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Implementation and Comparative Analysis of Rotation Invariance Techniques in Fingerprint Recognition

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Abstract: Years ago, many algorithms are published for fingerprint recognition and these algorithms has different accuracy rate. This paper deals with the study of the existing fingerprint recognition algorithms in order to improve the performance of the proposed fingerprint algorithm to develop an efficient novel system.

We proposed a system which uses various rotation invariance techniques such as PHT, PST, PCT and we have implemented these equations studied the comparative analysis on the basis of various parameters. The output results indicate a significant improvement of the fingerprint recognition pattern.

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Keywords: Rotation Invariance, Polar Harmonic Transform, PCT, PST

I. Introduction

The term biometric comes from the Greek words bios (life) and metrikos (measure). It is well known that humans intuitively use some body characteristics such as face, eyes, hand, finger, iris, gait, or voice to recognize each other. Since, today, a wide variety of applications require reliable verification schemes to confirm the identity of an individual, recognizing humans based on their body characteristics became more interesting in emerging technologies and applications. Traditionally, passwords and ID cards have been used to restrict access to secure systems but these methods can easily be breached and are unreliable. Biometric cannot be borrowed, stolen, or forgotten, and forging one is practically impossible.

A biometric system is essentially a pattern-recognition system that recognizes a person based on a feature vector derived from a specific physiological or behavioral characteristic that the person possesses.

That feature vector is usually stored in a database after being extracted. A biometric system based on a physiological characteristics is generally more reliable than one which adopts behavioral characteristics, even if the latter may be more easy to integrate within certain specific applications.

Biometric system can than operate in two modes: verification or identification. While identification involves comparing the acquired biometric information against templates corresponding to all users in the database, verification involves comparison with only those templates corresponding to the claimed identity. This implies that identification and verification are two problems that should be dealt with separately [1]. Fingerprint is one of the famous used for personal identification.

II. What is Fingerprint Recognition

A fingerprint is the feature pattern of one finger (Figure 1.1). It is an impression of the friction ridges and furrows on all parts of a finger. These ridges and furrows present good similarities in each small local window, like parallelism and average width.

Figure 1.1 Fingerprint image from a sensor

However, shown by intensive research on fingerprint recognition, fingerprints are not distinguished by their ridges and furrows, but by features called Minutia, which are some abnormal points on the ridges (Figure 1.2). Among the variety of minutia types reported in literatures, two are mostly significant and in heavy usage:

- Ridge ending - the abrupt end of a ridge
- Ridge bifurcation - a single ridge that divides into two ridges

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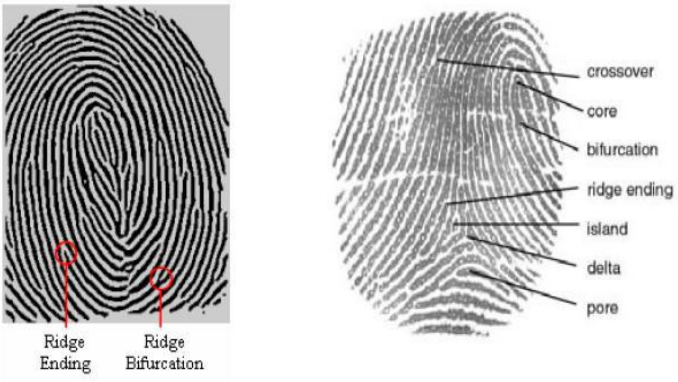

(a) (b)

Figure 1.2 (a) Two Important Minutiae Features (b) Other Important Features

Fingerprint recognition (sometimes referred to as dactyloscopy) is the process of comparing questioned and known fingerprint against another fingerprint to determine if the impressions are from the same finger or palm. It includes two sub-domains: one is fingerprint verification and the other is fingerprint identification [2].

III. Transforms Used in Proposed Model

Rotation invariant moments and transforms are such processes, which successfully deal with these situations. There are two types of rotation invariant moments and transforms: orthogonal and non orthogonal.

The orthogonal rotation invariant moments (ORIMs) and orthogonal rotation invariant transforms (ORITs) are more effective in performance because they have minimum information redundancy and hence better information compactness. A few low order moments and transforms are sufficient to capture the essential features of an image.

Among the ORIMs Zernike moments (ZMs), pseudo Zernike moments (PZMs) and orthogonal Fourier Mellin moments (OFMMs) are the most popular.

The ORITs that were introduced recently by Yap et al. [3] include the polar complex exponential transforms (PCET), polar cosine transforms (PCT) and polar sine transforms (PST). These transforms are collectively known as PHTs. The difference between ORIMs and ORITs is that the radial parts of the kernel functions in ORIMs are polynomials and in ORITs these are sinusoidal functions.

The PHTs are preferred to ORIMs because PHTs are computationally very fast [4] and the high order transforms are numerically stable, where as the ORIMs are less efficient and high order moments are numerically unstable. Because of their attractive features, PHTs have recently been used in many image processing applications.

Liu et al. [5] observed that PHTs-based features yield results comparable to state-of-art methods for fingerprint classification.

An extensive evaluation of invariance property of PHTs for image representation in terms of rotation, scale and noise has been conducted by Li et al. [6]. The authors observed that the ORITs are more suitable than ORIMs for applications, which require many features. The results are compared with ZMs and PZMs, and it is observed that the performance of PHTs is better than that of ZMs and PZMs.

Recently, Miao, et al. [7] have applied PHTs on Radon images for object recognition. They have also compared their results with that obtained by ZMs, OFFMs and Radial Fourier Mellin moments. Through the theoretical analysis and experimental results, it is observed that the performance of PHTs for image description is much better than the three moments especially under noisy conditions.

In this paper, we propose a method for the fast computation of the PHTs by developing recursive relations for the radial and angular parts of the kernel functions of the transform. An 8-way symmetry/anti-symmetry property is used to enhance the speed of the algorithm.

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Earlier only fingerprint matching was done but in this paper we have proposed a model which proves the rotation invariancy of fingerprints.

We have also studied the comparative analysis on these Rotational Invariant Techniques on basis of False Matching Ratio (FMR), False Rejection Ratio (FRR) or False Non-Matching Ratio (FNMR) and Accuracy.

❖ Polar Harmonic Transforms

Polar harmonic transforms consist of the polar complex exponential transform (PCET), PCT and PST [3].

They have identical mathematical representation with a difference in the radial part of the kernel function. Let

$f(r,\theta)$ be a continuous image function defined on a unit disk

$D=\{(r,\theta)\ 0 \le r \le 1, 0 \le \theta \le 2\pi\}$. The PHTs of order n and repetition m are defined by

$$A_{nm} = \lambda \int_0^{2\pi} \int_0^1 f(r,\theta)\, V^*_{nm}(r,\theta) r d\, r d\theta \qquad (1)$$

where n, m = 0, ±1, ±2,.... . The kernel function $V^*_{nm}\ (r,\theta)$ is the complex conjugate of the function $V_{nm}\ (r,\theta)$ determined by

$$V_{nm}(r,\theta) = R_n(r) e^{jm\theta} \qquad (2)$$

With $j = \sqrt{-1}$. The radial part of the kernel function and parameter λ are expressed as:

$$\text{PCET}: R_n(r) = e^{j2\pi n r^2}, \quad \lambda = \frac{1}{\pi} \qquad (3)$$

$$\text{PCT and PST}: R_n(r) = \begin{cases} Cos\,(\pi n r^2)\ , for\ PCT \\ Sin(\pi n r^2)\ ,\ for\ PST \end{cases}$$

(4)

$$\lambda = \begin{cases} \frac{1}{\pi}\ ,\ n = 0 \\ \frac{2}{\pi}\ ,\ n \neq 0 \end{cases} \qquad (5)$$

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IV. Model

A. Definitions

(a) **False Acceptance Rate (FAR):** It is defined as the fraction of candidates falsely accepted by a biometric system. Low value of FAR shows that the biometric system can efficiently capture the inter-class variability through its feature representation and matching. FAR which is also sometime referred as False Match Rate (FMR), is given by

$$FAR = \frac{Number\ \ of\ Imposter\ \ Accepted\ \ \times 100}{Total\ \ No.of\ Imposter\ \ comparison} \%$$

(b) **False Rejection Rate (FRR):** It represents the fraction of candidates falsely rejected by a biometric system.). Low value of FRR shows that the system can capture intra-class variations efficiently through its feature representation technique and matching. Thus, FRR is given by

$$FRR = \frac{No.Of\ Genuine\ \ Persons\ \ rejected\ \ \times 100}{Total\ \ No.of\ Genuine\ \ comparison} \%$$

B Proposed Model

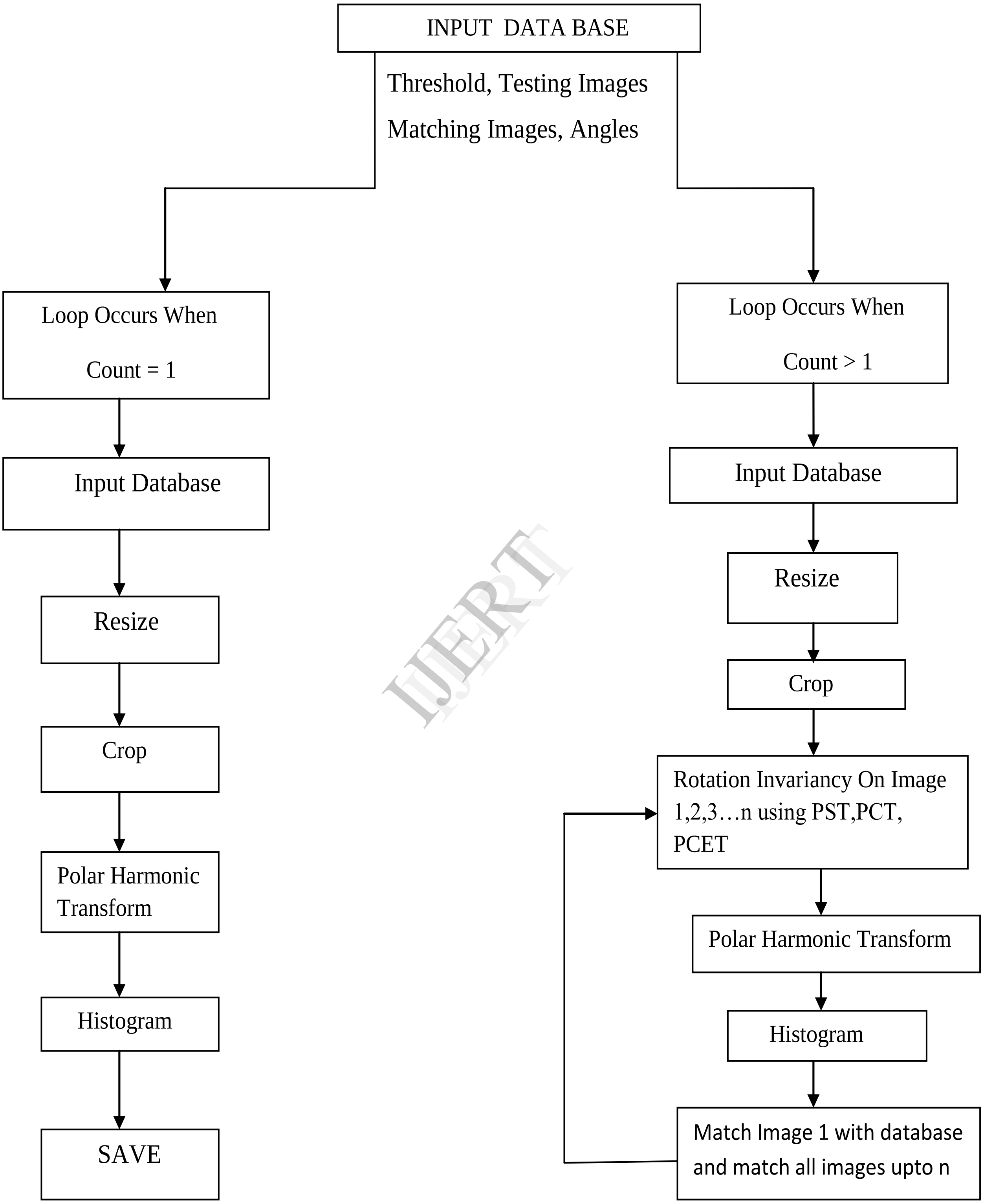

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Figure 1.3 Framework Of the Proposed Model

V. Performance Analysis And Results

Following Table1: Shows the False Acceptance Rate (FAR) and False Rejection Rate (FRR) at different Threshold values. The values in this table are obtained using first rotation Invarint technique known as Polar Sine Transform (PST) which varies at different angles (eg: 30,45, 60,90)

Table1: RESULT ANALYSIS (PST)

	Threshold 1	Threshold 2	Threshold 3	Threshold 4
Threshold	1	2	3	4
False Accept	0	3	1	0
False Accept %	0%	58.3%	58.3%	50%
False Reject	0	3	1	0
False Reject %	100%	41.6%	41%	50%
Accuracy	0%	175%	87.5%	100%

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Following Table 2: Shows the False Acceptance Rate (FAR) and False Rejection Rate (FRR) at different Threshold values. This values in this table are obtained using first rotation Invarint technique known as Polar Cosine Transform (PCT) which varies at different angles (eg: 30, 45, 60, 90)

Table 2: RESULT ANALYSIS (PCT)

	Threshold 1	Threshold 2	Threshold 3	Threshold 4
Threshold	1	2	3	4
False Accept	8	3	1	0
False Accept %	50%	41.6%	75%	0%
False Reject	8	3	1	0
False Reject %	66.6%	58.3%	25%	100%
Accuracy	33.3%	62.5%	112.5%	0%

Following Table 3: Shows the False Acceptance Rate (FAR) and False Rejection Rate (FRR) at different Threshold values. This values in this table are obtained using first rotation Invarint technique known as Polar Cosine exponential Transform (PCET) which varies at different angles (eg: 60, 90, 120,145)

Table 3: RESULT ANALYSIS (PCET)

	Threshold 1	Threshold 2	Threshold 3	Threshold 4
Threshold	5	4	6	3
False Accept	0	2	0	0
False Accept %	100%	83.3%	66.6%	33.3%
False Reject	0	2	0	0
False Reject %	0%	16.6%	33.3%	66.6%
Accuracy	100 %	125%	100%	100%

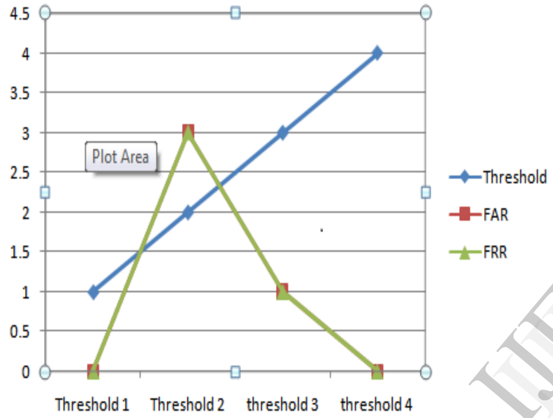

Figure 1.4 (a)

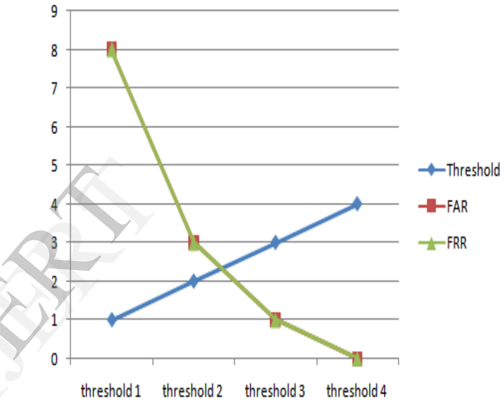

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Figure 1.4 (b)

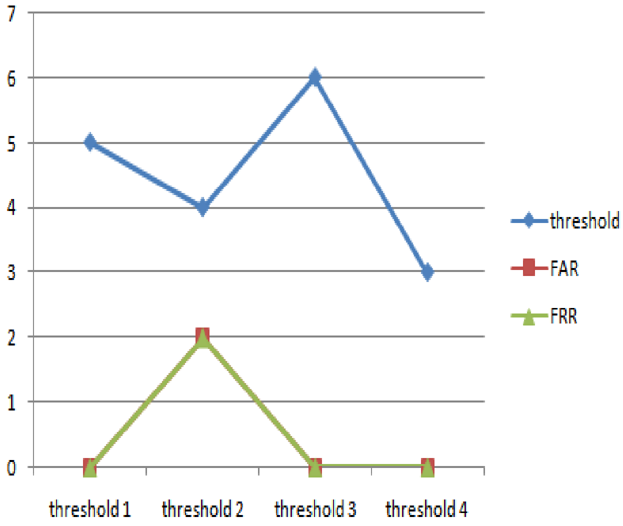

Figure 1.4 (C)

Figure 1.4 (a), (b), (c) Shows FAR & FRR vs. Threshold On basis Of PST, PCT, PCET

VI. Conclusion and Future Work

In this paper, we have presented rotation invariancy in fingerprints which is basically obtained from rotation invariant techniques i.e PHT and analyzed all the techniques or algorithms of PHT i.e PST, PCT, PCET. A fast method is developed in this paper for the calculation of PHTs.the comparison is made among all these three techniques varying the threshold values and obtaining FAR and FRR by rotating images at different angles as shown in results. This shows that the proposed method is suitable for applications where PHT coefficients are used as features in real-time environment involving large databases or on devices with low computation power

In future these techniques can be used with Support Vector Machnies (SVM) so that it can provide better results.

VII. References

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