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Person Recognition Based on Knuckle Print Biometric Features Computed using Radon Transform

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Abstract— In this paper we have proposed a novel person identification system that uses knuckle print features extracted by using Radon transform. The knuckle print image has been viewed as a texture image. The local features from the knuckle print represent the texture information present in the image in better sense. Radon transform computes the line integral along parallel paths in a certain direction. In this paper line integrals of the knuckle print image have been computed at 60 different directions ranging from 0-180 degree with the interval of 3 degree. These feature vectors of size 256×60 have been used as the feature map. Knuckle print images from PolyU database have been used to test the performance of the proposed algorithm. Maximum recognition accuracy of 94.33% has been achieved with the algorithm for PolyU knuckle print images. Testing time required for matching of the query image with that of the stored images from the database is 0.76 sec shows that the algorithm is computationally efficient.

Keywords— knuckle prints, Radon transform, Euclidian distance..

I. INTRODUCTION

Biometrics helps to provide the identity of the user based on the physiological or behavioural characteristics of the person. Every biometric technology has its own merits as well as limitations. Thus, none of the existing biometric systems can be considered as the best for all the applications [1]. Different biometric identifiers are used for automatic recognition of personal identity. One of the well known biometrics systems having very high accuracy is iris based system [2]. But iris acquisition system is very expensive and has high failure to enrolment rate. Also it requires very high cooperation from user. Fingerprint based biometric systems are most widely and popularly used throughout the world because of its simplicity, low cost and good accuracy. Small amounts of dirt or grease on the finger may affect the performance of fingerprint based biometric system. Biometric systems based on hand geometry suffers from the fact that the sensors are of high cost and low accuracy. The ear based recognition has a problem of ear being partially or fully occluded due to hair or cap [3]. Face based recognition system is low cost requiring only a camera mounted in a suitable position such as the entrance of a physical access control area. However, face based systems are less acceptable than fingerprint based systems [4]. Amongst various types of biometric identifiers, hand based biometric is attracting considerable attention of the researchers. Recently, the finger-knuckle-print (FKP), which refers to the inherent patterns of the outer surface around the phalangeal joint of one's finger, is becoming highly unique and that can serve as a distinctive biometric identifier. An FKP image contains plentiful line-like textures. The texture in the outer finger surface especially in the area around the finger joint, are termed as FKP. Recognition of FKP [5], a micro texture in spatial domain provided by local binary pattern (LBP) and macro information in frequency domain acquired from the discrete cosine transform (DCT) is used to represent FKP image. Classification of two feature sets is done by using support vector machines. The main challenges biometric system faces are safety and they should provide confidentiality. For storing biometric templates securely and verification purposes the focus is on using this new biometric identifier FKP [6]. FKP recognition algorithm [7] used Band-Limited Phase-Only Correlation (BLPOC) based local block matching. 2D-DFT of images is obtained for extracting important information for image representation. Biometric authentication applications used phase-based image matching, BLPOC based matching for recognition. Matching score is calculated by correcting global and local distortions between FKP images using BLPOC-based local block matching. An efficient method based of FKP recognition [8] suggests extraction and assembly of local as well as global features of FKP. Local feature includes orientation information which is extracted using Gabor filters. It is clear from the studies of psychophysics and neurophysiology that local and global information are important aspects in image perception. Global features are nothing but Fourier transform coefficients of an image extracted from Fourier transformed image by increasing scale of Gabor filters. Linking of local and global features is done by using time-frequency analysis framework. For FKP verification both local and global information is used and global information is used for refinement of alignment of FKP images while matching. Weighted average of local as well as global matching distances is the final matching distance of two FKP's. Another technique for person identity authentication based on FKP

[9] developed data acquisition device for capturing FKP images and efficient algorithm for processing acquired images. Extracting a local convex direction map of FKP image on the basis of a coordinate system is defined for alignment of images and cropping ROI for extracting features is done. 2D Gabor filtering is done for extracting local orientation information from an image. Angular distance metric is used for measuring similarity between two competitive code maps. Development of FKP database and performance of proposed technique was examined with experimental results demonstrating efficiency and effectiveness of this biometric characteristic.

Recently, monogenic code [10] is developed for this distinct biometric identifier i.e. FKP. Monogenic signal theory is used for FKP recognition. Monogenic code is 3-bit vector obtained by binarization of monogenic signal which gives local phase and orientation information at each image pixel position. This method is most suitable for real-time applications as time required for extracting features is minimum and accuracy is also good as compared to other verification techniques.

II. BLOCK DIAGRAM OF SYSTEM

The personal identification system using knuckle prints operates in two modes namely enrolment phase and identification phase. During the enrolment phase, several knuckle prints of the persons obtained from the FKP scanner are passed to the system. The samples captured by knuckle print scanner are passed through pre-processing and feature extraction to produce the templates which are then stored in the database. In the identification/recognition mode, the query knuckle print image is passed to the system. These query knuckle prints are passed through pre-processing and feature extraction block. The extracted features from the query knuckle print are then compared with templates stored in the database in order to find the correct match. A distance measure is used to find the close match between the query knuckle print and the template imprints stored in the database.

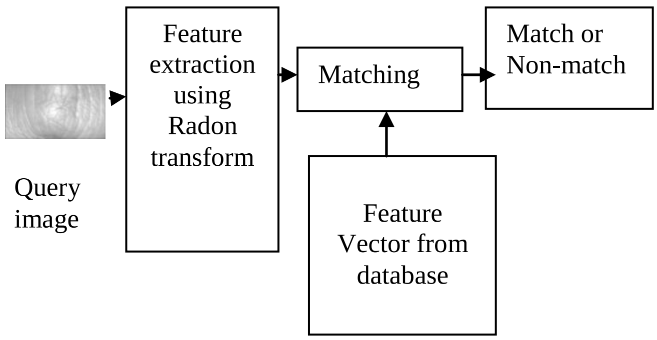

Figure.1 Block diagram of the knuckle print recognition system.

Block diagram of the knuckle print recognition system using Radon transform is as shown in Figure 1. It consists of five modules namely, finger knuckle print acquisition using FKP scanner, preprocessing like histogram equalization, feature extraction using Radon transform, matching using Euclidian distance and storage of the templates as the database.

III. FEATURE EXTRACTION

Line property of Radon transform

Radon transform [11] of a 2-D image $f(x, y)$, denoted as $P_\theta(t)$, is defined as its line integral along a line inclined at an angle θ from the y-axis and at a distance t from the origin (see Figure 2).

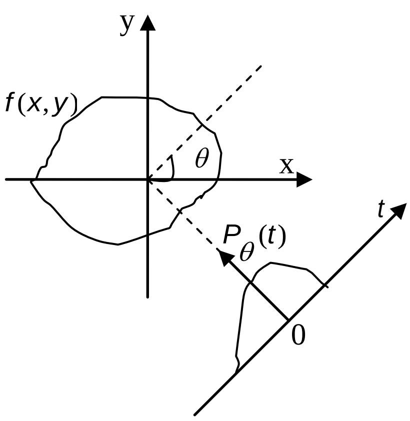

Figure.2 Radon transform $P_\theta(t)$ is the 1-D projection of $f(x, y)$ at an angle θ.

In other words $P_\theta(t)$ is the 1-D projection of $f(x,y)$ at an angle θ, and is given as

$$P_\theta(t) = \iint f(x,y)\,\delta(x\cos\theta + y\sin\theta - t)\,dxdy \qquad (1)$$

where,

δ is the dirac distribution.

The line property of Radon transform is an important property utilized for rotation estimation of the shapes in a knuckle print image. Radon transform assumes a function that contains line,
which is modeled with a delta function.

$$g(x,y) = \delta(y - p^* x - \tau^*) \qquad (2)$$

Hence, the function has non-zero values only if (x,y) lies on the line with certain fixed parameters (p^*, τ^*). In this case the Radon transform is given by

$$\check{g}(p,\tau) = \iint_{-\infty}^{\infty} \delta(y - p^* x - \tau)\,\delta(y - px - \tau)\,dxdy \qquad (3)$$

$$= \int_{-\infty}^{\infty} \delta((p - p^*)x + \tau - \tau^*)\,dx$$

$$= \begin{cases} \dfrac{1}{|p - p^*|} & \text{for } p \neq p^* \\ 0 & \text{for } p = p^* \text{ and } \tau \neq \tau^* \\ \int_{-\infty}^{\infty} \delta(0)\,dx & \text{for } p = p^* \text{ and } \tau = \tau^* \end{cases} \qquad (4)$$

Note that for $p = p^*$ and $\tau = \tau^*$, the result is written as infinite function integrated over an infinite interval, hence the result is infinite at that point. If the finite terms are neglected, Radon transform of a line produces a peak (with infinite value) in the parameter domain, and the position of the peak matches the line parameters. This property has the basis of edge feature detection in images, which is demonstrated in Figure 3.

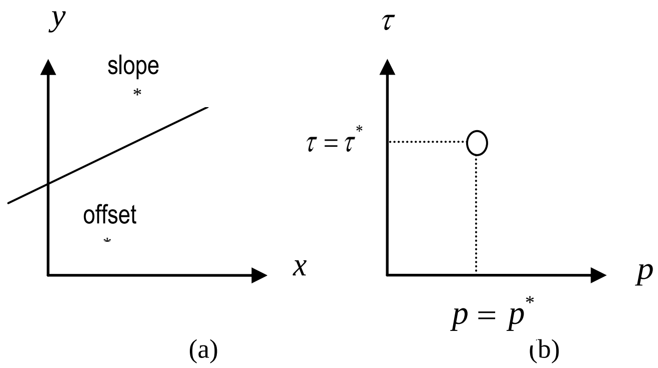

Figure 3 Line property (a) A 2-D function $g(x,y)$,

(b) Corresponding Radon transform $\check{g}(p,\tau)$.

Various steps involved in Radon transform based knuckle print feature extraction are as follows:

***Step* 1 Acquire the knuckle print image.**
***Step* 2 Preprocessing of the acquired knuckle print image.**
***Step* 3 Compute the Radon Transform to generate the feature vector.**

In this step we have extracted features of knuckle print using Radon transform. The local features extracted from the knuckle print represent the textural information present in the knuckle print image in better sense.
The Radon transform of a square integrable function $f(x_1, x_2)$ is defined as,

$$RA(t,\theta) = \int f(x_1, x_2)\delta(x_1 \cos\theta + x_2 \sin\theta - t)\, dx_1 dx_2 \qquad (5)$$

where, δ is the Dirac distribution.

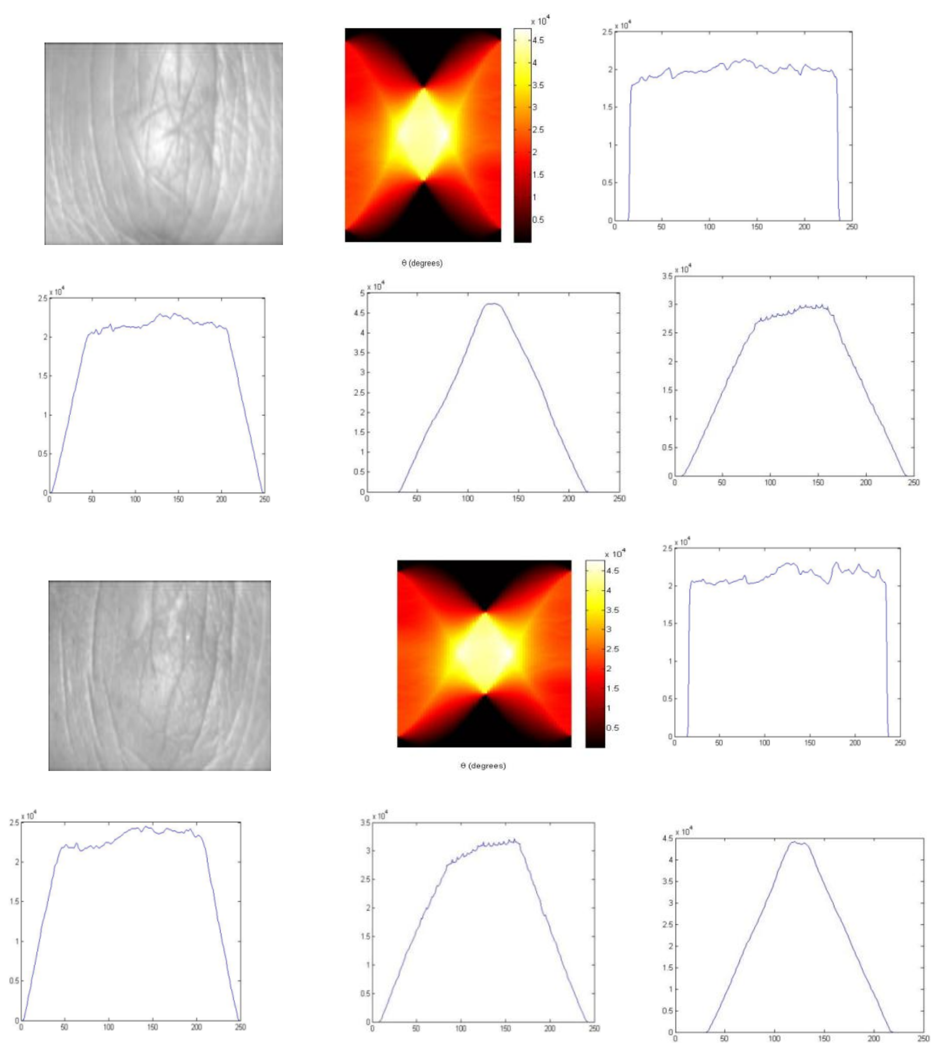

Figure 4 Radon projections at 0, 22.5, 45, 67.5 and 90 degree for two different knuckle prints and their respective hotplot.

Radon transform computes the line integral along parallel paths in a certain direction. In this work line integrals of the knuckle print image have been computed at 60 different directions. The 60 directions (orientations) from 0-180 degree with the interval of 3 degree have been selected empirically. Thus the feature vector size becomes 185×60 that has been used as the feature map. These feature maps are used to represent and match a query knuckle print image. Figure 4 illustrates the significant variation in Radon projections of two different knuckle print images at few sample orientations.

IV. RESULTS AND DISCIUSSIONS

The algorithm has been implemented and tested on Pentium-IV processor with 2.6 GHz, 512 MB RAM under MATLAB environment. The performance analysis of the algorithm has been evaluated using the knuckle print images from the standard PolyU database available on the Hongkong polytechnic website [12]. The Biometric Research Centre (UGC/CRC) at "The Hong Kong Polytechnic University" has developed a real time FKP capture device, and used it to construct a large-scale FKP database, which is freely available for academic, noncommercial uses. The FKP images were collected from 165 volunteers. The samples were collected in two separate sessions to generate 48 images from 4 fingers (left index finger, the left middle finger, the right index finger, and the right middle finger) were collected from each subject. The total database contains 7,920 images from 660 different fingers. For our experimentation purpose we have divided these images into equal halves in order to generate two datasets namely Set1 and Set2. Set1 is used for enrollment of the person in the database and Set2 is used for identification or verification of the person. Initially all the knuckle print images from Set1 with resolution of 256×512 with 256 grayscales are extracted and histogram equalization is carried out on all these images. Then Radon transformed images have been obtained from these localized knuckle print images from Set1. As the local features represent the texture information present in the knuckle print image in better sense, the Radon transformed knuckle print image is used as the feature map. The feature maps of all the knuckle print images have been stored in the database. When a query knuckle print image from Set2 is applied, its feature vector is generated and matched with the feature vectors available in the database. The Euclidian distance classifier has been used to find the minimum distance for the stored template image that best matches with the query image. Maximum recognition accuracy of 94.33% has been achieved with the algorithm for PolyU knuckle print images. Testing time required for matching of the query image with that of the stored images from the database is 0.76 sec shows that the algorithm is computationally efficient. Percentage FAR and GAR is plotted at various thresholds in Figure 5.

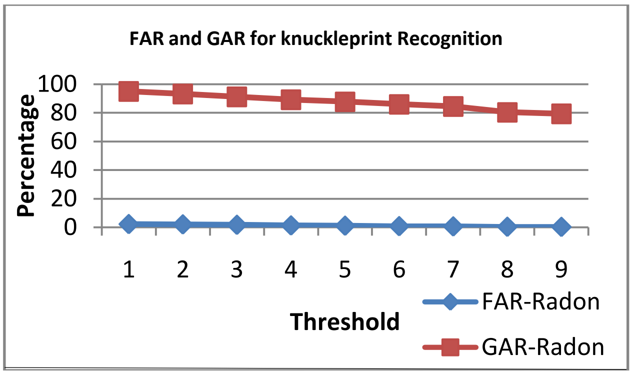

Figure 5 Percentage FAR and GAR plotted at various thresholds.

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