiple instances of same body parts, (such as two fingers, or two irises) [6]. Multi-instance systems can be cost-effective since a single sensor is used to acquire the multi-unit data in a ordered fashion[5].

Also Fusion of biometric instances proves an efficient way out to these various problems already cited: Interclass similarities, Intra-class variations, Noisy Data and Spoofing attack. Information fusion can be performed into four system architectures: **Fusion at the Sensor Level**: Fusion refers to the consolidation of data obtained using multiple sensors of a biometric using a single sensor. **Fusion at the Feature Extraction Level**: In this architecture, the information extracted from the various sensors is encoded into a combined feature vector, which is then compared to an enrollment template and assigned a matching score. **Fusion at the Matching Score Level**: In this architecture, feature vectors are created separately for each sensor and then compared to the enrollment templates, which are stored separately for each biometric feature. Based on the nearness of feature vector and template, each subsystem now computes its own matching score. These individual scores are finally combined into a total score, which is handed over to the decision module. **Fusion at the Decision Level**: In this architecture, a separate authentication decision is made for each biometric trait. These decisions are then combined into a final vote. Fusion at the decision level is rather freely coupled system architecture, with each subsystem performing like a single biometric system [7].

## II. RELATED WORKS

Mounir Amraoui et al. [8] presented a novel approach use of multi-instance feature fusion based on micro texture in spatial domain. Uniform Local Binary Patterns (ULBP) is used to ensure the extraction features for each biometric instance. Then, ULBP descriptors for each combination from two instances at the score levels are fused. For classification City-block and Euclidean. The authors experimental results conducted on FKP database indicate that the proposed method shows a reliable recognition rate.

Lin Zhang et al. [9] proposed an effective FKP recognition scheme by extracting and assembling local and global features of FKP images. The experimental results conducted on FKP database demonstrate that the proposed local–global information combination scheme could significantly improve the recognition accuracy obtained by either local or global information are lead to promising performance of an FKP-based personal authentication system. The authors experimental results
conducted on FKP database indicate that the proposed scheme could achieve much better performance in terms of EER and the decidability index than the other state-of-the-art competitors.

Wafa El-Tarhouni et al. [10] proposed the Multi-scale Shift Binary Pattern (MSLBP) descriptor which extends the original SLBP to multi-scale to get more robust and discriminative representation of FKP features. The classification of this new proposed feature is performed by using Principle Component Analysis and Random subspace Linear Discriminant Analysis. Experimental results show that the proposed MSLBP descriptor-based feature has improved the performance of FKP recognition.

Swati M R et al. [11] proposed a biometric authentication system which makes use of finger knuckle image of a person as biometric trait. In this method, Gabor filter with different orientation and scales are applied to extract feature from FKP image. Then dimensionalities of the extracted feature are reduced by using Kernel principal component analysis method. Later Linear Discriminate Analysis (LDA) algorithm is applied to increase the class separability feature. And finally Euclidean distance measure is used in the classification stage. The author demonstrates that the good recognition rate is achieved.

Harbi AlMahafzah et al [12] proposed the use of multi-instance feature level fusion as a means to improve the performance of Finger Knuckle Print (FKP) verification. The Log-Gabor has been used as feature extraction algorithm. Four matching score normalization techniques experimentally evaluated to improve the performance fusions of different instances. Result shows that it gives better performance than single instances.

III. PROPOSED METHODOLOGY

Figure 2 represents work flow diagram for proposed Finger Knuckle Surface Identification

A. Finger Image Acquisition

A user initially enrolls in biometric system by providing biometric data in this case it is Finger Knuckle Print (FKP). The backside of finger is to be acquired using digital camera. In this case the experiments are developed for personal authentication using IIT Delhi Knuckle Database.

B. Pre-Processing

At first local co-ordinate system is constructed for each unprocessed image, in order to focus only on the Finger knuckle region in the FKP image. Then Region of Interest (ROI) is extracted from the original image. Localization of region of interest is required for the feature extraction of each of these images. The region of interest is the region having maximum knuckle creases [8]. It is necessary to make a local coordinate system for each Finger Knuckle image. With such a coordinate system, an ROI can be cropped from the original image for consistent feature extraction and matching. The Region of Interest is to be involuntarily extracted using the edge detection based approach. This gives segmented finger knuckle image. The finger surface is extremely curved and results in irregular reflection which also generates shadow. The knuckle images therefore have low contrast and uneven illuminations. These undesirable effects are to be reduced using image enhancement techniques [14].

C. Feature Extraction

The enhanced knuckle image consists of curved lines and creases. Knuckle curved lines and creases are to be detected for feature extractions. In the proposed system knuckle features has been extracted using the following feature extractors:

1. Discrete Cosine Transform:

Discrete Cosine Transform (DCT) is a prime tool first introduced by Ahmed et al. [13]. Ever since then, it was widely used as a feature extraction and compression in various applications on signal
and image processing due to its greater properties, i.e., de-correlation, energy compaction, separability, symmetry and orthogonality. The

local information of an individual’s FKP can be obtained by using block-based DCT as follows: A FKP image is divided into blocks of 8 by 8 pixels size. Each block is then represented by its DCT coefficients. From the obtained DCT coefficients only a small, generic feature set is retained in each block. It has been proved that the maximum information necessary to achieve high classification accuracy is contained in the first low frequency DCT coefficients via zigzag scanning [15].

2. **Discrete Wavelet Transform**

The Discrete Wavelet Transform (DWT) measures frequency at different time resolutions and locations. The signal is projected into the time frequency plane. The basic functions are

\[ \Psi_{j,k}(t) = 2^j 2^{j/2} \Psi 2^j t - k \]

where \( \Psi \) is the mother wavelet function. Any square integrable real function \( f(t) \) can be represented in terms of this bases as

\[ f(t) = \sum_{j,k} c_{j,k} \Psi_{j,k}(t) \]

and the \( c_{j,k} = \langle \Psi_{j,k}(t), f(t) \rangle \) are the coefficients of the DWT.

3. **Gabor Filter**

Gabor feature is a linear filter used for edge detection. The Gabor filter can simultaneously capture the spatial and frequency uncertainty information. It has a real and an imaginary component which may be formed into a complex number or used individually. When bank of Gabor filter with dissimilar orientation and scale is applied on the ROI FKP image, it produces distinct Gabor features related to ROI FKP image. Gabor function has a transfer function of the form

The value of \( \Sigma_{Onf} \) is 0.5 and value of \( d\theta_{OnSigma} \) is 0.75. Gabor has two components which are radial and angular components. The radial component controls frequency band and the angular component controls orientation to which the filter responds.

\[ H(\omega, \varphi) = e^{- \left( \frac{\left( \ln \left( \frac{\omega}{\omega_0} \right) \right)^2}{2 \left( \ln \left( \frac{2\pi \sigma_f}{\omega_0} \right) \right)^2} \right)} \cdot e^{- \frac{(\varphi - \varphi_0)^2}{2\sigma^2}} \]

4. **Uniform Local Binary Pattern**

The Local Binary Pattern operator was first introduced by Ojala et al [16] who has shown the high discriminative power of this operator for texture classification. The original LBP operator labels the pixels of an image by thresholding the 3 _ 3 neighborhood of each pixel with the center value and considering the result as a binary string or a decimal number and uses the resulting binary valued image patch as a local image descriptor. It was originally defined for 3 _ 3 neighborhoods, giving 8 bit codes based on the 8 pixels around the central one. Formally, the LBP operator takes the form

\[ LBP(x_c, y_c) = \sum_{n=0}^{2^7} 2^n S(i_n - i_c) \]

Where in this case \( i_c \) and \( i_n \) are the gray-level values at \( c \) and \( n \), and \( S(u) \) is 1 if \( u \geq 0 \) and 0 otherwise. The LBP encoding process is illustrated below.

An addition to the unique operator was made in and called uniform patterns: an LBP is ‘uniform’ if it contains at most two bitwise transitions from 0 to 1 or vice versa. This means that a uniform pattern
has no transitions or two transitions. The thought behind the LBP uniform is to detect characteristic (local) textures in image, like spots, line ends, edges and corners.

Through its recent extensions, the LBP operator has been made into a really powerful measure of image texture, showing excellent results in terms of accuracy and computational complexity in many empirical studies. Computational time is considerably reduced. Furthermore, LBP’s are resistant to lighting effects which means that they are invariant to monotonic gray-level transformations, and they have been shown to have high discriminative power for texture classification [17].

D. Feature Fusion

Fusion of biometric systems, algorithms and/or traits is a recognized solution for the improvement of authentication performance of biometric systems. Researchers have shown that multi-biometrics, i.e., fusion of multiple biometric evidences, improves the recognition performance [13].

In this paper the feature sets originating from multiple biometric algorithms like DCT, DWT, Gabor and ULBP are consolidated into a single feature set by the application of suitable feature normalization, transformation, and reduction schemes. The prime benefit of feature-level fusion is the detection of correlated feature values generated by different biometric algorithms and identification of a salient set of features that can improve recognition accuracy.

E. Classification

This paper classifies the FKP by finding out the nearest match of the test image. The training FKP were processed to extract the feature vectors. The extracted feature vector was used for matching the FKP in the database. The matching scores were used for classification of the FKP. In the proposed method K Nearest Neighbor classifier is used. In this scheme an image in the test set is identified by means of assigning to it the label of the nearest point in the learning set, where distance are measured in image space [18]. The Euclidean distance metric is frequently chosen to determine the closeness among the data points in KNN. A distance is assigned among all pixels in a dataset. Distance is defined as the Euclidean distance between two pixels.

$$d(x, y) = \sqrt{(x_1 - y_1)^2 + \cdots + (x_n - y_n)^2}$$

The Euclidean distance is given by: This Euclidean distance is by means of default in a KNN classifier. But the distance between two features may be measured based on one of the distance cosine and correlation.

Fig 2. Work Flow diagram for Proposed Finger Knuckle Surface Identification
III. RESULT

The performance of the proposed knuckle recognition system is evaluated using IIT finger knuckle print database (IIT Delhi Finger Knuckle Database). IIT FKP database consists of finger knuckle images captured using low resolution camera in a contact free manner. In this dataset, FKP images of index finger, middle finger, ring finger, little finger and thumb finger were captured. The performance of the system is measured by way of calculating the accuracy, sensitivity and specificity of the classifier. The accuracy represents extension as much as which the classifier classifies the images based on the given label. The sensitivity represents how exactly it classifies the records to each class and specificity represents the rejection rate of the data to every class.

Table 1. Performance values of Proposed system

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Accuracy</td>
<td>0.9100</td>
</tr>
<tr>
<td>Precision</td>
<td>0.8989</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.5500</td>
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</tbody>
</table>

The accuracy is the key to the overall performance of a system. In the proposed system, the accuracy is very much increased compared to the existing biometric techniques and subsequently, the overall performance.

IV. CONCLUSION AND FUTURE WORK

In this paper we have presented a multi feature-based FKP recognition approach. The primary algorithm utilizes the Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Gabor Filter and the Uniform Local Binary Patterns for local representations of the FKP image. Indeed, these four feature sets capture extraordinary and complementary information. We investigated the impact of fusing all the four feature extractor information. We have shown that the multi-feature fusion at feature level outperforms the accuracy of each classifier and we are able to achieve the good recognition rate of 91% and it also reduced the problem of False Acceptance Rate and False Rejection Rate. As a future work, we want to try different classifier combination such as Neural Network, Support Vector Machine, Decision Tree etc.

REFERENCES


