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Polar Harmonic Transform for Fingerprint Recognition

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ABSTRACT:- Fingerprint recognition refers to the automated methods of verifying a match between two fingerprints. Fingerprints are the most popular biometrics used to authenticate a person as it is unique and permanent throughout a person's life. Polar Harmonic Transforms (PHTs) are orthogonal rotation invariant 2D transforms that provide various numerically stable features for fingerprint recognition. The kernel functions of PHTs are basic waves and harmonic in nature which consists of sinusoidal functions that are inherently computation intensive that can be used to generate rotation invariant features. PHTs are characterized by low time complexity and numerical stability. In this project, Polar Harmonic Transforms (PHTs) are introduced for rotation invariance in thumb impression recognition, namely, Polar Complex Exponential Transform (PCET), Polar Cosine Transform (PCT), and Polar Sine Transform (PST). Orthogonal kernels of PHTs are more effective in terms of information compactness and minimal information redundancy. A fast approach of computation of Polar Harmonic Transform for thumb impression recognition with low values of FAR and FRR have been implemented.

Keywords:- Fingerprint, PHT, PCET, PCT, PST.

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I. INTRODUCTION

The increasing of society care to security threat has born new ways to protect software, hardware, building and even network system from outside party attacks. One of the security ways is by using biometric system. Such system use human body which always can be brought and not possible to leave it at home or loss during the trip. The technology becomes a popular identification and verification tool. Biometric fingerprint recognition systems are the most common used biometric technology due to their long tradition. Fingerprint identification systems have been developed for more than hundred years and the identification of person through their unique fingerprint. The pattern formed when the human still in obstetric [11], [12]. A fingerprint is a feature pattern on one finger that composed of many ridges and valleys as shown in Fig. 1. These ridges and valleys are the black and white portion of the fingerprint and present good similarities inn each small window, like parallelism and average width for a longtime. Today, among all the biometric techniques, the most widely used biometric identification form is fingerprint identification. It has been used in numerous applications. The problem is to develop algorithms which are rotation invariant in the fingerprints and are able to deliver accuracy in real time. There is a great variation in Fingerprint matching algorithms in terms of false positive and false negative errors. They may also vary with respect to features such as image rotation invariance and independence from a reference point given as the center or the core of the fingerprint pattern.

Fig. 1: A fingerprint image acquired by an Optical Sensor.

Fingerprint recognition is a complex pattern recognition problem. The real challenge is matching fingerprints is the high variability commonly found between different impressions of the same finger which is caused by factors like rotation between different acquisitions, skin conditions like dirt, cut etc. or noise of the sensor and so on. The vast majority of contemporary fingerprint authentication systems are feature extraction based i.e., minutiae based. Minutiae based systems generally rely on finding the correspondences between the minutia points present in query and reference fingerprint images. These systems normally perform with high quality fingerprint images. But using these methods, when the fingerprint is rotated at any angle, it will not detect the data authentication. So, Polar Harmonic Transforms is being implemented which help is recognizing the fingerprint at any of the angle rotated.

Fingerprintsareconsideredtobethebestandfastestmethodofbiometricidentification. They are secure to use, unique for every person and does not change in one's lifetime. Besides these, implementation of fingerprint recognition system is cheap, easy and accurate up to satisfiability. Fingerprint recognition has been widely used in both forensic and civilian applications. Compared with other biometric features, fingerprint based biometrics is the most proven technique and has the largest market shares. Not only it is faster than other techniques but also the energy consumption by such system is very less.

One of the main issue in fingerprint recognition that when the images is rotated at different angles the system is not able to match the fingerprint with the rotated fingerprint even when both the fingerprints are the same because when the image is rotated, the location of its features also get changed. The does not provide data authentication. So, the research objective of the thesis is to propose an algorithm using Polar Harmonic Transforms (PHTs) which helps in recognizing the fingerprint at any of the angle rotated.

Polar Harmonic Transforms (PHTs) are a set of 2D transforms which are based on a set of orthogonal projection bases, to generate a set of features which are invariant to rotation [1]. PHTs represent a set of transforms whose kernels are basic waves and harmonic in nature. PHTs consists of three different transforms, namely, Polar Complex Exponential Transform (PCET), Polar Cosine Transform (PCT) and Polar Sine Transform (PST). The PHTs are characterized by low-time complexity and numerical instability. The kernel functions of PHTs are orthogonal. Orthogonality of kernel means that an image is projected onto a set of pairwise orthogonal axes, and hence the classifier can be simple. The features based on orthogonal kernels are more effective in terms of information compactness and minimal information redundancy Owing to these characteristics, PHTs are well suited for various applications such as Fingerprint classification [5], Pattern recognition [4], Character recognition, Image reconstruction [2], etc.

Anjali R. et al [1] proposed two Polar Harmonic Transform (PHT) equations, Polar Complex Exponential Transform (PCET) and Polar Cosine Transform (PCT) in a rotatory two dimensional graphical plane for thumb pore identification and for rotation invariant image representation. YapP.T.et al [2] introduced a set of Polar Harmonic Transforms (PHTs), based on a set of orthogonal projection bases, to generate a set of features which are invariant to rotation. Liu M. et al [5] uses Polar Harmonic Transforms to produce a set of features rotation invariant fingerprint representation and show the use of PHTs the orientation fields of fingerprints to extract compact and rotation invariant use in fingerprint classification. Chander K. et al [8] provides an approach to speed up the fingerprint matching by classifying the fingerprint pattern into different groups at the time of enrollment and improves fingerprint matching while matching the input template with the stored template. In order to increase the computation speed, Yang Z. et al [3] proposed an efficient method of kernel computation based on relative prime number theory to compute PCT after analyzing the point distribution on two dimensional discrete space known as Fast Polar Cosine Transform (FPCT). Madhuri et al [6] proposes an efficient fingerprint recognition technique which is based on robust local features for fingerprint representation and matching. Manisha S. et al [7] proposed Rotation Invariant Template Matching for fingerprint identification, bio-medical imaging, remote sensing and feature tracking. Thai V. Hetal [9] presents a method for computation of polar harmonic transforms that is fast and efficient.

Rest of the paper as follows. Section II describe the proposed method for fingerprint recognition. Section III presents experimental results followed by conclusion in section IV.

II. PROPOSED METHODOLOGY

The proposed scheme is based on the Polar Harmonic Transforms (PHT). Any one image from the database is taken as the training image. Then, it is cropped into circle to reduce the number of pixels for a large image. Circle is generally formed to remove its edge, so that we can move the image at any angle during the training session and during the testing session. On applying PHT algorithm, it extract the features of the image. After this, a testing image is taken from the database. The image is rotated at desired angle and PHT algorithm is applied. Now, Euclidean distance is calculated between the training and the testing images. Then, the system shows if the fingerprint is matched. The False Acceptance Rate (FAR) and False Rejection Rate (FRR) is also calculated. Lower the FAR and FRR values, more accurate is the result.

This section describes the algorithm proposed for the implementation of rotational invariant fingerprint recognition using Polar Harmonic Transform.

1. Load a fingerprint image from the database.
2. Resize the image to reduce pixels(for large images), say 150∗150 pixels
3. Crop the image to get region of interest
4. Apply PHT on the fingerprint image
5. Extract features of the cropped image
6. Apply histogram, h1 and save the image(A)
7. Take a cropped image from step(2)
8. Rotate the image at specific angles
9. Again apply PHT on the cropped image
10. Apply histogram, h2 and save the new image(B)
11. Calculate Euclidean Distance(ED) between the two images i.e., image(A) and image(B) as: $ED(h1, h2) = \sqrt{mean(h1 - h2)^2}$ (1)
12. Loop through step 8 to 11 to calculate ED at various rotated angles
13. Fingerprint Matching: If ED≤1 i.e., set threshold value, then, the result is matched else, not matched.
14. Repeat steps 1–13 using PHT

Lower the value of Euclidean Distance, more accurately matched the image. Fig. 2 shows Block diagram of Fingerprint Matching System.

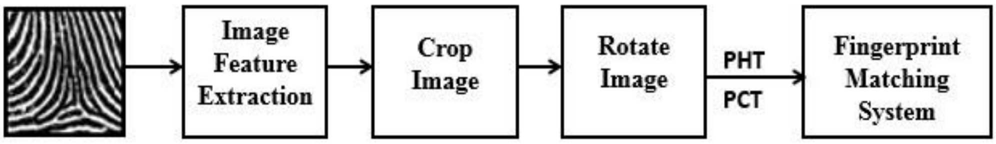

Fig. 2: Block diagram of Fingerprint Matching System.

III. EXPERIMENTAL RESULTS

The evaluation and testing of the proposed approach has been done on CASIA database. This database consists of 100 different fingerprint images. From an image database, each test image is rotated by various angles and is matched against the original image to compute the False Rejection Rate [6], [10]. So, False Rejection Rate (FRR) is the ratio of the number of false rejections divided by the number of identification attempts. FRR is also known as False NonMatch Rate or Type I error. FRR is the fraction of genuine fingerprints which are rejected.

$$FRR = \frac{Number\ of\ genuine\ fingerprints\ rejected}{Total\ number\ of\ genuine\ tests} \quad (2)$$

Again from an image database, each test image is rotated by various angles and is matched against the original image to compute the False Acceptance Rate [6], [10]. So, False Acceptance Rate (FAR) is the ratio of the number of false acceptances divided by the number of identification attempts. FAR is also known as NonMatch Rate or Type II error. The FAR is the fraction of imposter fingerprints which are accepted.

$$FAR = \frac{Number\ of\ imposter\ fingerprints\ accepted}{Total\ number\ of\ imposter\ tests} \quad (3)$$

FAR and FRR are very much dependent on the biometric factor that is used and on the technical implementation of the biometric solution. Furthermore, the FRR is strongly person dependent, a personal FRR can be determined for each individual. Also, FRR might increase due to environmental conditions or incorrect use, for example when using dirty fingers on a finger print reader. Mostly the FRR lowers when a user gains more experience in how to use the biometric device or software. FAR and FRR are key metrics for biometric solutions for, some biometric devices or software even allow to tune them so that the system more quickly matches or rejects.

From the database images, only one image is considered the training image with testing images being hundred. The training image is matched with the hundred testing images. Fig. 3 shows that, for a training image number 11, with the angle of rotation 100, the number of matched images are 13 and non-matched images are

87. Fig. 4 shows FAR and FRR for test images for training image 4 at rotation angle of 100. From the parameters calculated (Table I) for the testing images at different angles of rotation, Table II shows the angle of rotation with the accuracy for some of the angles. The accuracy shown in Fig. 5 is high and different for different angles of rotation and the training image.

Table I: Parameter results of PHT applied on test images with training image 11.

Angels of rotation	Parameters									
	Euclidean Distance (ED)								FAR	FRR
	ED_1	ED_2	ED_3	ED_4	ED_5	ED_6	ED_7	ED_8		
10	389.61	388.79	1.50	339.58	390.94	388.64	393.94	391.82	2	0
20	388.20	337.82	2.20	340.29	390.49	388.55	392.97	389.17	2	0
30	390.76	341.26	9.01	337.99	391.64	389.79	394.56	392.53	2	0
40	390.14	337.90	5.48	345.51	391.38	390.05	395.89	391.11	2	0
50	391.11	338.96	0.17	342.50	391.91	389.70	394.91	392.09	2	0
60	387.75	337.82	2.03	336.31	390.76	387.49	392.53	390.14	1.74	0.26
70	388.82	337.28	0.26	336.75	390.76	387.49	392.53	390.09	1.74	0.26
80	387.93	337.64	0.70	335.96	389.70	387.14	392.70	389.17	1.74	0.26
90	389.96	339.14	1.67	338.61	390.85	389.43	394.83	392.35	2	0
100	389.26	338.79	1.85	335.52	390.94	388.11	394.03	388.11	2	0
110	388.20	338.43	3.97	333.48	389.79	388.02	393.50	388.82	2	0
120	389.61	340.20	0.17	338.88	391.56	389.26	393.77	391.91	1.74	0.26
130	390.41	341.53	1.94	339.85	391.64	391.03	395.27	391.11	2	0
140	391.73	338.70	0.17	340.64	391.47	391.56	396.68	329.35	1.74	0.26
150	389.52	338.52	1.59	336.67	392.44	387.14	392.79	391.47	2	0
160	389.79	337.82	0.88	339.58	391.64	391.64	393.85	390.94	1.74	0.26
170	390.32	336.05	0.70	337.20	391.91	390.67	393.21	391.73	1.74	0.26
180	389.43	337.64	5.48	337.46	391.56	387.40	393.41	390.67	2	0

Table II: Performance in presence of rotation for training image 11.

Angle of Rotation	Accuracy in %age
80	86.66
100	86.66
120	86.66
170	86.66

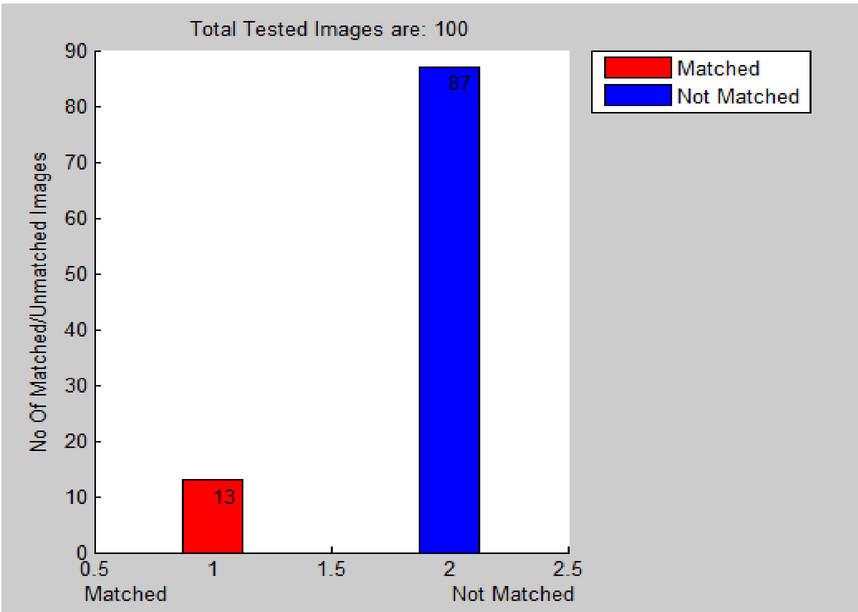

Fig.3: Matched and Unmatched Image score distribution for training image 11 at rotation angle of 100.

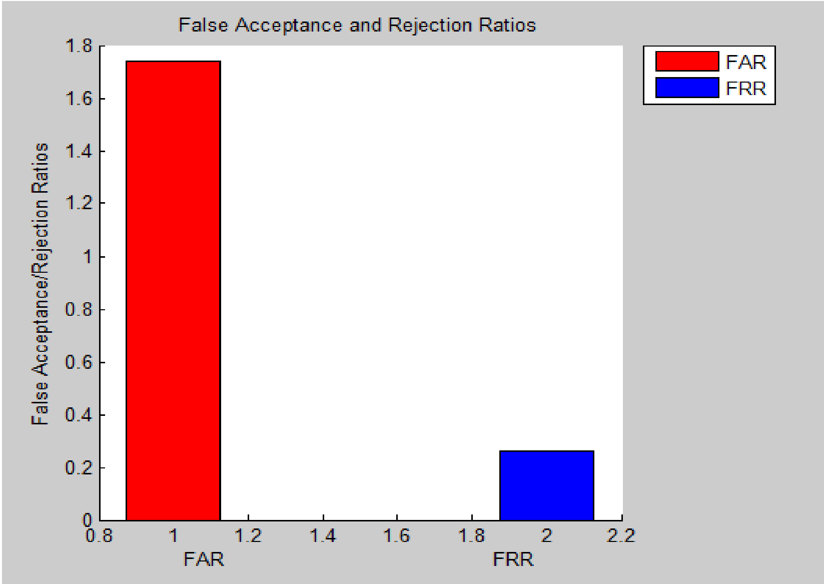

Fig.4: FAR and FRR for test images for training image 11 at rotation angle of 100.

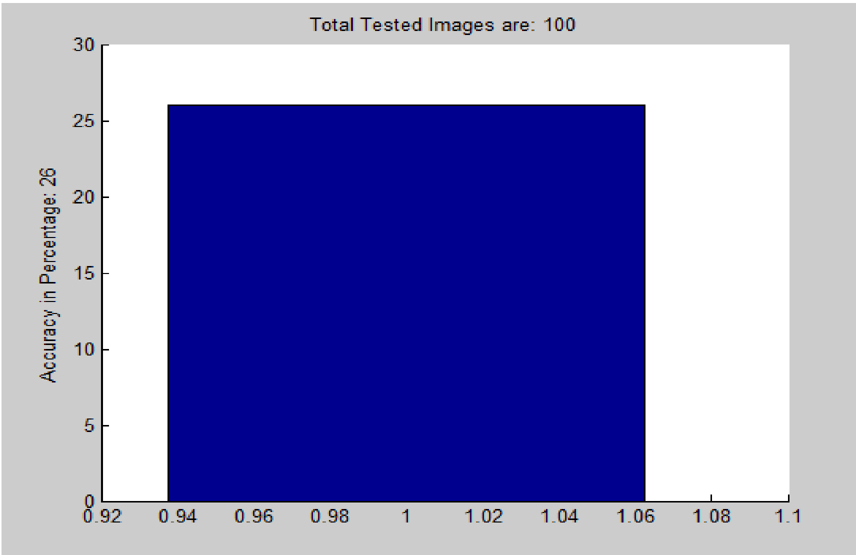

Fig.5: Graph shows the accuracy percentage of matched images for training image 11 at rotation angle 100.

IV. CONCLUSIONS

A new fingerprint recognition system which uses image as the feature has been proposed in this thesis. A set of Polar Harmonic Transforms (PHTs), namely, Polar Cosine Exponential Transform, Polar Cosine Transform and Polar Sine Transform, have been proposed to generate rotation invariant features for fingerprint identification. The kernel function of PHTs consists of sinusoidal function that are inherently computation intensive which is used to generate rotation invariant features. The result obtained shows both matched and unmatched images of the database system irrespective of the angle of rotation both with low values of FAR and FRR which shows that the probability of errors is the least. A large set of database images are tested with training images and at various angles of rotation and the images are matched based on the Euclidean distance. The Euclidean Distance achieved is different for different images and for matched images, its value it either equal or less than the set threshold value i.e., 1. The accuracy of matched images for different images at different angle is high. Lower the Euclidean Distance and less number of matched images, the more accurate is the system. Polar Harmonic Transforms are very fast and efficient, providing high performance based on the number of fingerprints present in the database.

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