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Improved Distorted Fingerprint Matching Performance Based on Fuzzy Logic

Shubhangi E. Inagle[1], Dr. Ayesha H. Butalia[2]

[1]*Departmen of Computer Engneering, G.H. Raisoni Institute of Engineering and Management, Ahmednagar*
[2]*Department of Computer Engneering, G.H. Raisoni Institute of Engineering and Management, Wagholi*

Abstract — *Due to the inimitability and persistence, human identification by fingerprints is considered most reliable. There are many challenges faced in fingerprint recognition system as distorted fingerprints are of squat quality and contains less features. In this paper, spurious minutiae are removing using fuzzy rules. This paper introduces a novel method to detect a distortion using fuzzy classifier and rectify it. Then, Enhanced fuzzy feature match (EFFM) is proposed to match fingerprints. The orientation field and minutiae are attribute vectors for fuzzy classifier. The proposed method upgrades the performance and the accuracy of fingerprint matching.*

Keywords- *Orientation Field Estimation, fuzzy feature match (FFM)*

I. INTRODUCTION

Due to distinguishing physiological and behavioral traits, fingerprints are considered most reliable biometric identification system. Highly precise and advanced commercial fingerprint recognition systems are available in market. Fingerprint recognition is well researched problem. But these systems get affected by fingerprint acquisition, skin distortion, moisture or dark mehandi drawn on palm. If a dark mehandi is drawn on palm, scanners are not able to capture an image. So it becomes essential to use multispectral fingerprint scanners during fingerprint acquisition. Fingers get wrinkled or shriveled, when dipped in water for a long period. Wrinkled fingerprints or mehandi on fingerprints cause non-isometric deformation. It means the distance between minutiae and core point may get varied.


Fig. 1 a) A wrinkled fingerprint b) Fingerprint with mehandi

If fingerprint image acquired during acquisition is of squat quality, it adds noise, forged minutiae to an image and removal valid one. It increases false recognition rate of fingerprint recognition system. It becomes crucial point to enhance fingerprint image, remove forged minutiae, and categorize fingerprint images to upgrade the matching performance.

A fingerprint is an exclusive prototype of ridges and valleys on the surface of a finger of an individual. Orientation field and minutiae are the most perceptive and reliable features. The attribute extraction is very important because valid attributes improves the accuracy of matching. Fingerprints consist of two types of distortions: photometric and geometric. Sensor noise, complex background leads to photometric distortions, whereas flexibility of the skin, finger disarticulation, contact pressure, skin moisture content, etc leads to geometric distortions[1]. A lot of research has done to handle distortions. But still existing systems has some loopholes. To handle distortions, existing systems use scanners having video capturing capacity which cause increase in cost. To store videos in database needs more memory as well as more processing time. It becomes crucial to develop distortion detection and fingerprint matching algorithm based on single image.

It has been suggested to use the ridge orientation map and period map of a registered fingerprint as the input feature vectors to detect elastic distortions. To find out whether the input fingerprint is tainted or not, SVM classifier is trained. To renovate the distortion in the input fingerprint, a nearest neighbor approach is used. However it does not work on rolled fingerprint[2].

This paper focuses on fingerprint image enhancement, elimination invalid attributes, detection and correction of deformation. Fuzzy set theory handles uncertainty and elusiveness proficiently. So, to eliminate forged or false minutiae from fingerprint image, fuzzy logic is used. The enhanced fuzzy feature matching (*EFFM*), a triangular feature vector is used to calculate the semblance score between query and template fingerprint. But first, we find out matched triangles then find out attached matched triangles.

The rest of the paper is organized as follows: Section 2 presents literature survey of previous approaches to restructure an orientation map and fingerprint matching. Section 3 presents the proposed method based on ridge orientation and frequency information. Section 4 presents conclusions and future work.

II. LITERATURE REVIEW

Authors developed the concept of short time Fourier transform (STFT) Analysis for image enhancement This approach is noise sensitive so needs orientation smoothening of a fingerprint image before the enhancement[3]. Authors have designed an idea of using a prior knowledge of fingerprint orientation field to reconstruct it. Authors considered that orientation field estimation of latent fingerprints is analogous to real word error in spelling correction. Using a set of true orientation fields, dictionary of reference orientation patches is build. The use of a single global dictionary for the whole fingerprint has a drawback that a valid local ridge patterns may appear at an impossible location of fingerprint[4].

It has been suggested to utilize a localized dictionaries-based orientation field estimation algorithm. After latent fingerprint acquisition, noisy orientation patch is replaced by real orientation patch in the local dictionary to correct it. Here main problem is to locate the location of a noisy orientation patch. A Hough transform-based fingerprint pose estimation algorithm is recommended in order to locate it. Estimating distorted region from poor quality latent fingerprints is a very tricky predicament and also a very under-researched topic. But in above both approaches, noisy training dataset causes addition false orientation patches in a dictionary [5].

In order to improve the performance of deformed fingerprint matching, it is suggested to use an orientation patch dictionary to restructure orientation map and continuous phase patch dictionary to restructure the ridge pattern are constructed. The drawback of this algorithm is: reconstruction the field of ridge frequency directly by using the minutiae position and direction is not possible [6]. Authors proposed latent orientation field estimation via convolutional neural network utilizes prior knowledge of fingerprints and enhances the performance. Superior quality images are provides as an input to train the convolutional neural network. In this algorithm also, noisy and squad quality training fingerprint images affects the matching performance.

In recent years, a lot of research and invention has done to deal with the distortions in fingerprint images and improve an accuracy of fingerprint matching. Authors put forward an idea of a normalized fuzzy similarity measure (NFSM) based method to handle nonlinear distortions. Here, the suggestion of using local topological structure matching to improve the invariance of global alignment is mentioned. To evaluate the resemblance between the registered and query fingerprints, NFSM is executed [8].

Authors designed a ridge feature extraction algorithm to make better the exactness of fingerprint matching and to decline the time complexity of ridge feature extraction process. Authors have executed algorithm for fingerprint matching which is uses a combination of ridge features and minutiae distribution as an attribute vector. Ridge features such as ridge count, ridge length, ridge curvature direction, and ridge type and the minutiae features like minutiae type, orientation, and position and then performed breadth first search (BFS) to identify the analogous match up of minutiae. But this algorithm could not work well for fingerprint images with petite forefront region and poor quality images [9]. It has been implemented a minutiae-based algorithm to recognize and compare fingerprint pattern. The distance between the minutiae and core points is an input attribute to calculate the matching scores for fingerprint images [10S].

III. ENHANCED FUZZY FEATURE MATCH *(EFFM)*

Matching wrinkled fingerprints and fingerprints with mehandi to the registered fingerprints is a challenging problem as poor quality of image and less information. Hence, it is necessary develop a new approach to overcome this problem. Uncertainties and imperfection in an image can be efficiently handled using fuzzy logic. In order to improve the matching performance and accuracy, we proposed to use fuzzy logic.

3.1 Preprocessing

As we are focusing on fingerprints with a dark mehandi, it is necessary to multispectral fingerprint scanners to obtain fingerprints from user. Now it becomes crucial to enhance it because distorted images are of squad quality. So, raw fingerprint is converted into gray scale image. Histogram equalization is recommended to distribute the most frequent intensity values and in order to enhance the contrast between foreground and background region. It upgrades in feature extraction accuracy. Now histogram equalized image is binarized using an adaptive local thresholding technique. To remove superfluous pixels of ridges and to reduce ridge to one pixel, thinning of images is proposed.

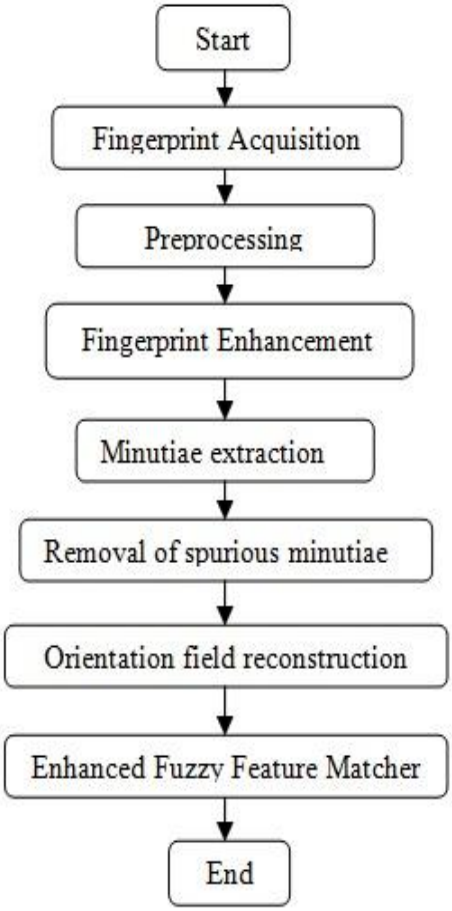

Fig. 2 The Proposed system

3.2 Feature extraction

Minutiae are the most discriminating and consistent features. Minutiae are the points at ridge endings and ridge bifurcation. Using Rutovitz Crossing Number (CN) method, the minutiae points are extracted from the skeleton image.

P1	P2	P3
P4	P5	P6
P7	P8	P9

Fig. 3 3X3 neighborhood

Here, to calculate *CN* value 3X3 window is used to consider 8 neighboring pixels. The *CN* value is computed as follows:

$$CN = 0.5 \sum_{i=1}^{8} |P_i - P_{i-1}| \quad (1)$$

CN	Property
0	Isolated Point
1	Ridge ending point
2	Continuing ridge point
3	Bifurcation point
4	Crossing point

Table 1. Properties of crossing number

To discard forged minutiae, fuzzy rules are used. Average Euclidian distance (D) between two points in fingerprint is calculated. To eliminate forged minutiae, following fuzzy rules is used.

a) Distance between bifurcation point and termination < D, remove that minutiae

b) Distance between two bifurcation points < D, remove bifurcation.
c) Distance between two terminations < D, remove termination [12].

This method is easy and computationally proficient.

Orientation field represents the flow of ridges structure. The enhanced feedback is generated by calculating the orientation differences of distorted fingerprints and rolled or plain fingerprint. The enhanced feedback is used to rebuild the orientation field.

Gabor filtering possesses frequency selective and orientation selective properties. Gabor filter is used to remove noise from the fingerprint image without affecting the ridge structure and to enhance the ridge pattern .

3.3 Distortion Detection and rectification

Fuzzy classifier is trained to detect distortion in fingerprint. It uses stochastic approach. In case of unavailability of the training data set, the fuzzy classifier is trained using the prior knowledge. Training fuzzy classifier takes less time and also gives more accuracy as it is train to work with precise values. Fuzzy Classifiers can detect all the types of altered fingerprints i.e. Obliteration, imitation and distortion. To rectify distortion, a nearest neighbor approach is used.

3.4 Fingerprint matching using Enhanced Fuzzy Feature Match *(EFFM)*

In the enhanced fuzzy feature match *(EFFM)* methodology, the distance between minutiae, the direction angle between two minutiae, the orientation angle, the angle between the orientation of minutiae with the direction of the interior angle bisector and the type of minutiae are attributes of input vector.

Here, attribute vector of each triangle is expressed as:

$$FT_K = \{d_{ij}, d_{jk}, d_{ik}, \Psi_i, \Psi_j, \Psi_k, OZ_i, OZ_j, OZ_k, \alpha_i, \alpha_j, \alpha_k, T_i, T_j, T_k\} \quad (2)$$

d_{ij} = the distance between minutiae i and j, Ψ_i = the angle between the direction from minutiae i to j and the direction from minutiae i to j, OZ_i = the orientation differences within the region of minutiae i, α_i = the angle between the orientation of minutiae with the direction of the interior angle bisector of corner. T_i, T_j, T_k are the minutiae types of coordinates of triangle.

Let FT_I be a feature set of input fingerprint.

$$FT_I = \{d_{ij}, d_{jk}, d_{ik}, \Psi_i, \Psi_j, \Psi_k, OZ_i, OZ_j, OZ_k, \alpha_i, \alpha_j, \alpha_k, T_i, T_j, T_k\} \quad (3)$$

Let FT_T be a feature set of input fingerprint.

$$FT_T = \{d_{ij}', d_{jk}', d_{ik}', \Psi_i', \Psi_j', \Psi_k', OZ_i', OZ_j', OZ_k', \alpha_i', \alpha_j', \alpha_k', T'_i, T'_j, T'_k\} \quad (4)$$

These two attribute set of local triangle of input and registrred fingerprints are used to calculate the similarity between fingerprints. Measure the similarity between fingerprints as follows:

$$\overrightarrow{D_{diff}} = \{|d_{IJ} - d_{IJ}'|, |d_{jk} - d_{jk}'|, |d_{ik} - d_{ik}'|\} \quad (5)$$

$$\overrightarrow{\Psi_{diff}} = \{|\Psi_i - \Psi_i'|, |\Psi_j - \Psi_j'|, |\Psi_k - \Psi_k'|\} \quad (6)$$

$$\overrightarrow{OZ_{diff}} = \{|OZ_i - OZ_i'|, |OZ_j - OZ_j'|, |OZ_k - OZ_k'|\} \quad (7)$$

$$\overrightarrow{\alpha_{diff}} = \{|\alpha_i - \alpha_i'|, |\alpha_j - \alpha_j'|, |\alpha_k - \alpha_k'|\} \quad (8)$$

These are genuine distorted pattern parameters.

Above feature vector is used to map the similarity between the input and template fingerprint. The enhanced fuzzy feature match *(EFFM)* Algorithm:

a) Find out triangles of input and template fingerprint having same minutiae type.
b) Test the resemblance between triangles.
c) If a pair of triangles is matched, then find out matched triangles which are attached to the previously matched triangle edges.
d) If no two triangles are matched, consider new attribute vector and go to step b) and c).
e) The area of matched triangles is greater than threshold value, fingerprints are matched.

IV. CONCLUSION

We proposed to use multispectral fingerprint scanners for scanning fingerprint. There are two types of distortions: photometric and geometric distortions. In this paper, we focused on geometric distortions which occur due to skin distortions, fingerprint displacement, wrinkled fingerprint, etc. Due to squad quality of images, minutiae are extracted using crossing number concept. To remove forged minutiae, fuzzy logic is applied as fuzzy logic handles uncertainties and more efficient. Fuzzy classifier is proposed to detect distortion and a nearest neighbor approach to correct the distortion field. So, it improves the accuracy of fingerprint matching. Enhanced fuzzy feature matcher *(EFFM)* is used for fingerprint matching which provides accuracy.

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