

A Novel Approach To Classification Based FingerPrint Verification System

Shailendra Patel, Ananya Bhattacharya, Pankaj Kumar

Abstract— Fingerprints are the most oftenly used biometric feature for a person credentials and verification in the field of biometric identification. Fingerprints possess two main types of features that are used for automatic fingerprint identification and verification. First is the Ridge and Furrow structure that forms a special pattern in the central region of the fingerprint and second is the Minutiae details which is associated with the local ridge and furrow structure. In this paper, we have concentrated our implementation on Minutiae based method followed by the discussion about the implementation of a minutiae based matching technique. This approach has been intensively studied, and also is the backbone of the current available fingerprint recognition products. In particular we are interested only in two of the most important minutia features i.e. Ridge Ending and Ridge bifurcation. In a traditional biometric recognition system, the biometric template is usually stored on a central server during enrollment. The candidate biometric template captured by the biometric device is sent to the server where the processing and matching steps are performed. This paper presents an approach to speed up the matching process by classifying the fingerprint pattern into different groups at the time of enrollment, and improves fingerprint matching while matching the input template with stored template. To solve the problem, we take several aspects into consideration like classification of fingerprint, singular points etc. The algorithm result indicates that this approach manages to speed up the matching effectively, and therefore proves to be suitable for large database like forensic divisions.

Index Terms— Biometrics, Identification, Minutiae points, Ridge ending and Bifurcation, Singular points, Verification.

1 INTRODUCTION

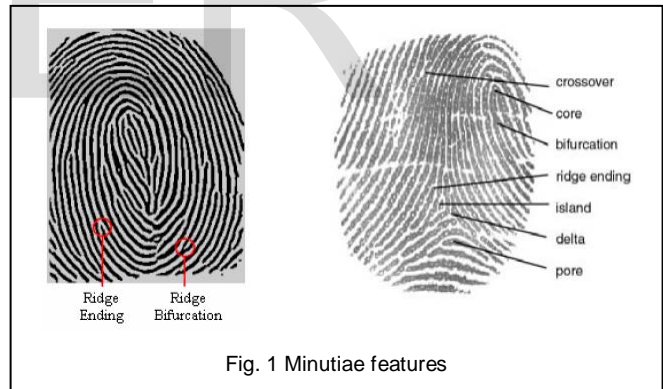
Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify an individual and verify their identity. Because of their uniqueness and consistency over time, fingerprints have been used for over a century, more recently becoming automated (i.e. a biometric) due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition, the numerous sources (ten fingers) available for collection, and their established use by law enforcement and immigration.

1.1 Fingerprint

A fingerprint is the feature pattern of one finger. 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.

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. Among the variety of minutia types reported in literature, two are mostly significant and in heavy usage:

- Ridge ending - the abrupt end of a ridge
- Ridge bifurcation - a single ridge that divides into 2 ridges



1.2 Fingerprint Matching Techniques

The large number of approaches to fingerprint matching can be coarsely classified into three families:

Correlation-based matching: Two fingerprint images are superimposed and the correlation between corresponding pixels is computed for different alignments (e.g. various displacements and rotations).

Minutiae-based matching: This is the most popular and widely used technique, being the basis of the fingerprint comparison made by fingerprint examiners. Minutiae are extracted from the two fingerprints and stored as sets of points in the two dimensional plane. Minutiae based matching essentially consists of finding the alignment between the template and the input minutiae sets that results in the maximum number of

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minutiae pairings.

Pattern-based (or image-based) matching: Pattern based algorithms compare the basic fingerprint patterns (arch, whorl, and loop) between a previously stored template and a candidate fingerprint. This requires that the images be aligned in the same orientation. To do this, the algorithm finds a central point in the fingerprint image and centers on that. In a pattern-based algorithm, the template contains the type, size, and orientation of patterns within the aligned fingerprint image. The candidate fingerprint image is graphically compared with the template to determine the degree to which they match.

A typical block diagram of biometric matching systems is shown in Figure below:

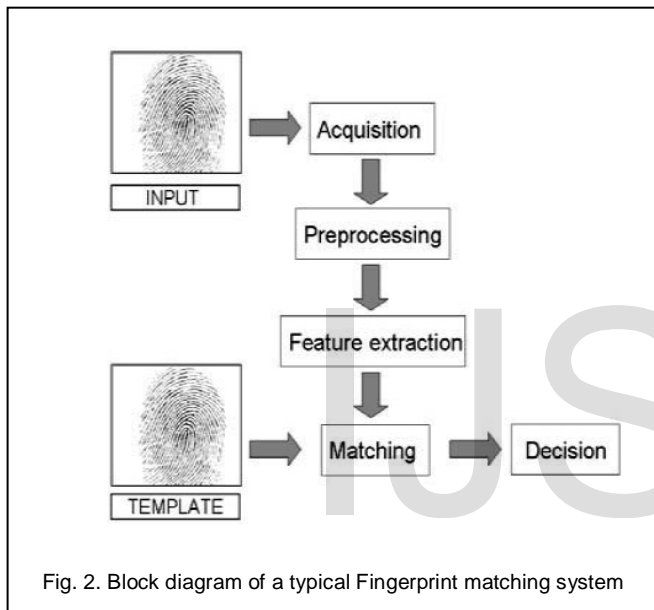


Fig. 2. Block diagram of a typical Fingerprint matching system

In this paper we have discussed about the implementation of a minutia based matching technique. This approach has been intensively studied, also is the backbone of the current available fingerprint recognition products.

2 PREVIOUS WORKS

For fingerprint identification AFIS (Automated Fingerprint Identification System) is used which needs to compare the input fingerprint to the whole fingerprint database. This technique is complex for some applications. In last few years several scientists have proposed a large number of methods for fingerprint classification and identification. To reduce the number of comparisons and response time, a new scheme has been proposed by scientists Francis Galton and Edward Henry. This scheme is used with existing AFIS database and also used for the systems that require compatibility with human classifications. In this scheme they classified the fingerprint data based on finger's features like number of cores and number of deltas. [3, 4]

2.1 Henry Fingerprint Classification system

It permits for logical classification of fingerprints of both hands and fingerprint records grouped based on fingerprint

pattern types. Henry classification system decreases the effort necessary to search the fingerprint data from a large database. In the Henry fingerprint classification system each finger is assigned a number based on their occurrence in the hand. The right thumb is assigned the number = 1 and it ends with the left little finger (pinky), with its number = 10. In this system each finger is assigned with the numerical values for the finger and this is done for all the fingers in both the hands. Fingers without whorl pattern like arch or loop pattern are assigned the value = 0 (zero) and with whorl are assigned the value = 1. According to the Henry fingerprint classification system, assigned finger number, finger values and pattern type of finger are shown in Table 1. [5, 6, 7, 11].

TABLE 1
HENRY FINGERPRINT CLASSIFICATION SCHEME

Left Hand					
Name	Pinky	Ring	Middle	Index	Thumb
Finger Number	10	9	8	7	6
Value(if Whorl)	1	1	2	2	4
Design Type	Arch	Loop	Whorl	Loop	Arch
Finger Value	0	0	2	0	0
Right Hand					
Name	Thumb	Index	Middle	Ring	Pinky
Finger Number	5	4	3	2	1
Value(if Whorl)	4	8	8	16	16
Design Type	Loop	Whorl	Arch	Arch	Loop
Finger Value	0	8	0	0	0

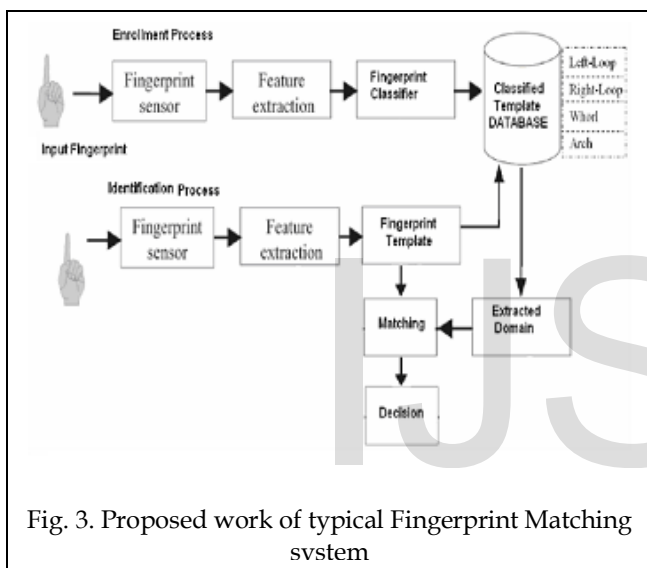
$$PGR = [1 + (\text{sum of even finger value})] / [1 + (\text{sum of odd finger value})]$$

$$PGR = [1+(2+8)]/1+0 = 11/1$$

Fingerprint data are stored into database with their relative PGR value. If all the fingers of both hands contain whorl values, then $PGR = 31:31$, if any person does not contain whorl values then $PGR = 1:1$. The major drawback of this scheme is that fingerprints of both hands are required. Moreover, because of the storage requirement of fingerprints of both the hands large memory space is required. [9, 10]

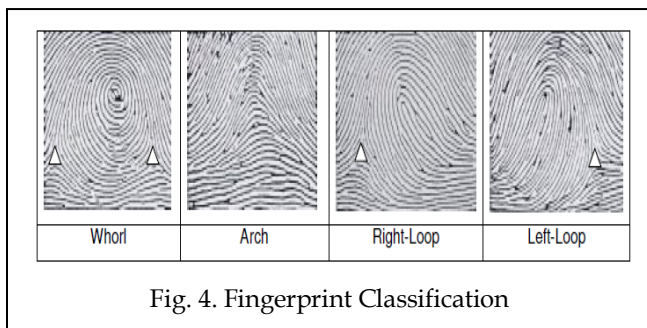
3 PROPOSED WORK

The proposed work for fingerprint matching is shown in a block diagram in figure 3. The steps performed for fingerprint enrollment and identification/ verification are shown in the figure below.



3.1 Fingerprint Classifier

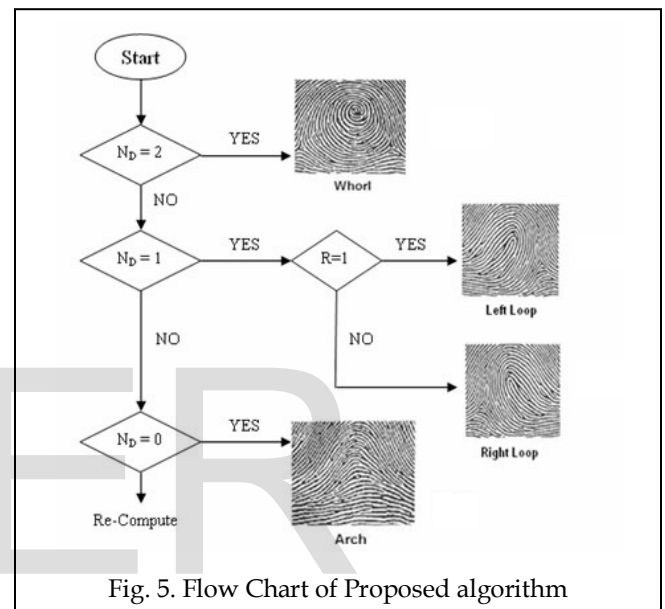
Fingerprint classifiers classify the input fingerprint into four major categories namely Left-Loop, Right-Loop, Whorl and Arch. The proposed classifiers works on the basis of singular point (Delta) extracted. If there are two deltas then it will be counted as whorl or twin loop. If there is no delta then it will be counted as arch. If only one delta is there then it will be either left loop or right loop.



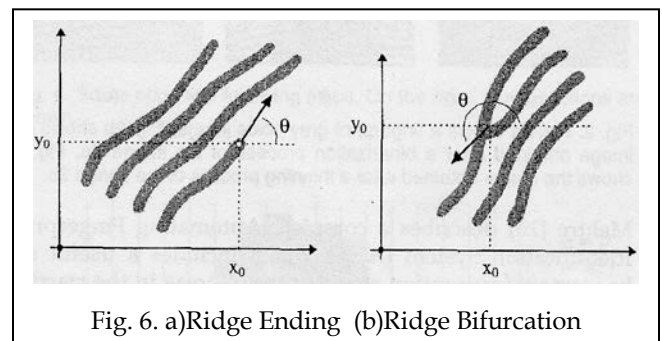
3.2 Fingerprint Classification Algorithm

- Step1. Find the total number of delta points in fingerprint template. i.e ND.
 - Step2. If $ND=2$ the fingerprint is of whorl type.
 - Step3. Elseif $ND=1$ and $R=1$, the fingerprint is of left loop type.
 - Step4. Elseif $ND=1$ and $R=0$, the fingerprint is of right loop type.
 - Step5. Else fingerprint is of arch type.
- Where R is the axis of symmetry.

The flowchart of our proposed algorithm is shown in the figure 5



We have concentrated our implementation on Minutiae based method. In particular we are interested only in two of the most important minutia features i.e. Ridge Ending and Ridge bifurcation. (Figure 6)



4 RESULTS AND DISCUSSIONS

In implementation, we use MATLAB version 7.10 as an implementation platform. This work is mostly based on the Image Processing toolbox; it is a part of MATLAB tool and the work is focused on designing a classification based speedup fingerprint identification system that is highly expandable

using MATLAB environment. The main benefits of the MATLAB environments are: simplicity, code database, code libraries, PC operation, platform export, User Interface etc. This implementation presents the experimental procedures used for Fingerprint Identification. It also provides the results obtained from the mathematical calculation and discusses the comparison of previous and proposed scheme.

4.1 Experimental Results

A fingerprint database of BIT staff having a total of 1000 fingerprint is used to test the experiment performance. Out of thousand fingerprints 300 are of left loop type, 425 are of right loop type, 175 are of whorl type and 100 are of arch type. The algorithm is capable of differentiating fingerprints at a good rate by setting an appropriate threshold value.

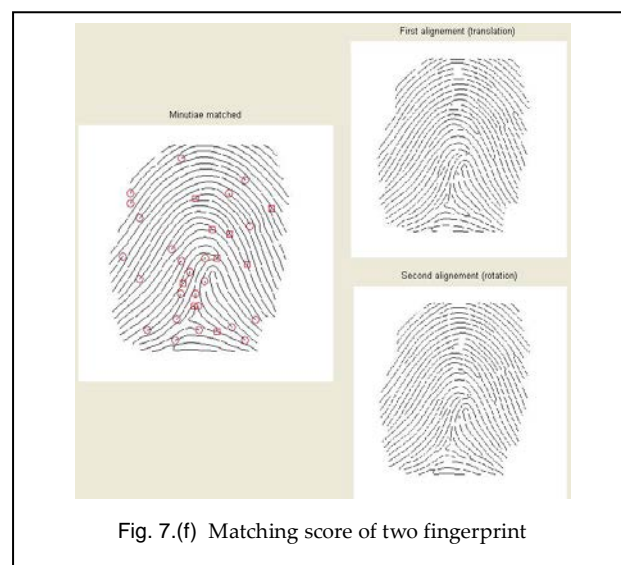
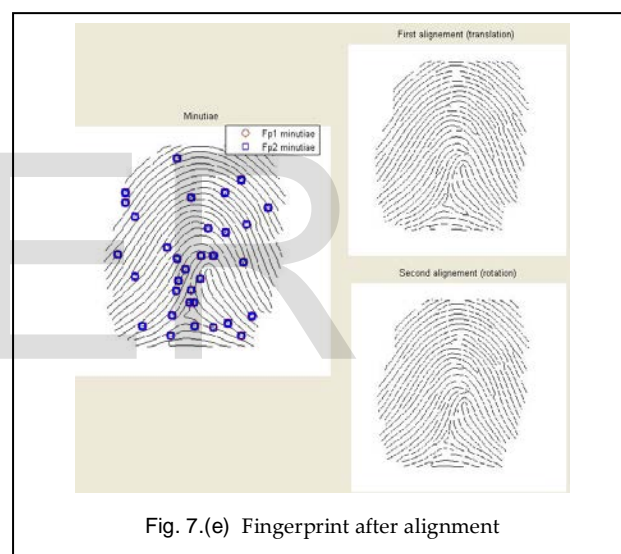
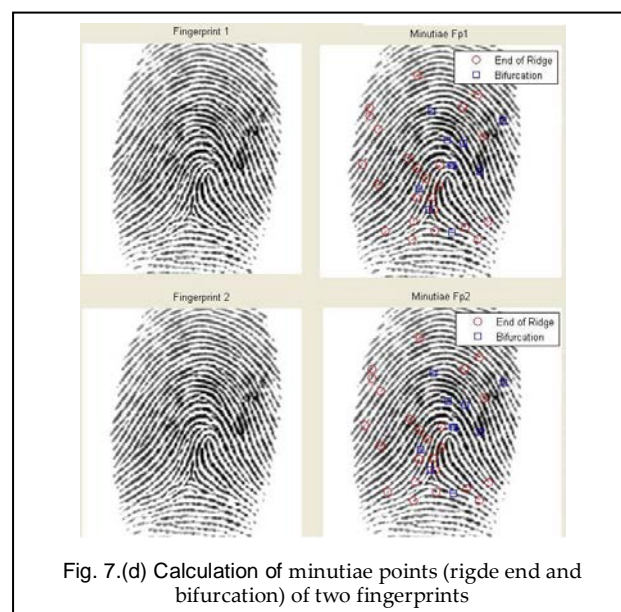
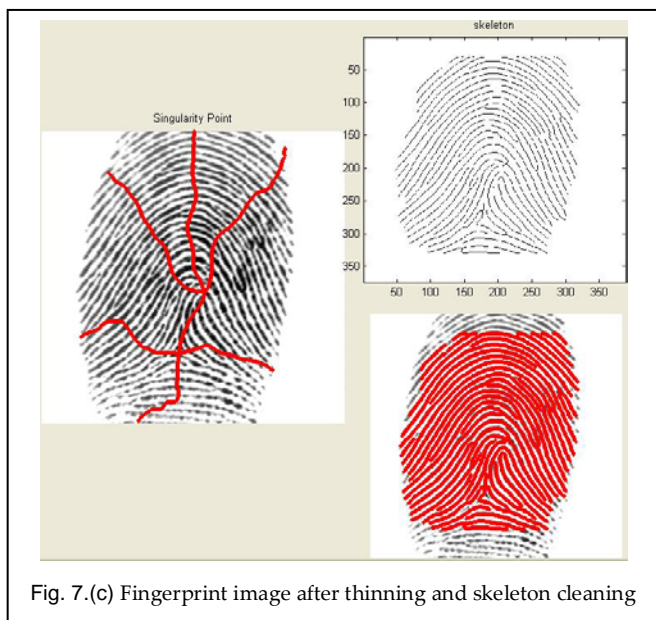
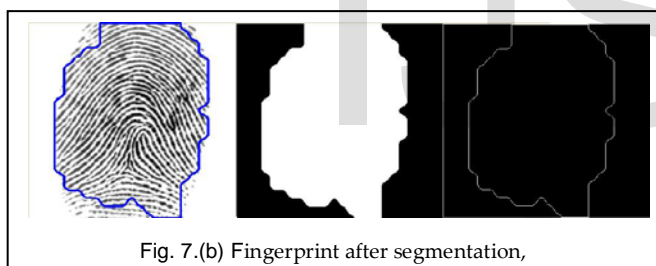
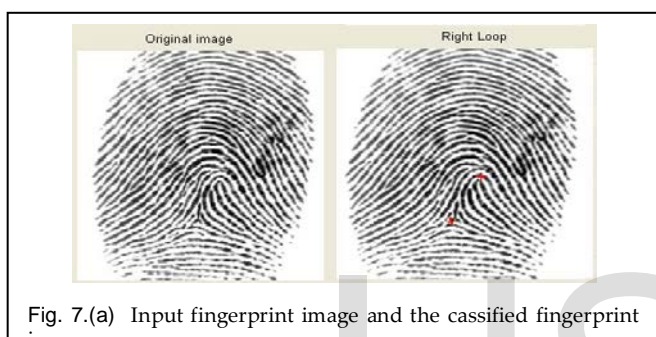


Figure 7(a) shows the input fingerprint image and the classified fingerprint image. First of all the fingerprint is classified which shows us that to which group the input fingerprint actually belongs. Here a random fingerprint is taken as input, and using the position of singularity points it is computed that the input image belongs to the Right loop class. Then the fingerprint image is segmented from the background by calculating relevant part of fingerprint and contour which is shown in figure 7(b). Figure 7(c) shows fingerprint image after thinning and skeleton cleaning. In this step, morphological skeleton is cleaned and false holes are removed. Then two fingerprints are selected and there minutiae points (ridge end and bifurcation) are calculated as shown in figure 7(d). Figure 7(e) shows the two fingerprints after alignment. Two alignments are performed. In the first alignment, correlation between skeletons is used to find the best alignment according to the translation. In the second alignment, correlation between skeletons is used to find the best alignment according to the rotation. Figure 7(f) shows the matching score of two fingerprints by evaluating the distance between the minutiae.

Two indexes are used to determine the performance of a fingerprint verification system: First is FRR (false rejection rate) and the other is FAR (false acceptance rate). FAR-describes the number of times, someone is inaccurately positively matched, Whereas FRR- derives the number of times, someone who should be identified positively is instead rejected. Table 2 shows the comparative analysis of the two algorithms on the basis of these two indexes.

- FAR

$$(\%) \text{ FAR} = (\text{FA}/\text{N}) * 100$$

FA= number of incidents of false acceptance
N=total number of samples

- FRR

$$(\%) \text{ FRR} = (\text{FR}/\text{N}) * 100$$

FR=number of incidents of false rejections
N=total number of samples

TABLE 2
RESULTS AND COMPARISON

	FCMB Algorithm		NACBM Algorithm	
Threshold value	FAR	FRR	FAR	FRR
7	0.073%	12.4%	0.09%	7.1%
8	0.023%	14.6%	0.02%	9.4%
9	0.012%	16.9%	0.01%	12.5%
10	0.003%	19.5%	0.005%	14.3%

FCMB - Fast Classification based Matching
NACMB - Novel Approach to Classification Based Matching

5 CONCLUSION

In this paper, we proposed a classification algorithm for fingerprints based on ridge pattern and this algorithm leads to proposal of a new scheme of bio-metric identification. Firstly we examined the previous fingerprint classification scheme, and proposed a new identification scheme. After the experimental results it is found that the proposed scheme is faster than previous scheme. It is also concluded that the proposed scheme reduces the memory requirements, because only one hand is used for identification.

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