# Efficient Fingerprint Verification System Using Cancelable Template

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## Abstract

*Fingerprint based verification system is widely used for verification of person's identity. Since fingerprints cannot be changed, once they are lost it is not possible to change, they are compromised forever, so the proposed cancelable templates for the transformation of the biometric are used and we use that transformation for verification. In the fingerprint based system, minutiae are considered the main features of the fingerprint. The minutiae are extracted and then the transformation is applied on the minutiae, these transformation are non-invertible transformations, so that the fingerprint templates are irreversible, so these transformations can be used to revoke and replace whenever the fingerprints are compromised.*

*Keywords - Fingerprint Verification, Minutiae Extraction, Cancelable Template, Transformation, Matching*

## 1. Introduction

A fingerprint is the pattern of ridge endings and ridge bifurcations. A fingerprint is thus defined by the uniqueness of the local ridge characteristics and their relationships. Minutiae points are these local ridge characteristics that occur either at a ridge ending or a ridge bifurcation. A ridge ending is defined as the point where the ridge ends abruptly and the ridge bifurcation is the point where the ridge splits into two or more branches. Minutiae points are considered the main features of the fingerprint templates.

Fingerprint based verification has been one of the most successful biometric techniques used for personal identification. Fingerprint based verification systems offer several advantages over traditional methods like password and token based verification system. Fingerprints are unique and available only to the individual. It enhances user's convenience by alleviating the need to memorize long and random passwords. Fingerprints are associated with the user and cannot be stolen. As well as advantages there are few concerns associated with fingerprints, if a fingerprint is compromised it is lost forever and possibly for every application associated with it. Hence, it is required to protect the fingerprint template for secrecy of the biometric information and the stored template information should be different for each database or application so that cross matching is avoided and it can be renewed when compromised.

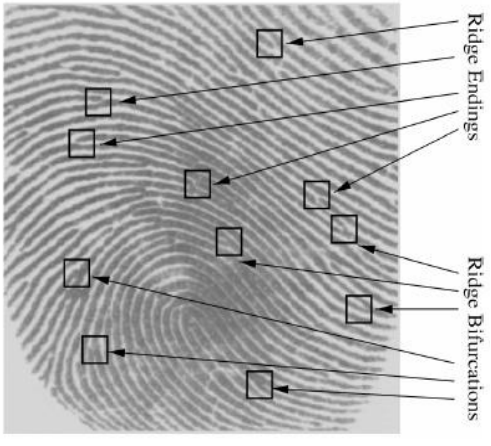


**Fig. 1 Ridge Endings and Ridge Bifurcations**

Cancelable template is used for privacy protection of the fingerprint, once the main feature of the fingerprint, minutiae are extracted, these minutiae points are transformed and made non invertible so that they are irreversible. These transformed templates are stored and these transformed templates are used for matching for person's identity or verification.

In this paper, we propose the one way transformation of the fingerprint distortedly to secure the template. The rest of the paper is organised as follows. Section 2 introduces the related work on the cancelable biometrics, section 3, the proposed non invertible transformation is described and finally section 4 gives the conclusion.

## 2. Related Work

Ratha at al. [1] reported and described the problems in biometrics and designed three non-invertible transformations. In these transformations one way function is designed such that the biometric image is

modified into a new form. The three transformations are Cartesian, Polar and functional transformations.

### 2.1. Cartesian Transformation

In the Cartesian transformation, the fingerprint minutiae space is measured into rectangular coordinate with reference to the positions of the singular points. This coordinate system is divided to fixed cell size. The cells are numbered in a sequence. Each cell contains some minutiae points, in this transformation minutiae cell positions are changed for non- invertibility. Figure 2 shows, the transformed version does not match the original version of the fingerprint minutiae positions since the minutiae cell positions are displaced randomly for non-invertibility. The cell mapping in the transformation is governed by a mapping matrix where many cells can be mapped into one cell.

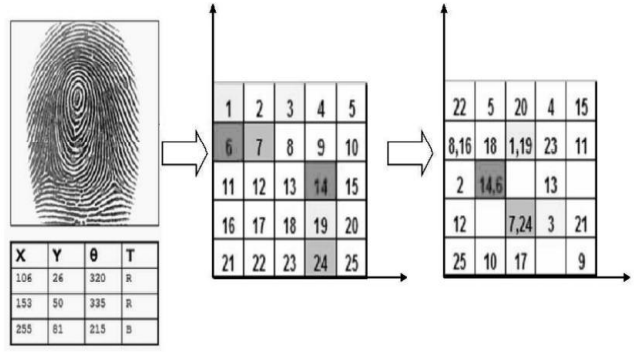


**Fig. 2 Cartesian Transformation** (adopted from Ratha et al. PAMI, 2007)

### 2.2. Polar Transformation

Polar transformation is similar to Cartesian transformation, instead of rectangular cells the cells are measured into polar sectors. The minutiae positions are measured in polar coordinates with reference to the core position. The angles are measured with reference to the orientation of the core. The coordinate space is now divided into polar sectors that are numbered in a sequence (see Fig. 3). The process of transformation now consists of changing the sector positions. The minutiae angles also change in accordance to the difference in the sector positions before and after transformation.

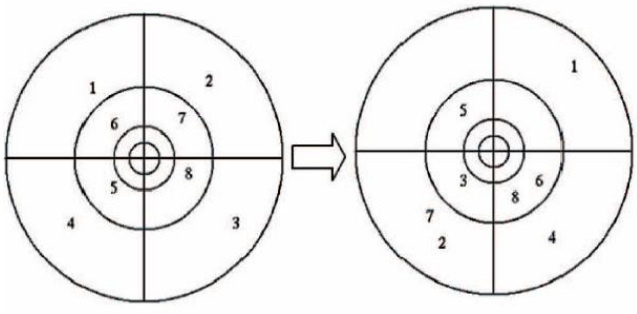


**Fig. 3 Polar Transformation** (adopted from Ratha et al. PAMI, 2007)

### 2.3. Surface Folding Transformation

In surface folding transformation, a mixture of 2D Gaussians and 2D electric potential field random charge distributions are used to transform the minutiae points. Since the transformations used in the mixture are locally smooth, this will only have a minimal effect on the error rates and will not reduce the discriminability of minutiae to any large extent when compared to the previous two transforms. As a small change in minutiae position of the original fingerprint can lead to a large change after transformation especially if the point crosses a sharp boundary, proper pre-alignment with reference to the position of the core point is required to make sure that the fingerprint minutiae is transformed consistently across multiple instances of minutiae.

As shown in the fig. 4, in surface folding transformation both the position and the orientation of the minutiae are changed by some parametric transfer function. Conceptually, the minutiae are embedded in a sheet which is then crumpled. This function is locally smooth but globally not smooth.

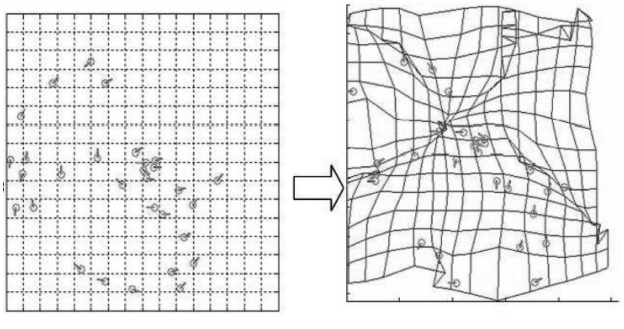

**Fig. 4 Functional Transformation** (adopted from Ratha et al. PAMI, 2007)

## 3. The Proposed Method

In this section, the technique has been proposed to improve the security of the biometric systems which are based on cancelable biometrics. We introduce the method by performing the minutiae extraction so that the fingerprint features are extracted and these minutiae point locations are distorted by transforming fingerprint minutiae and performing matching in the transformed form. The transform is application dependent, meaning that the templates cannot be reused by other applications. The method can be described in the following steps.

### 3.1. Minutiae Extraction

The first step in the method is the extraction of minutiae. The minutiae points are extracted as follows. The image is binarised, and then the skeleton of the image is formed (Fig. 5).

**Fig. 5 Binnarized Image**

The binary image is thinned (Fig. 6) as a result of which a ridge is only one pixel wide, then a smaller region of the fingerprint is taken and in this small region minutiae points are located. The minutiae points are those which have a pixel value of one (ridge ending) as their neighbour or more than two ones (ridge bifurcations) in their neighbourhood. Shown in Fig. 7 is the smaller region selected with minutiae points.

This ends the process of extraction of minutiae points. The fingerprint features of the original template are extracted.

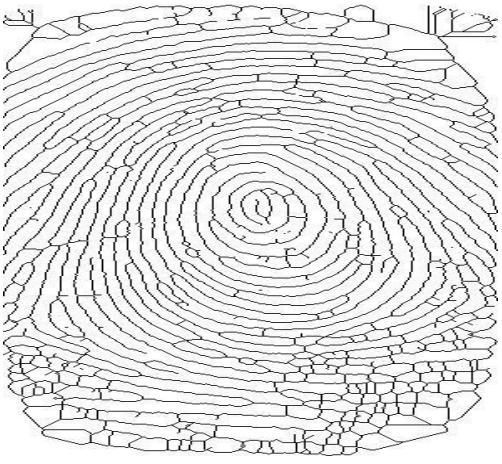

**Fig. 6 Thinned Image**

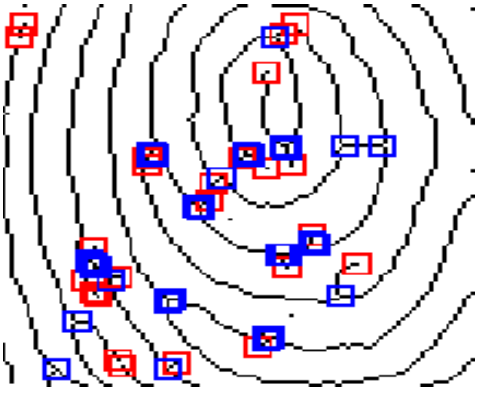

**Fig. 7 Minutiae points**

### 3.2. Non-Invertible Transformation

The one way transformation is performed on the original minutiae template of the fingerprint so the inverse of the transformation is not possible. In our proposed system, x and y co-ordinate positions of the minutiae are changed, we randomly generate the new co-ordinates of the minutiae points, this transforms the minutiae points into new positions and to make the transformation non-invertible, 10% of the rows and columns of the image matrix are made identical.

For an example, if the image is 255X255 matrix, random numbers between 1 to 255 are generated and few of them are made identical for non invertibility. Same is done for x and y positions.

Since we changed minutiae positions and few of them are identical inverse of the matrix is not possible, hence achieving cancelable template. The proposed method of non-invertible transformation is easy to

implement and can be changed with each application or whenever necessary.

### 3.3. Matching

The final step in the proposed method is matching where the transformed templates are compared, in our method we initialize the minutiae count to zero and count increases by one if the x and y co-ordinates positions matches, these co-ordinates are of ridges and bifurcations of the original and query fingerprint. If the minutiae count value is greater than 90% of the original minutiae point, then it is a match.

## 4. Experimental Analysis

The database PolyU HRF DB II [9] is used for our test. It consists of 168 different users and each user has 10 fingerprint images. We used MATLAB 7.9 on Windows operating system.

In the case of compromised fingerprint in the database, we should be able to cancel the fingerprint template and assure diversity, by transforming into new fingerprint template. The transformed template will be distant compared to its previous template. When comparison is performed between different fingerprint templates, they are 90% accurate.

The block diagram of the proposed method is as shown in Figure 8.

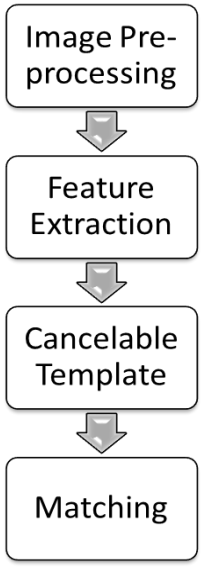


**Fig. 8 Block diagram of the proposed method**

## 5. Conclusions

While Biometrics are more advantageous over password and token based security system, security and privacy of the biometric becomes a concern since once lost means they are compromised forever, we addressed the solution for the security and privacy by cancelable biometric wherein we use the transformed template so that original template is secured, even compromised we can change the transformation function and increase the security of the biometric, this is non-invertible wherein original template is never recovered from the transformed template.

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