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Personal Authentication Using FDOST in Finger Knuckle-Print Biometrics

N. B. Mahesh Kumar, K. Premalatha

Abstract**—**The inherent skin patterns created at the joints in the finger exterior are referred as finger knuckle-print. It is exploited to identify a person in a unique manner because the finger knuckle print is greatly affluent in textures. In biometric system, the region of interest is utilized for the feature extraction algorithm. In this paper, local and global features are extracted separately. Fast Discrete Orthonormal Stockwell Transform is exploited to extract the local features. Global feature is attained by escalating the size of Fast Discrete Orthonormal Stockwell Transform to infinity. Two features are fused to increase the recognition accuracy. A matching distance is calculated for both the features individually. Then two distances are merged mutually to acquire the final matching distance. The proposed scheme gives the better performance in terms of equal error rate and correct recognition rate.

Keywords**—**Hamming distance, Instantaneous phase, Region of Interest, Recognition accuracy.

I. Introduction

IN ancient days, conventional modes such as password system, PIN number system and ID cards system are used for the authentication purpose. Biometric system is extensively used in individual authentication system than conventional methods. The genetic traits like fingerprint, face, iris, palmprint, hand geometry, finger vein and hand vein are used as biometric systems. Biometric behaviours like palmprint, fingerprint, hand vein and hand geometry are widely used due to high user acceptance. The image sample of membrane wrinkles and creases, the external finger knuckle surface is greatly distinctive. Hence this biometric feature is used as a distinctive biometric system [1]. The inner surface of the finger knuckle print is widely used in holding of objects. Therefore, it is not easily damaged by intruder. The criminal activities are not associated with finger knuckle print and hence it has higher user acceptance [2]. The traces of the knuckle surface are not appeared on the sensor device and hence it cannot be forged easily. It is affluent in texture and used as best biometric system. In this work, a local–global feature fusion technique is proposed for finger knuckle-print biometric scheme. The instantaneous phase is extracted as the local feature by Fast Discrete Orthonormal Stockwell Transform (FDOST). The global feature can be acquired by aggregating the size of the FDOST. The FDOST is converted to the Fourier transform of the entire image, if the size of the FDOST is raised to infinity. Therefore the local information cannot be obtained but the finest resolution for the global frequency analysis of the image achieved. Hence the Fourier transform coefficients are clearly considered as the global information. The arrangement between intra-class finger knuckle-print ROIs can also be refined by the global Fourier features. Those two matching distances are estimated by matching the local and the global information separately. Then matching distances are merged by union rule to acquire the final corresponding distance. The architecture of the proposed scheme is revealed in Fig. 1.

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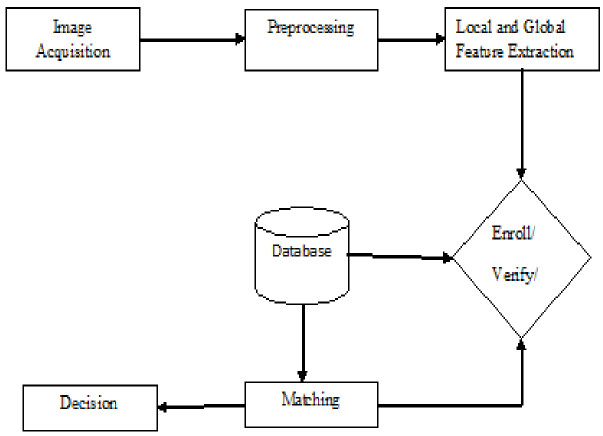


Fig. 1 The architecture of the proposed finger knuckle-print based recognition scheme

The proposed work is structured as follows. Section II depicts the related works on finger knuckle-print authentication. Preprocessing and ROI extraction is discussed in Section III. Section IV illustrates the local and global feature extraction and matching. Section V presents Local-global information fusion for finger knuckle-print recognition. Experimental results and Discussion are demonstrated in section VI. Section VII reports the conclusion.

II. Related Works

The spatially localized features are created by subspace techniques like Principal Component analysis (PCA), Linear Discriminant Analysis (LDA) and Independent Component Analysis (ICA) receives the increasing attention in the previous works [3]-[6]. The subspace coefficients are represented as feature vector and distance measure or classifiers are employed for matching. Further the Subspace techniques are used for dimensionality reduction. Jun et al. [5] projected a novel linear feature extraction technique called Weighted Linear Embedding (WLE). The Fisher criterion and manifold learning criterion like local discriminant embedding analysis were combined. The local feature is more important than non local feature according to the manifold learning theory. Therefore the local and global features are extracted. The local and non local information are combined by using Gaussian weighting. A recognition rate of 78.2% is achieved by applying WLE on right index finger. Yang et al. [3] utilized the Gabor wavelets in image analysis and pattern recognition for feature representation in FKP. The Gabor features are transformed into low dimensional space by PCA technique. Further orthogonal linear discriminant analysis (OLDA) transformation in PCA subspace is done. The features are classified using nearest neighbour classifier and 98% recognition rate is attained.

III. Preprocessing and ROI Extraction

FKP images collected from different fingers are extremely assorted. The spatial locality of the finger knuckle-print is different for various FKP images. Therefore each FKP image is aligned by building the local coordinate method. Fig. 2 (a) depicts the FKP image scanner device and Fig. 2 (b) depicts a sample finger knuckle-print image. Figs. 2 (c) and (d) depict ROI extraction system.

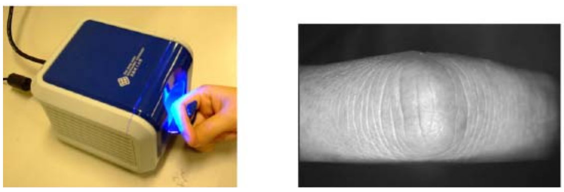


Fig. 2 (a) FKP image scanner device (b) Sample FKP image

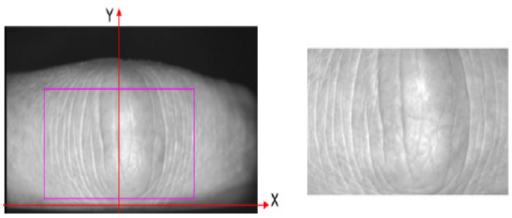
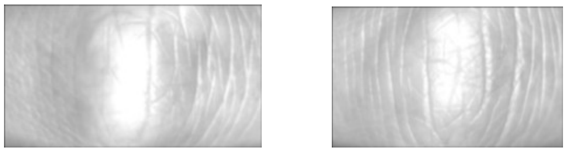


Fig. 2 (c) ROI Extraction system (d) ROI image

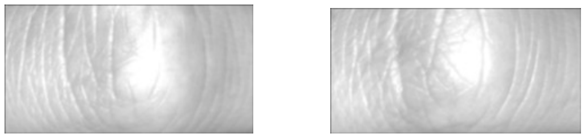
IV. Extraction of Local – Global Feature and Matching

A. Local Feature

The feature extraction technique of finger knuckle-print biometric scheme is exploited to acquire high-quality inter-class division in least time. The features of finger knuckle-print are extracted by using FDOST after the completion of pre-processing and ROI segmentation from finger knuckle-print. The sample finger knuckle-print and ROI image is shown in Fig. 3. The local variation of instantaneous-phase is utilized to extract features from finger knuckle-print. The instantaneous phase obtained by Fast Discrete Orthonormal Stockwell transform is the resolution of phase with respective to time. It is further revealed for signal contrasted to simply phase or amplitude representation. Hence, the instantaneous-phase features are more discriminant compared to merely amplitude or phase features. Thus, using instantaneous-phase for extracting finger knuckle-print features in the proposed scheme can classify the user with more likelihood in huge database of users. The extracted feature vectors from the live finger knuckle-print can be matched with feature vectors of enrolled finger knuckle-print features stored in the database for authentication. This scheme utilizes the nearest-neighbour approach to match the live and enrolled finger knuckle-print. If both live and matched finger-knuckle print are from the same group and it is called as authentic match, otherwise it is called as a fraud match. The distance between the feature vectors are calculated using Hamming distance.

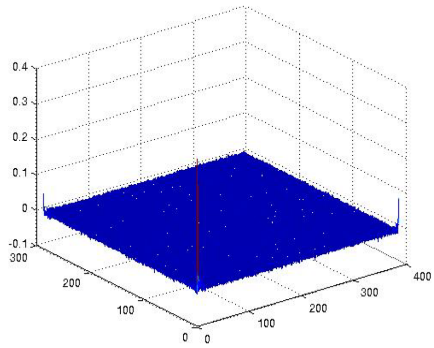


(a) (b)



(c) (d)

Fig. 3 FKP ROI images for PolyU Database from (a) left index fingers (b) left middle fingers (c) right index fingers and (d) right middle fingers



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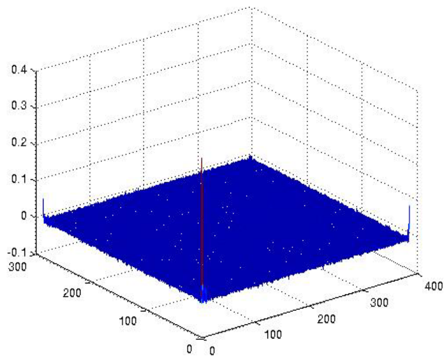

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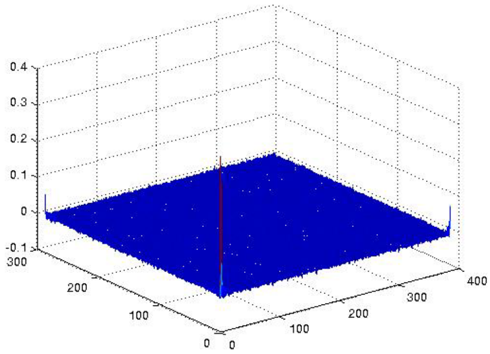

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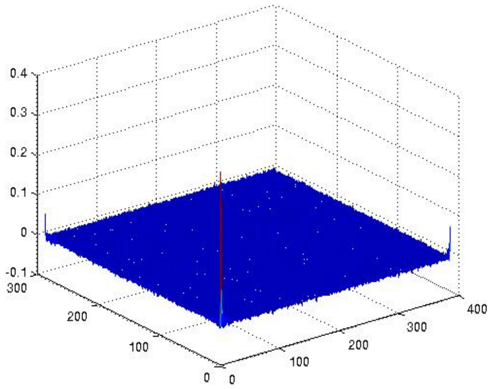
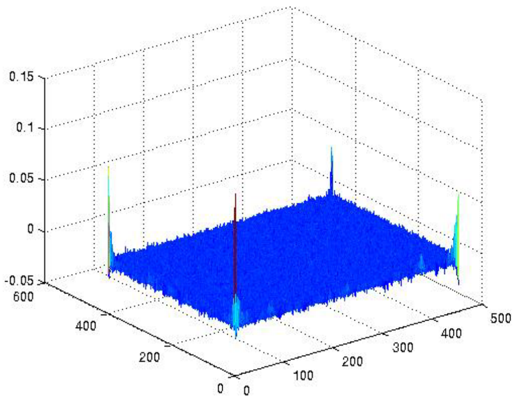


(d)

Fig. 4 POC function of FKP ROI images for PolyU Database from (a) left index fingers (b) left middle fingers (c) right index fingers and (d) right middle fingers



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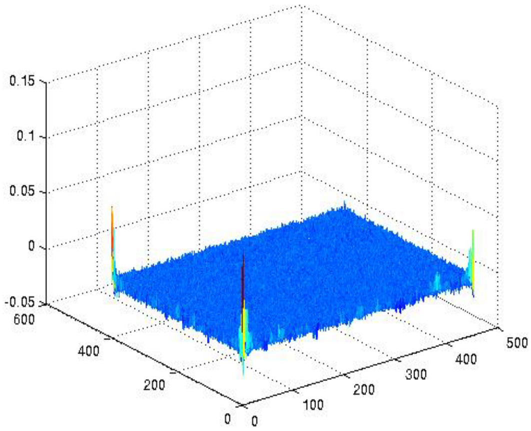

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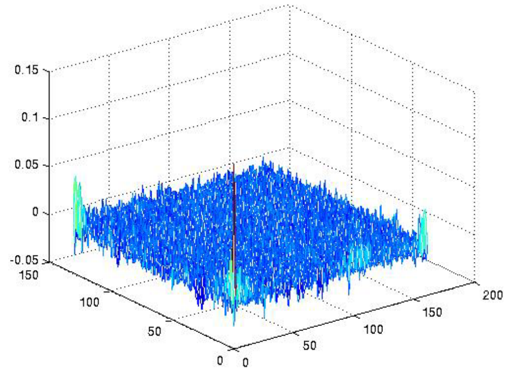

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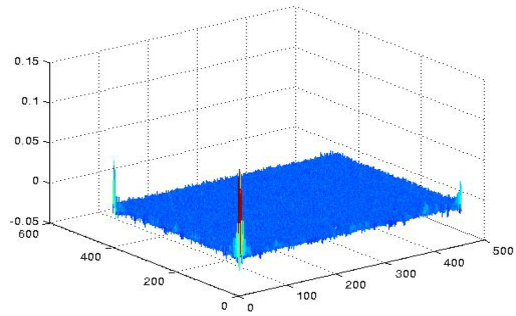


(d)

Fig. 5 BLPOC function of FKP ROI images for PolyU Database from (a) left index fingers (b) left middle fingers (c) right index fingers and (d) right middle fingers

B. Global Feature

FDOST is utilized to extract instantaneous phase feature and treated as a windowed Fourier transform. Band-Limited Phase Only Correlation (BLPOC) is introduced to match the global information of two FKP images. A matching performed between a pair of finger knuckle-print images from the same hand for genuine matching and hence BLPOC gives a large amount of sharper peak than Phase Only Correlation (POC) [7], [8]. Fig. 4 depicts an image matching using POC function. A matching is achieved between couples of finger knuckle-print images from different hand for imposter matching. Both the BLPOC and POC never exhibit a dissimilar cruel peak. The displacement between finger knuckle-print ROI images is aligned using BLPOC. The likeness between Fourier transforms of the aligned ROIs is calculated using BLPOC. Fig. 5 depicts an example of an authentic matching and a fraud matching using BLPOC function.

V. LOCAL - GLOBAL INFORMATION FUSION FOR KNUCKLE-PRINT RECOGNITION

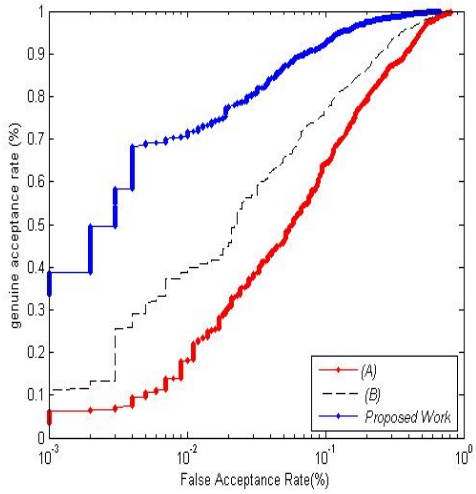
The relation between the general region and the area of the original ROI is checked in the finger knuckle-print scheme. Then two finger knuckle-print ROI images are matched and the matching distance is calculated. The peak value of BLPOC function between finger knuckle-print ROI images is utilized to measure the likeness of their Fourier transforms. Finally the two matching distance are achieved by combining the two distances using two different matchers. The Maximum weighted rule is used to assign the weights for the two matching distances. Then the final matching distance is obtained by fusing the two distances.

VI. EXPERIMENTAL RESULTS AND DISCUSSION

The experiments were carried out on PolyU FKP Database. It consists of 7920 images collected from 660 fingers [9]. The identity of the individual is compared with the biometric trait in the biometric verification system. The accuracy can be calculated through three parameters such as False Rejection Rate (FRR), False Acceptance Rate (FAR) and Genuine Acceptance Rate (GAR). The proportion of users which are recognized as no match is termed as False Rejection Rate. The proportion of users that are incorrectly recognized as other objects is called as False Acceptance Rate. The proportion of the queries that are correctly identified is defined as Genuine Acceptance Rate. Due to the difficulties of collecting samples of palmprint images and long running time of the large palmprint dataset in the systems, the proposed system is tested on a smaller number of samples. A test is conducted on by changing the size of the gallery samples of each person from 1 to 15. From 1 to 15 images per finger knuckle-print that is considered for training data. ROC is a plot of Genuine Acceptance Rate (GAR) against False Acceptance Rate (FRR) shown in Fig. 6. Thus, the investigational outcomes depict that the fusing local and global information that are collectively achieved better than the technique in the related works depending on the local and global features separately. The Decidability Index (DI) which gives the measure of the separability of authentic and fraud matching scores is used. DI can be defined as

$$DI = \frac{|\mu_1 - \mu_2|}{\sqrt{(\sigma_1^2 + \sigma_2^2)/2}} \quad (1)$$

where μ_1, μ_2 are the mean of the authentic matching distances and σ_1, σ_2 are the standard deviation of the authentic matching distances. The Distance distributions of authentic matching's and fraud matching' attained by proposed system are plotted as shown in Fig. 7. Table I depicts the Equal Error Rate (EER) comparisons with other methods. A performance measure of proposed finger knuckle-print authentication scheme is listed in Table II.



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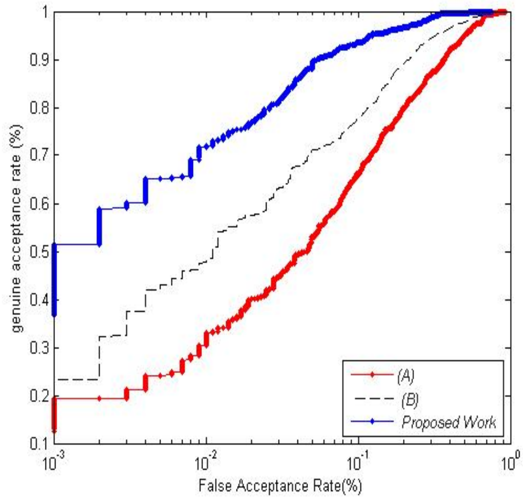

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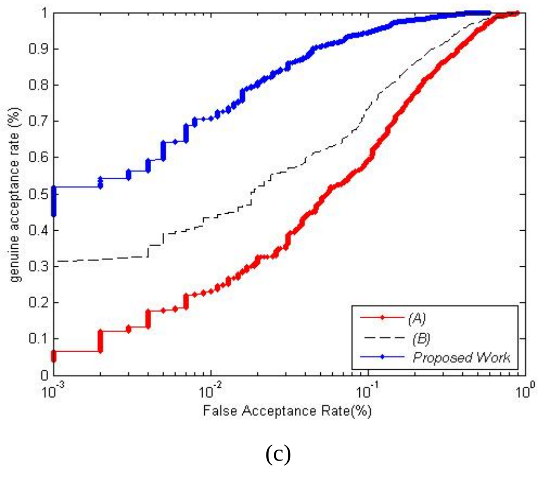

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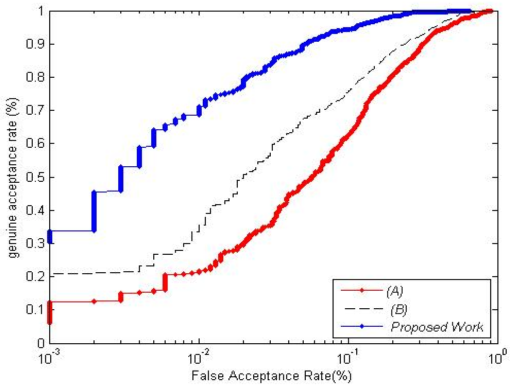

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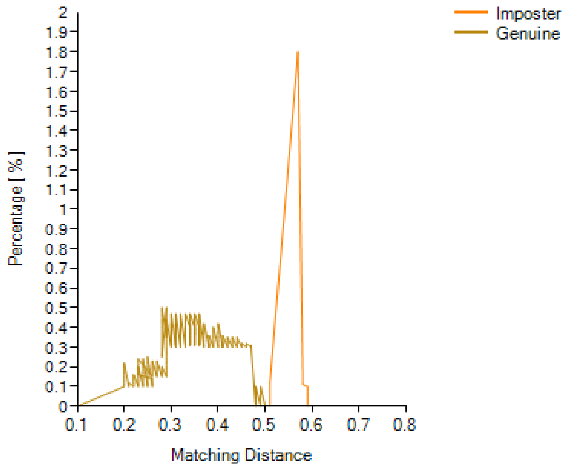
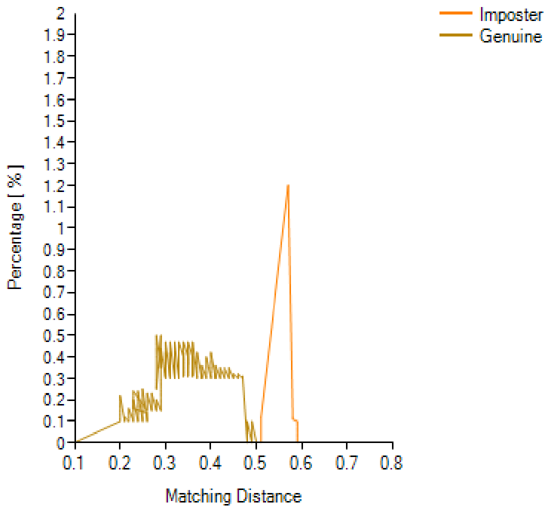
Fig. 6 ROC Curves of FKP images for PolyU database from (a) left index fingers (b) left middle fingers (c) right index fingers and (d) right middle fingers



(a)



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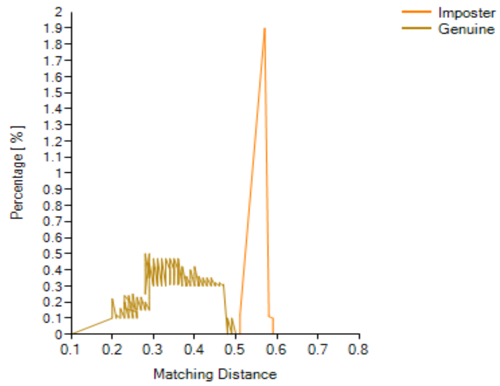

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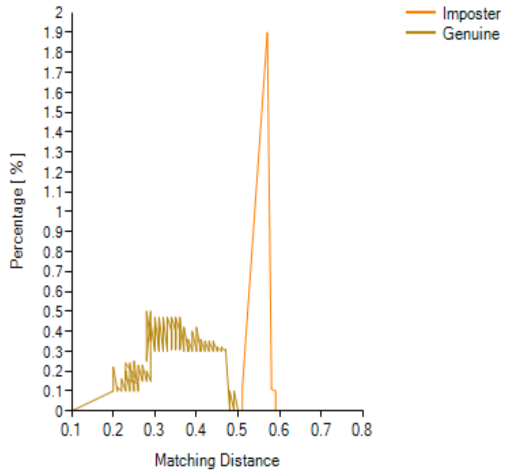

(d)

Fig. 7 Distance distributions of authentic matching's and fraud matching's of FKP for PolyU database from (a) left index fingers (b) left middle fingers (c) right index fingers and (d) right middle fingers

TABLE I
EERS (%) BY VARIOUS TECHNIQUES

Finger type	CompCode (A) [10]	LGIC (B) [11]	Proposed work
left index	2.06	1.65	1.15
left middle	1.96	1.45	1.06
right index	1.82	1.37	1.14
right middle	1.87	1.39	1.05

TABLE II
PERFORMANCE MEASURES OF THE PROPOSED WORK

finger type	CRR (%)	EER (%)	DI
left index	99.20	1.15	5.86
left middle	99.35	1.06	5.74
right index	99.46	1.14	5.82
right middle	99.24	1.05	5.71

VII. CONCLUSION

In this work, the local–global information fusion strategy is adopted in Finger knuckle-print authentication system. The local and global information play a vital role in pattern matching scheme. Fast Discrete Orthonormal Stockwell transform is utilized to extract the instantaneous phase as local features. Fast Discrete Orthonormal Stockwell transform is a time–frequency analysis technique. Hence the Fourier transform is obtained if the scale of the Fast Discrete Orthonormal Stockwell transform is increased to infinity. The Fourier transform is considered as a Global feature. Both local and global features are combined to increase the recognition accuracy of the FKP system. Therefore detailed experiments performed on FKP database that shows the proposed work provides good performance in terms of EER and CRR.

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