ISSN: 2277 – 9043
International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE)
Volume 3, Issue 10, October 2014

Dorsal Finger Knuckle Identification using Fuzzy Feature Matching

Kavitha Jaba Malar R, Joseph Raj V

***Abstract*— Biometric traits are now highly explored by researchers to identify a person. This paper presents an emerging biometric identifier, namely Dorsal finger knuckle Print (DFKP) for personal identification. A Fuzzy Feature Match based on Triangle Feature Set is applied for the improvement of distortions in finger knuckle prints verification system. This method is applied to get the best match with the original image and demonstrates that the minutiae template of an user may be used to reconstruct finger knuckle print images of CETS student and staff members. The performance of the method is also reported. This paper proposes the concept of fixed fingers and fixed number of triangles in the finger knuckle print. The concept of fixed fingers and fixed number of triangles in the dorsal finger knuckle print improves the performance of the method. The proposed system reduces the complexity of the dorsal finger knuckle print triangularization method. It also improves the accuracy.**

***Index Terms*— Distortion, Dorsal, Matching, Verification.**

I. INTRODUCTION

Biometric features have been widely used in personal authentication system because it is more reliable when compared to conventional methods like knowledge based. Hand based biometrics such as palm print, fingerprint and hand geometry are very popular because of their high user acceptance. Recently it has been found that an image pattern of finger knuckle surface has more advantages when compared to finger prints. The finger knuckle print refers to the inherent skin patterns that are formed at the joints in the finger back surface. It is not easily damaged since only the inner surface of the hand is used widely in holding of objects. The finger knuckle print is rich in texture and has a potential as a biometric identifier. Finger identification can plays an important role in crime scene. It is more important to identify unknown criminals at any crime. The finger-back surface, also known as dorsum of hand, can be highly useful in user identification and has not yet attracted the attention of researchers. Various finger knuckle recognition techniques, including finger knuckle Acquisition, enhancement, matching, and classification are developed and advanced rapidly. However, there are still difficult and challenging tasks in this field.

Manuscript received Oct 15, 2014.

Kavitha Jaba Malar R, Research Scholar, Mother Teresa Women's University, Kodaikanal - 624101, India, +919486479890.

Dr. Joseph Raj V, Department of Computer Science , Kamaraj College, Manonmaniam Sundaranar University, Thoothukudi - 628003, India..

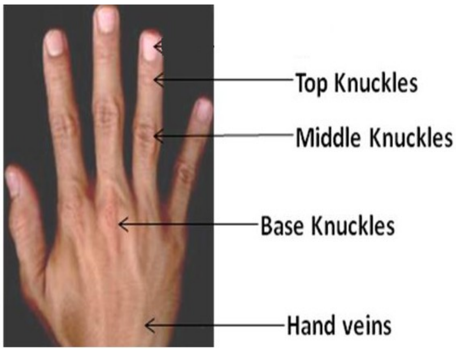

Fig.1. Dorsal Human Finger Knuckle Structure.

Dorsal Finger knuckle prints (DFKP), which refers to the inherent skin patterns of the outer surface around the phalange joint. It has high capability to discriminate different individuals. It is easily accessible, contact-less image acquisition, invariant to emotions and other behavioral aspects.

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II. LITERATURE SURVEY

Woodward and Flynn et al. [14] are the first scholars who made use of the finger knuckle surface in their work. They set up a 3D finger back surface database. They captures both a 640x 480 range image and a registered 640x480 24 bit color intensity image nearly simultaneously. The sensor dimensions are 213mm x 413mm x 271mm and it weighs around 11 kg. The sensor cost, size and weight, limits the use of this sensor in a commercial biometric system. Black cloth was chosen as the background to simplify the hand data segmentation task. The result is missing or inaccurate range image data near and at that location. The subject was instructed to place his or her right hand flat against the wall with the fingers naturally spread as the image is captured. Between image captures, the subject is instructed to remove his or her hand from the wall and then return it to approximately the same position. A total of 1191 hand range images were collected by the researchers which are publicly available.
C.Ravikanth et al. [8] developed a system for acquiring the finger back surface images. This imaging system uses a digital camera focused against a white background under uniform illumination. The camera has been set and fixed at a distance of 20 cm from the imaging surface. Non-uniform illumination cast shadows and reflections at the hand boundaries which significantly reduces the performance. Therefore, the image acquisition is uniformly illuminated by a fixed light source above the hand. The resolution of the acquired image is 1600 x 1200 pixels. Each subject is requested to place the hand on

the support with their back hand facing the sensor. The subject can visualize the placement of their hand from the live-feedback on small plasma display.

Lin Zhang et al. [5] development a system for FKP acquisition. This consists of four components FKP image acquisition, ROI extraction, feature extraction and feature matching. The people who provided the database were in age group from20-50 years. The samples were collected in two different sessions and the time interval between these two sessions was around 25 days. Six samples was collected from left index, left middle, right index and right middle fingers of each person and thus a total of 48 samples was available. The database thus consists of 7920 images from 660 fingers.

III. Proposed Work

As a preprocessing step, we have used orientation based algorithms to decide Region of Interest (ROI). Commonly dorsal surface of the hand have key features like Knuckle crease and hand vein have been used for Verification. At the initial stage of preprocessing we crop manually four indexes, middle, ring and little fingers from dorsal hand surface. The knuckle image represents oriented texture and has very rich structural information within the image. Orientation of crease appear in cropped dorsal finger image is large in middle knuckle of each finger.

The process for Dorsal FKP identification system can be divided into the following different stages:

- Image acquisition
- Feature extraction
- Matching

An acquisition system has been developed for the collection of dorsal finger knuckle Surface. A very user-friendly imaging system is constructed. This imaging system uses a web camera focused against a white background under uniform illumination. The camera has been set and fixed at a suitable distance from the imaging surface.

A. Database Establishment

In order to evaluate the proposed Dorsal FKP identification, a DFKP database is to be established by collecting right hand dorsal finger knuckle images of various persons. The DFKP images are collected from 50 CETS student and staff members. Four images, left index finger, the left middle finger, the right index finger and the right middle finger are taken for each person.

B. Finger extraction

The parameters are extracted from the dorsal finger knuckle print images. The located finger pixels are used to extract the knuckle regions for feature extraction.

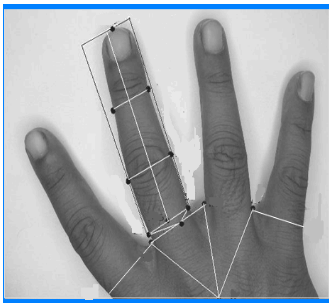

Fig.2. Geometrical Structure of DFKP

Four additional points are located from the finger contour. Two of them are at one-third of the distance between the fingertip and the base points of the finger and the other two at the two-third distance. The line joining the middle points of the line segments F1-F2 and F3-F4 defines the line of symmetry of the finger-strip region. The width of the strip is chosen to be the minimum distance between the base points of the finger (B1-B2). A total of 26 finger knuckle print geometry features are computed from each of the hand. The finger length is estimated as the distance between the finger tip and the midpoint of the base points of the finger. The distance between the intermediate points are estimated as finger widths.

IV. Fuzzy Matching

First step of the approach is to define features of the dorsal fingers. The next step is to define a local triangle feature set. The block of the matching is the local triangle feature of the finger knuckle prints. The feature vector of a dorsal finger knuckle structure (DFK) is defined by the distance between minutiae, the angle between the direction from minutiae, the orientation differences within the region of minutiae, distance between the four fingers except the thumb, the base point distance of the fingers and the length of mid finger knuckles. The feature set is defined by DFK. $DFK=\{FD_1,FD_2,FD_3,FD_4,BPD_1,BPD_2,BPD_3,BPD_4,IFM_1,IFM_2, IFM_3,IFM_4,d_{ij},d_{jk},d_{ik},\Psi_i,\Psi_j, \Psi_k,OZ_i,OZ_j,OZ_k,\alpha_i,\alpha_j,\alpha_{k,}\}$. The triangles are constructed by the triplets of minutiae satisfying the following constraint; it means that a minutia belongs to many triangles formed with other minutiae. There is one constraint during the process of constructing the local triangles: the maximum length of the edge in a triangle should be less than thr1, and the minimum length of the edge should be greater than thr2. The feature vector set, which consists of feature vectors, of all local triangles detected from a finger knuckle print, is used to represent the image. Finger knuckle matching is to find a similarity between two feature vector set, one from the template and another from the input dorsal finger knuckle print, respectively. A set of finger knuckle prints images used to derive a genuine distorted pattern parameter space. We choose the corresponding training samples for each database. For example, in the CETS staff database, we used training set to derive the genuine distorted pattern parameter space. The database set contains finger knuckle prints captured from students and staff members' hand, four images for each hand. In order to compute the genuine distorted pattern parameter space of the finger knuckle prints, we matched those impressions from the same hand and trained the distorted pattern parameters.

ISSN: 2277 – 9043
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Based upon fuzzy feature representation of finger knuckle prints, the similarities between the fuzzy features are used to characterize the similarity between finger knuckle prints. We introduce a fuzzy similarity measure for two triangles and extend it to construct a similarity vector including the triangle-level similarity for all triangles in two fingerprints. Accordingly, a similarity vector pair is defined to illustrate the resemblance between two images. The FFM method maps a similarity vector pair to a normalized quantity, within the real interval [0, 1], which quantifies the overall image to image similarity.

A. *Fuzzy Similarities*

The image-level similarity is constructed from triangle-level similarities. The FFM method computes the inner products of similarity vectors with weight vectors. To choose weight vectors, take the location of the triangles into account and assign higher weights to triangles closer to the center of the finger knuckle prints. Another choice is the area scheme. It takes the area covered by the triangle as the weight based on the viewpoint that the triangle of the proper area in a fingerprint. In the FFM method, both area and center-favored schemes are used. Consequently, the FFM measure for template and input fingerprints is defined as

$$\mathbf{Sim = [(1\text{-}p)\ w_A + pw_B\ ]\ L^{(T,I)}} \qquad (1)$$

Here w_A is the normalized area percentage of both template and input fingerprints, w_B is the normalized weight which favor triangle near the image center, p€[0,1] adjusts the significance of w_A and w_B and $L^{(T,\ I)}$ is the weighted entries of similarity vector of the overall image.
We first, calculate the deformed pattern feature vector and then measure the degree of membership of the fuzzy feature set. The modified Cauchy function is chosen due to its good expressiveness and high-computational efficiency. The membership function of the fuzzy feature set is defined as

$$C(\vec{f}) = \begin{cases} 1, & \text{if } h(\vec{f},\vec{g}) = \text{True} \\ \dfrac{1}{1+\left(\frac{\|\vec{f}-\vec{g}\|}{m}\right)^{a}}, & \text{otherwise} \end{cases} \qquad (2)$$

The similarity between template and input finger knuckle prints is constructed by triangle similarities. It is difficult to get the closed-form equation. The minutiae number of the template and input fingerprints, respectively, P { ⧫} is the probability that the similarity between the template and input fingerprints is greater than threshold. Here, we analyze the matched number of triplets of minutiae which satisfy the entire criterion in the matching process, and the probability of the local triangle feature set matching model.

V. Performance Analysis

The proposed system can analyze to predict whether a person should be claimed as a true client or an imposter. In order to evaluate the success of the system, a standard measurement is used to verify the acceptance errors and rejection errors. They are defined as follows:

- False Reject Rate (FRR)
- False Acceptance Rate (FAR)
- Equal Error Rate (EER)
- The FRR is the percentage of clients or authorized person that the biometric system fails to accept. FRR is defined as

$$\text{FRR} \quad = \frac{\text{Number of rejected clients}}{\text{Total number of client access}} * 100\% \qquad (3)$$

The FAR is the percentage of imposters or unauthorized person that the biometric system fails to reject. FAR is defined as

$$\text{FAR} \quad = \frac{\text{Number of accepted imposter}}{\text{Total imposter access}} * 100\% \qquad (4)$$

The EER is an optimal rate where FAR is equal to FRR. The accuracy of the biometric system is defined as

$$\text{Accuracy} = \max\ (100 - (\text{FRR+FAR})/2) \qquad (5)$$

For Dorsal Finger Knuckel1,

G = {372, 372, 372, 372}
V (G) = {50, 50, 50, 50}
∑ (G) = {9.47, 9.47, 9.47, 9.47}

Table I. Feature vectors of triangles in Dorsal Finger Knuckle (Sample)

DFK	i	j	k	Ψ_i	Ψ_j	Ψ_k	AT	PT
1-1	1.4	2.3	1.8	900	$51^{0}30$1	$38^{(}70$1	1.26	2.52
1-2	1.4	2.3	1.8	900	$51^{0}30$1	$38^{(}70$1	1.26	2.52
1-3	1.4	2.3	1.8	900	$51^{0}30$1	$38^{(}70$1	1.26	2.52
1-4	1.4	2.3	1.8	900	$51^{0}30$1	$38^{(}70$1	1.26	2.52

Table II. Feature vectors of Dorsal Finger Knuckle (Sample)

DFK	FD_1	FD_2	FD_3	FD_4	BPD_1	BPD_2	BPD_3	BPD_4
1-1	3.2	7.8	6.7	6.0	1.8	2.1	1.9	1.7
1-2	3.2	7.8	6.7	6.0	1.8	2.1	1.9	1.7
1-3	3.2	7.8	6.7	6.0	1.8	2.1	1.9	1.7
1-4	3.2	7.8	6.7	6.0	1.8	2.1	1.9	1.7

Table III. Feature vectors of Dorsal Finger Knuckle (Sample)

DFK	IFM_1	IFM_2	IFM_3	IFM_4
1 1	1.9	1.8	1.7	1.6
1-2	1.9	1.8	1.7	1.6
1-3	1.9	1.8	1.7	1.6
1-4	1.9	1.8	1.7	1.6

Table IV. Correlation of FKP and DFKP Performance.

Method	FAR	FRR	EER	Accuracy
FKP	2.97%	3.00%	2.99%	97%
DFKP	2.53%	2.96	2.98	98%

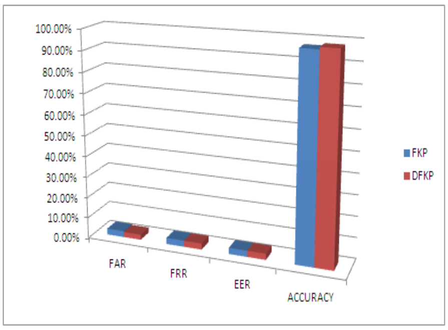

Fig.3.Comparison of FKP method with DFKP method.

VI. Conclusion

We studied a novel method for Dorsal Finger Knuckel matching. The Finger Knuckle is represented by the fuzzy feature that is local triangle feature set. The similarity between the fuzzy feature is used to character the similarity between Finger Knuckle. We introduce a fuzzy similarity measurement for two triangles and extend it to construct a similarity vector including the triangle-level similarity in two dorsal Finger Knuckles. Accordingly, a similarity vector pair is defined to illustrate the resemblance between two Finger Knuckle. Finally, the FFM method maps a similarity vector pair to a normalized quantity which quantifies the overall image to image similarity within the real interval [0, 1]. The studied algorithm has been experimented and evaluated with the Dorsal Finger Knuckle prints of CETS staff database. Experimental results confirm that the algorithm works well with the nonlinear distortions. Here we found 98% of accuracy in matching. The proposed concept of fixed area and fixed number of triangles in the Dorsal Finger Knuckel improves the performance of the triangularization method. The proposed system reduces the complexity of the local triangularization method. It also improves the accuracy.

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R.Kavitha Jaba Malar from India received the MCA degree from Manonmaniam Sundaranar University, Tirunelveli, India on 2001. Where she is currently pursuing the Ph.D. degree at Mother Teresa Women's university, Kodaikanal, India. She is presently working as a software developer at SRM InfoTech.

V. Joseph Raj received his PhD degree from Manonmaniam Sundaranar University, Tirunelveli, India and Post Graduate degree in Anna University, Chennai, India. He is presently working as a Professor and Head of the Department of Computer Science, Kamaraj College, Manonmaniam Sundaranar University, Thoothukudi, India. He has also worked as an Associate Professor in Computer Engineering in European University of Lefke, North Cyprus. He is serving as the Chairman of Computer Science Board of Studies of Manonmaniam Sundaranar University. He is guiding PhD scholars of various Indian universities. He has a vast teaching experience of about 25 years and research experience of about 18 years. His research interests include neural network, digital image processing, biometrics, network security and operations research. Research experience of about 18 years. His research interests include neural network, digital image processing, biometrics, network security and operations research.