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A SURVEY PAPER ON FINGER KNUCKLE PRINT RECOGNITION ALGORITHM

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Abstract: -For identification of a person, lots of exploration has been accomplish by the researcher in the field of the biometrics traits for identifying the person accurately. Due to its reliability and accuracy as compared to the tradition methods,, biometric feature based person identification system is getting popular day by day. Biometric characteristics play very important role in the performance of such system. Each and every individual has some inherent skin patterns which are unique. These patterns are formed at the joints of the finger at the inner part and also at the outer parts. Recent study reveals that these patterns are highly rich in texture and hence can be used to identify the person. One of the advantages of these biometrics traits is that they are very unlikely to damage. This paper is an effort to peep into the various methods used earlier for acquiring and developing system based on it. Comparative performance of the various methods is also presented in this paper.

Keywords: Biometrics, finger knuckle print, features, recognition system.

I. INTRODUCTION

Due to its reliability and accurately, biometric feature based person identification method Find more wider application as compared to the conventional algorithms like knowledge based technique i.e. password based method, PIN based method etc and token based method such as passport ID card etc. finger-print , face, palm-print, iris, voice, gait are some the physical and behavioural characteristics which are widely used in biometric system. Among all these biometrics traits, hand geometry based method such as fingerprint, palm-print etc are most popular because of the higher user acceptability rate. Recently it has been discovered through the extensive experimentation that the creases and the fold of the skin pattern of the lies in the joints of the outer finger knuckle print is highly unique and hence can be used as a distinctive biometric identifier[1]. As compared to the finger print it also has more advantage like it is not damaged easily because only the inner part of the palm is generally used when we fold our palm and the outer part is used very occasionally. Apart from this it is generally not involved in any kind of criminal activities which make it perfect for use acceptability[2]. One more advantage of this is that it cannot be forged as no people leave the traces of the knuckle print on the surfaces of the object touched or handled. Moreover, it is very rich in texture which makes it suitable as biometric identifier. Section 2 of this paper discuss various method adopted for capturing the Finger knuckle print(FKP), while section 3 discuss the various method and techniques adopted for identification of the person based on FKP. Finally section 4 presents the concluding remarks.

II. FINGER KNUCKLE PRINT ACQUISITION

Finger knuckle surface was first used by the scholar Woodward and Flynn in their research work "Finger surface as a biometric identifier" [3]. They have prepared the database of finger-back surface with the help of Minolta sensor 900/910. This sensor is capable of capturing the image with the resolution of 640x480 range image along with the registered 640x480, 24 bit colour image simultaneously. The dimension of the sensor is 213mmx413mmx271mm and its weight is around 11 Kg. The cost, weight and the size of this sensor was not suitable for the commercial biometric system. During the acquisition, the sensor must be placed approx. 1.3 m away from the wall which is covered with black piece of cloth. Black cloth was used in this method in order to simplify the data segmentation task. Before collecting the data, subject is instructed to remove all the jewellery or any other wearing which can affect the accuracy of the system. Jewellery actually scattered the emitted light and causes the degradation in the acquisition process. The subject was also instructed to place his or her hand flat with all the fingers stretched out. As many as 1191 hand range image were collected by the researcher and were made available to everybody who is doing research in this field.

(a) (b) (c)

Figure 1 (a) Intensity Image Sample (b) Range Image Sample (c) Range Image Detail

In the above figure, a sample colour images of hand with the resolution 640x480 .figure 1(b) represent the pseudo intensity range image of the same figure 1(a). Figure 1(c) shows the surface detail of the same image near the knuckle. In this type of image acquisition, the hand placement must be accomplished in such a way that there must be space between the two adjacent fingers.

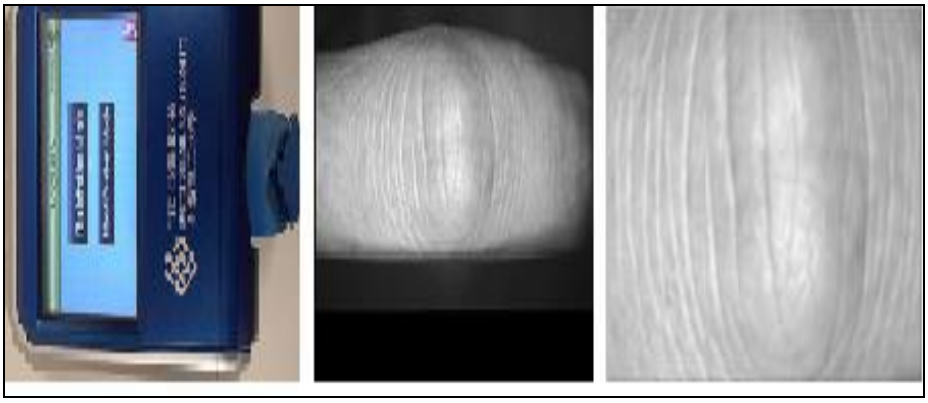
After pre-processing and segmentation operation of the image, a 3D range image of the hand is used to calculate the curvature surface representation of the index, middle and ring fingers. In order to compare the similarity, Normalized correlation coefficient was used [3].

Next noteworthy contribution was accomplished in this field by C. ravikanth in his paper *"Personal authentication using finger knuckle surface*" [1]. He also developed his own system to acquire the finger back surface images. His system consists of the digital camera for acquiring the images against the white background under uniform illumination. In this system the camera was set and fixed at a distance of 20cm from the imaging surface. Under non uniform illumination condition, the shadows and reflections from the hand boundary reduces the performance of the system significantly. Therefore uniform illumination was carried out with the help of light source. This system acquired the image with the resolution of 1600x1200 pixels. The subject can see the exact placement of his hand with the help of small plasma display which give the live feed back. The acquisition of the sample image is shown in the figure 2(b) given below.

(a) (b)

Figure 2 (a) Acquisition of finger back image (b) Acquired Image

Next noteworthy contribution was done by the Lin Zhang in his paper "Online Finger-Knuckle –Print Verification for Personal Authentication" [4]. He also designed a system for FKP acquisition. It consist of 4 modules or component i.e. FKP image Acquisition module, ROI (Region of Interest) extraction module, feature extraction module and feature matching module. Figure 3(a) represents the FKP recognition system developed by him. The FKP image captured by the system is shown in the figure 3(b). The extracted region of interest (ROI) of the captured FKP image is shown in the figure 3(c). These are now publically available in the PolyU database. As many as 165 persons FKP is collected using this system. Most of the person used for this database is in the age group of 20-50 years. These sample are collected in two different session. These sessions are 25 days apart. Left index, left middle, right index, right middle fingers of each person is sued for sample collection. Database thus comprises of the total images of 7920 from 660 fingers images.



(a) (b) (c)

Figure 3 (a) FKP Recognition System (b) Captured Image (c) Extracted ROI

III. RECOGNITION ALGORITHMS

A bio metrics system which is designed for the identification of the person can recognize the person on the basis of the algorithm on which it is designed. Two types of recognition algorithm are most widely used-

i. Template based- This method work by computing the template of the user and then comparing this template with the template already stored in the database. This method is called one to many matching.

ii. Verification based- this type of system generally requires identity proof of the user such as ID card ID number, Smart card etc for authentication. The user identity is then matched with the master template for authentication. This is known as the one to one matching.

The algorithm used for recognition or identification must be accurate and fast. The performance of the biometric system can be judged by the error rate. There are basically two types of error rate are used in biometric system

a. FAR(false acceptance Rate)
b. FRR(False rejection rate)

This error rate can be defined as-
The threshold value for which FAR becomes equal to the FRR is called equal error rate(EER)[30]. The accuracy of the biometric system can be computed using following
Formula-

FAR= No. of False acceptance / Total no. of Imposter Attempt

FRR= No. of False Rejection / Total no. of

Genuine attempts

Accuracy = max (100-(FRR+FAR)/2)

This is the same formula which used in the paper [26].

In the literature, various proposed Recognition algorithm based on the FKP can be divided in to the following categories-

i. Subspace based method
ii. Coding method.
iii. Other method.
iv. Fusion method.

A. Subspace method-

In the subspace method [4, 5, 6, 7], spatially localized features are created. This method is attracting a lot of attention in the literature. Since the localized feature are efficient for implementing the region based identification so this method is assumed to be more tolerant to the occlusion[1].Principal component analysis(PCA), Independent component analysis(ICA) and Linear discriminate analysis are some of the methods which are used in this method In this method sub space coefficients are used as the feature vector. For matching purpose , classifier or distance measure is used. This method is also used for reducing the dimension.

Lin Jhang [4] in his paper titled "Monogenic Code: A Novel Fast Feature Coding Algorithm with Applications to Finger-Knuckle-Print Recognition " proposed weighted linear embedding technique(WLE) which is s new feature extraction algorithm. This method is the combination of the fisher criterion and manifold learning criterion such as local discriminate embedding analysis.
Manifold learning theory clearly suggests that non local information carry less information than the local information and hence can be used as feature vector and can be extracted. For combining the local and non-local information Gaussian weighting is used in this method.
In this method, WLE is adopted for finding the mapping vector in such a way that the ratio of weighted class vector to weight within class vector has maximum values. Nearest neighbourhood classifier is used for classification purpose in this method. Same algorithms have also been tested on palm-print and comparative study of PCA LDA WLE and LDE has been accomplished. Accuracy of about 78% is achieved by applying the WLE on the right index fingers of about 1000 people.

Yang in their paper titled "Finger Knuckle-Print Recognition Using Gabor Feature and OLDA" [5] proposed another recognition method based on the finger knuckle print. In his method the authors used the Gabor features of the finger knuckle. This work was inspired by the fact that the Gabor wavelet has been used earlier in the image analysis and pattern recognition task. PCA was used in this algorithm for reducing the dimensional space of the Gabor features.

PCA was used to transform Gabor features in to low dimensional space. Further orthogonal linear discriminant analysis (OLDA) transformation in PCA subspace is done and classified using nearest neighbour classifier and efficiency as high as 98% was obtained. This paper compares the performance of the individual fingers and shows that the left index finger provides better performance.

Xiaoyuan Jing in their work "Orthogonal Complex Locality Preserving Projections based on Image Space Metric for Finger-Knuckle-Print Recognition" [8] simultaneously considered distances and angles between image data vectors to measure data similarities in hope of more sufficiently capturing the manifold structure. In order to highlight the distinction among angles between different data and enhance the complimentary information of angles compared with distance, a new type of image angle measurement in a shifted image space

that is cantered at the data mean is proposed. Both angle and distance are fused using the parallel fusion strategy based on which the complex locality preserving projection is used extract the low dimensional feature that can better preserve the manifold structure of the input data set. In order to remove the redundant information, orthogonal complex locality preserving projections (OCLPP) is used. Four images were randomly selected during the training process and recognition rate of 88% was achieved for the left index finger. This method is compared with other subspace methods like PCA, CPCA, LPP, CLPP and OCLPP in their proposed work.

B. Coding Methods

Different coding algorithms are proposed in the literature. [9, 10, 11, 12] and basically iris code is the foundation of these coding algorithms. These coding techniques have been used widely for palm print recognition [13, 14, 15, 16,17] and have provided good recognition results. The finger knuckle surface is highly rich in lines and creases which are curved but are highly unique in individuals.

Hence Ajay Kumar [18] in his work "Personal Identification using Finger Knuckle Orientation Features" relies on the local feature instead of the global information for better performance. Pre-processing steps in his method take care of the illumination variation. In order to avoid the wrap around due to the intrinsic modulo operation, instead of the finite radon transform (FRT), Modified finite radon transform (MFRT) to effectively and efficiently locate the orientation of the lines and the crease around a local neighbourhood. The dominant direction is then coded using binary bits which are considered as the knuckle code. For similarity measurement, hamming distance is computed which gives the accuracy of about 98.6%.

Jun Yin in their paper titled "Weighted Linear Embedding and Its Application to Finger Knuckle-Print and Palm print Recognition" [19] evolved a framework to secure FKP images and offered a strategy for adjusting the FKP pictures by adaptively building a neighbourhood arrange framework for each image. The base of the FKP image is steady because of securing technique embraced. Thus this is expected as X axis of the ROI facilitate framework by fitting this limit as a straight line. A curve model for FKP was then settled and the convexity extent is resolved. This greatness will achieve the base at the focal point of the joint and this position can be utilized to set the Y axis of the organize framework. When this organizes framework is settled then a ROI sub image of 110 x 220 is extricated. Gabor filtering is utilized from which the introduction data is extricated and represented as Competitive Code. Precise separation is utilized for coordinating and an EER of 1.09% was accomplished.

Rui Zhao in their paper titled "A Novel Approach of Personal Identification Based on Single Knuckle print Image" [20] proposed a fast feature extraction and coding method called the Monogenic code based on the Monogenic signal theory and is used for FKP recognition. For a two dimensional signal f(x) the monogenic signal is defined as the combination of f and its Ritz transform which is a vector valued extension of the Hilbert transform in the 2D Euclidean space. The code represents each pixel as a 3 bit code obtained by extracting the signs of the three components of the monogenic signal. It reflects the local orientation and phase information of the pixel under consideration. This method is shown to achieve similar verification accuracy in comparison to the state of art FKP verification methods.

Lin Zhang in his paper titled "A Novel Ritz Transforms based Coding Scheme for Finger-Knuckle-Print Recognition"[21] applied the coding method because of the merits like high accuracy, robustness high matching speed along with the compactness. Hence based on the capability of the Ritz transform to characterize the visual pattern, this research work offered an encoding the visual pattern of the FKP by second order Ritz transforms. The code scheme is called the Ritz comp code which is six bit code scheme. This code actually carries the advantage of the Ritz transform and the comp code for representing the local image feature together. Matching process is accomplished by computing the hamming distance. This coding is said to have a better performance as far as verification accuracy is concerned and make it better among the coding method.

C. Other Methods

In the literature [22, 23, 24] different techniques of image processing is applied to extract the feature like texture, line feature of local and global region in finger knuckle print.
The combinations of the local and global information are bound to give better recognition accuracy.

During the exploration of the FKP recognition technology Zhu Lei Quing in the paper titled "Finger Knuckle print recognition based on SURF algorithm" [24] offered a novel feature presentation as well as the matching method of the FKP which was based on the speeded-up robust feature (surf). It is an improvement over the scale invariant feature transform. In this method, a coordination system is set on the basis of the convex direction map of FKP for alignment of the image and feature extraction is carried out by ROI cropping. In the next step, Fast Hassian detector is applied to extract the key point for which the orientation is assigned according to the Haar wavelets inside the neighbour circle area of the key points. This results in to a construction of the orientation invariants descriptor for each key points. In matching process, the distance between the closest and the second closest neighbour are compared and distance ratio is computed. So all the matches in which the distance ratio is less 0.6 is retained. This process is accomplished to find the correspondence between the key point set of training images and the template. Geometric constraint is applied by using the Random Sample Consensus (RANSAC) which removes the false matching probability. This method is robust against the rotation variation and view point changes which prove its robusticity. An accuracy of 90.63% for verification and the accuracy of the 96.91% for identification is obtained through this method.

Lin Zhang in his paper titled "Ensemble of local global information for finger-knuckle-print recognition", [21] suggested that both global and local features are vital for image perception. His above findings was based on the psychophysics and neurophysiology studies of the FKP. On the basis of the above mentioned cause he offered a Local Global Information combination (LGIC) technique.

Gabor filter is used to extract the orientation information using four scale and six orientation. This orientation information is coded using the competitive coding scheme. All the image having the abundant like line structure suits this method and give the high accuracy, robustness variation in illumination and fast matching. Fourier transform of the FKP image is obtained by increasing the scale of the Gabor filter to infinity.
The Fourier coefficient obtained by applying the Fourier transforms work like a global feature. In order to match the two competitive code maps, angular distance based on the normalized hamming distance is applied. Similarity measurement of the global information of the two images obtained by the Fourier transform is carried out using the BLPOC (Band limited phase only correlation). So in this method, two different matching operations is performed for local and the global feature and the two distance obtained as d1 and d2.
These two distance are fused by applying the matcher weighting (MW) rule distance. This technique is able to achieve the EER as low as 0.402.

Rui Zhao et al.[11] presented a novel approach of person recognition using the single knuckle print only. This method uses light database to train the classifier and hence reduce the burden of the large database.
The edge of the image can be defined as the discontinuity in the gray level values of the pixel. So the main lines in the finger knuckle are due to the discontinuity in the gray level. So in order to extract the main lines and to remove the effect of the noise a predefined template of the dimension 3x5 is used as the gradient operator for extracting the edge information and hence the line features of the FKP.

In order to reduce the possibility of getting wrong recognition which may be due to the variation in the precise location while acquiring the different standing postures, eight different images were obtained by applying the translational operation. Original image and the eight different translational image makes total of nine images which are used to confirm the user identity by maximization of the cross correlation. This method confirms the FKP as one of the biometrics trait for recognizing the person with the recognition accuracy of about 95.68%.

Z.S.Shariat Madar and Karim Faez [25] in their work "A Novel Approach for Finger-Knuckle-Print Recognition Based on Gabor Feature Fusion" offered a recognition method based on the orientation features of the FKP and PCA and LDA for this purpose. Orientation of the image is acquired by the gabor filter. Eight different orientation and five different scales are used for extracting the orientation information from FKP. PCA is used here for dimensional reduction by PCA(Principal component analysis) analysis. Since the PCA and LDA combination provides good performance therefore LDA is applied on the PCA weight. Euclidean distance is computed for matching operation. Though this method is tested for all the four fingers but it was found that the right middle finger provides the highest accuracy of about 75.35%. By incorporating the fusion of the feature level information for different finger combination, recognition rate of 98.8% can be obtained.

D. Fusion Method

The accuracy of the biometrics system can be improved further by incorporating the fusion techniques [26]. Different fusion methods [5, 26, 27, 28, 29] are used for for different biometrics traits. There are four different fusion techniques such as

(i) Sensor level fusion (ii) Feature level fusion (iii) Rank level fusion (iv) Sore level fusion.

Out of these methods, score level fusion method has been used widely.

Z.S.Shariat Madar and Karim Faez [25] offered another efficient method which uses the information fusion at different level. Two feature vectors are extracted from each image. The ROI was segmented into twenty two division of 1100 pixel each, AAD was computed on individual division.
Five scale and ten orientations are obtained for each of these images and again the computation of the AAD is carried out. By this process 110 features were extracted. In order to reduce the dimension, PCA along with LDA is used which gives the 164 most suitable features. Minimum Euclidean distance was used for comparison of the combination of the two features.
Two different experiments were carried out in which each individual finger are first tested for the accuracy and then the combination of different fingers were also carried out to check the recognition rate. Left index finger was found to give the highest accuracy of 89.9% while the fusion of the entire four finger provided an accuracy of the 96.56%.

Abadallah Meraoumia in his paper titled , "Fusion of Finger-Knuckle-Print and Palm print for an Efficient Multi-biometric System of Person Recognition" .[27] suggested another fusion based biometrics recognition system in which fusion of FKP and palm print modalities were carried out. Phase correlation function (PCF) is used in this scheme for matching purpose. Two dimensional DFT of the palm print image was obtained. The cross correlation of the two dimensional inverse DFT of the phase component is also carried out. This is known as the PCF.

The distinct impulse of the PCF is used for matching. For two similar images, PCF gives the two sharp distinct peak and for two dissimilar images, PCF peak significantly drops. Extensive analysis is carried out for separate fingers and the right index finger is said to have the better performer.

L.Shen et al.[11] in his work, tried to find out the various way to improve the accuracy of the recognition by combining the multiple hand based biometrics and FKP. In this method first of all the gabor feature is extracted from the palm print image and then it is convolved with a group of wavelets of distinct frequencies, orientations and scales. A two bit code which represents the local feature of the image is defined. Similar process is adopted for FKP images also and fusion code is then derived.
Scores obtained from both the strategy are combined at the decision level. Similarity between the two subjects is determined by computing the hamming distance.

Y.Zhang in his paper titled "Hand-based single sample biometrics recognition"[28]

Offer another fusion based method which is obtained by fusing the two biometrics i.e middle inner surface of the finger and the palm print features. Statistical information and the structural information are used to derive the discriminant features of both the modalities.

Locality preserving projection (LPP) which is based on the wavelet transform are used to extract the features. This step reduces the effect of the affine transform. In order to improve the discriminant ability of high frequency sub-bands of the palm print, mean filtering is used for enhancing the structural information.

Both the features are fused at score level for recognition of the person.99.56% of accuracy is said to have obtained.

IV. CONCLUSION

Finger knuckle print being a new trait of biometrics, entered into a family of the biometrics few years ago. Finger knuckle print actually curved like line which are full of rich texture. These texture makes the finger knuckle as the unique features. All the previously designed image processing techniques that are used for the person identification biometrics, can also be used with the finger knuckle print and promising results are obtained by using these techniques. From the context of this paper it is clear that the fusion techniques, among all the techniques are reported to be high recognition rate.

From the discussion above it can be concluded that the finger knuckle print has very wide scope and it can be expanded to enhance the accuracy.

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