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Performance Improvement by Classification Approach for Fingerprint Identification System

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Abstract: ***In the world of Information Technology, Information Security is an important factor. For Information Security, authentication plays a vital role. And for Secure Authentication now a days biometric based authentication ('who you are', e.g. Fingerprint) replace the Knowledge Based ('what you know', e.g. Password) and Object Based Authentication ('what you have', e.g. Token). Biometric authentication is the method which identifies or verifies the person based on his/her physiological or behavioral characteristics. The fingerprint is most widely used in biometric world. In Fingerprint Authentication different three levels (The Global or Galton level, The Local Level, The Very Fine Level) of Feature extraction techniques are used at the time of Fingerprint Identification and Verification. In Global or Galton Level identify the flow of ridges and valleys and also extract delta and core point features which classify the fingerprint in different pattern group like arch, tented arch, whorl, left loop and right loop. In tradition biometric recognition approach, the fingerprint template is match with all the template of the database. So, it will take long time for the individual's authentication. In this paper present an approach which speed up the matching process by classifying the fingerprint template database on various fingerprint pattern group. So, instead of matching process done on whole database it will be done on specific fingerprint pattern group and reduce the no. of matches and improve the performance 3 time faster than the traditional approach.***

Index Terms: Biometrics, classification, identification, verification, minutiae points, singular points.

I. INTRODUCTION

When you touch something with your fingers, you leave a specific impression on the touched item. This is called a fingerprint, or it defines: A fingerprint is an impression on a surface of the curves formed by the ridges on a fingertip, especially such an impression made in ink and used as a means of identification. [1] A fingerprint is the feature pattern of a finger. Each person has unique fingerprint and the basic characteristics of that can't change throughout the life. Because of this reason fingerprints are widely used for identification and verification. A fingerprint is a pattern of ridges and valleys. See in below Fig. 1. The ridges are the dark areas of the fingerprint and the valleys are the white areas that exist between the ridges. [2].

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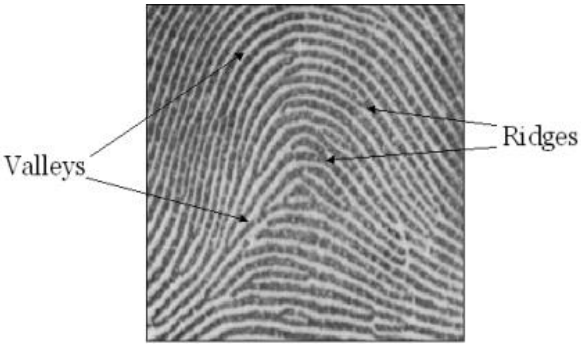


[Fig. 1. Ridges, Valleys]

II. TRADITIONAL APPROACH OF FINGERPRINT RECOGNITION

The Fingerprint Recognition is work on three phases.

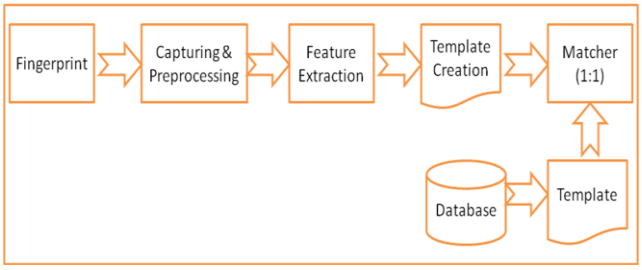
A. Enrollment Phase

In this user has to enroll his/her biometric data during this phase. When users enroll for the first time his/her fingerprint image is capture, features are extracted and feature set stored in database as a template. And after that either Verification/Identification are done for authentication.

[Fig. 2. Enrollment Phase]

B. Verification Phase (1:1 Match)

In this phase verify a person's identity by comparing the captured biometric data with her own biometric template(s) which are stored in system database. In this system a person who want to be recognized claims an identity, usually via a PIN (Personal Identification Number), a user name, a smart card, etc., and the system conducts a one-to-one comparison to check whether the claim is true or not.



[Fig. 3. Verification Phase]

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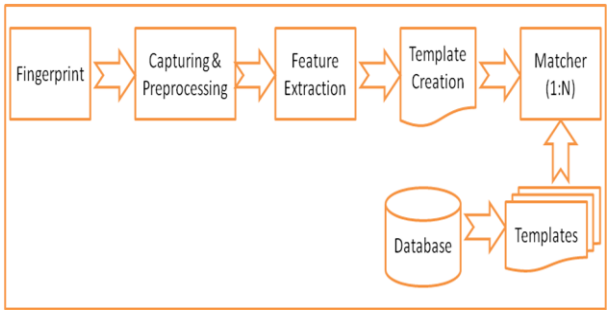
C. Identification Phase (1:N Match)

In this phase recognizes an individual by searching the template into the database of all the users for a match. In this system conducts a one-to-many comparison to create a person's identity. [3]



[Fig. 4. Identification Phase]

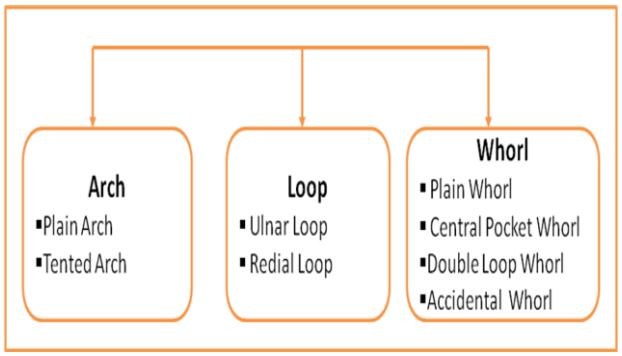
III. FEATURE EXTRACTION IN FINGERPRINT RECOGNITION

Three level of Feature Extraction can be done.

1) Level 1: Global Level or Galton Level
2) Level 2: The Local Level
3) Level 3: The Very Fine Level

A. Level 1: Global Level or Galton Level

You can see the fingerprint is a "landscape" full of papillary lines. There is two parts of the papillary lines the higher (called ridges) and the lower (valleys) see in Fig 1. At this level identify the whole features like the flow of ridges and valleys, core and delta point (singular points), ridge count and ridge orientation. Based on this classify the fingerprint in different groups. There are mainly three groups like Arch, Loop and Whorl. Each group is divided in smaller group shown in below Fig. 5.



[Fig. 5. Fingerprint Classes]

Each group is divided based on singular point features which is a collection of core and delta point.

Core Point: It is at the center of the fingerprint lines. It is located on the spike in the innermost ridge of fingertip.

Delta: Delta is point where two ridges are diverging.

Ridge orientation map – It show the direction of the ridges and valleys. And it is used for classification, image enhancement and minutia feature verification.

Ridge frequency map – It is the reciprocal of the ridge distance in the direction perpendicular to local ridge orientation. It is extensively utilized for contextual filtering of fingerprint images.

The above features are used for fingerprint classification group like below.

1) Arches

Arches are one type of fingerprint which is made by ridges that start from one side of the fingertip and end on other side. Fig 6 show the Plain Arch and Tented Arch.

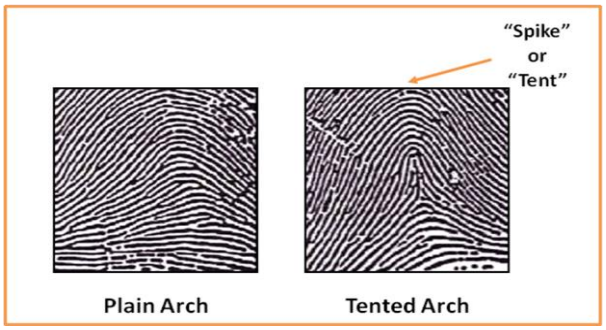


Fig. 6. Types of Arches]

Plain Arch

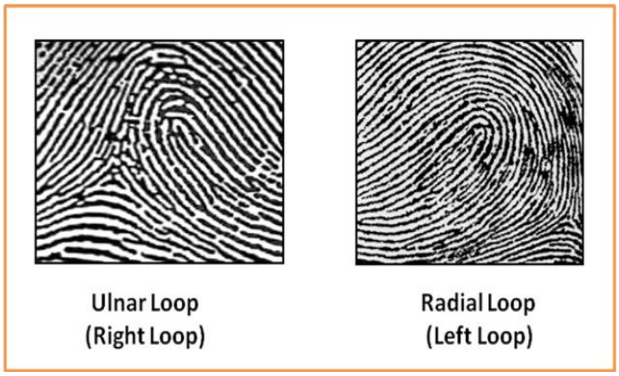
In this ridges enter on one side and exit on the other side. Plain Arch has no delta and no core point.

Tented Arch

It is same as the plain arch, but has a spike or tent in the middle. It has one delta and one core point. The delta is at the middle point.

2) Loop

In Loop Pattern ridge line start and end on the same side of the fingertip. Fig.7 show the Ulnar Loop and Radial Loop.



[Fig. 7. Ulnar and Radial Loop]

Ulnar Loop

It is also called as Right Loop because in this pattern Loop opens toward right or the ulna bone. It has one core and one delta point. And the delta point is at the left side.

Radial Loop

It is also called as Left Loop because in this Loop opens toward the left or the radial bone. It also has one core and one delta point. And the delta point is at the right side.

3) Whorl

In this ridge lines are like circle which do not start or end on either side of the fingertip. If there are two core and two delta point then it will consider as a Whorl pattern. Fig 8 show the different types of whorl.

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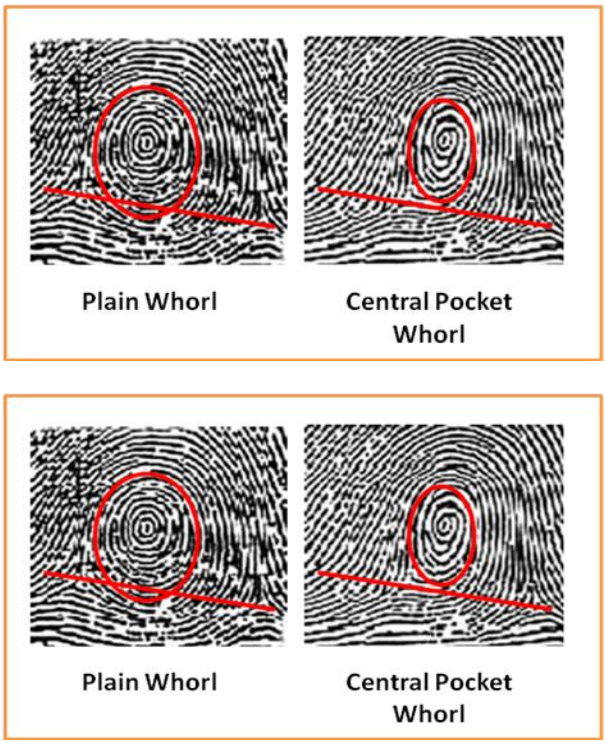


[Fig. 8. Types of Whorl Loop]

Plain Whorl
In this pattern the delta line cuts the inner pattern area. Draw a line between the two deltas. If some of the curved ridges touch the line, it is a plain whorl.

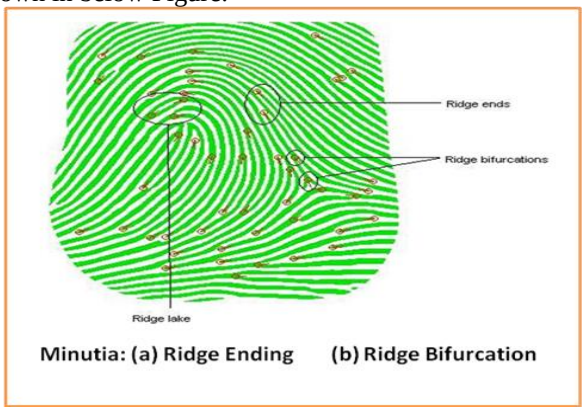
Central Pocket Whorl
In this delta line doesn't cuts the inner pattern area. Draw a line between the two deltas. If none of the center core touches the line, it is a central pocket whorl.

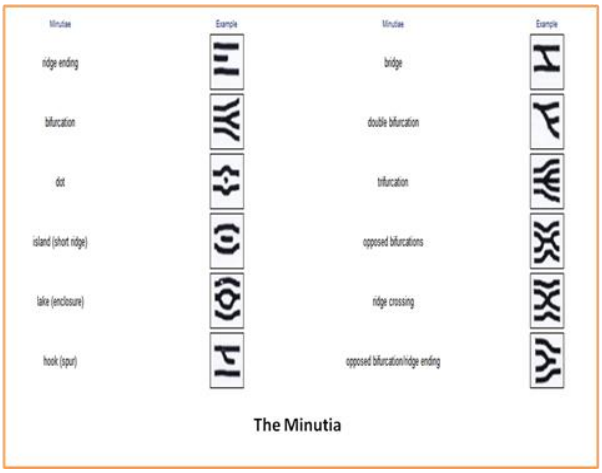
Double Loop Whorl
It is made with any two loops and combined into one fingertip is consider as Double Loop Whorl.

Accidental Whorl
If there is more than two deltas then consider it as an accidental whorl.

B. Level 2: The Local Level

In this level the minutiae are identifies. Minutiae mean different local ridge characteristics. A minutiae characteristic is either a ridge termination, where a ridged ends, or a ridge bifurcation, where a ridge diverges into two new branch ridges see in Fig. 9. Other minutiae are the combination of ridge ending and ridge bifurcation it might be: islands, dots, independent ridges, lakes, spurs and crossovers etc which is shown in below Figure.



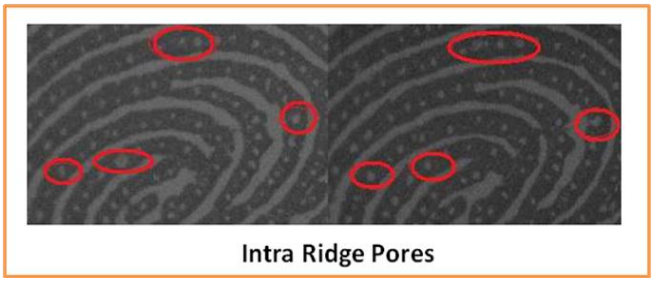


[Fig. 9. The Minutia: Ridge Characteristics]

Sir Francis Galton (1822-1922) was the first person who observed the structures and permanence of minutiae. Therefore, minutiae are also called "Galton details". They are used by forensic experts to match two fingerprints. There are about 150 different types of minutiae [7-8] categorized based on their configuration.

C. Level 3: The Very Fine Level

Level 3 Features are intra-ridge details in fingerprint. These are essentially sweat pores which are considered highly unique and become helpful to identify a person. Sweat pores can be viewed as small dots on the ridges. However, to be able to view this information, a high resolution image of the fingerprint is required. Studied [9] said there are 23 to 45 pores per inch. And 20 to 40 pores are used to identify of an individual. A pore can be either closed or open. A closed pore is entirely enclosed by ridge, while an open pore intersects with the valley lying between two ridges shown in below Fig. 10.



[Fig. 10. The Pores]

IV. PROBLEMS ASSOCIATED WITH THE TRADITIONAL APPROACH

In traditional approach all the templates of fingerprints are stored in database. In Identification phase the template of user will match with the all the templates of database [1: N match]. Therefore it will take long time to authenticate the user.

Consider that there are 2, 40, 000 templates in database. Let's assume the time to perform a single match = 1 ms (1 milli seconds).

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A. *Performance of Traditional Approach*

For the first template match, it will take =1 X 1 = 1 ms
For the last template match it will take = 1 X 2, 40, 000 = 2, 40, 000 ms= 240 sec. = 4 min.
So in average case the time required that is approximately 3-4 min.

V. APPLYING THE CLASSIFICATION APPROACH

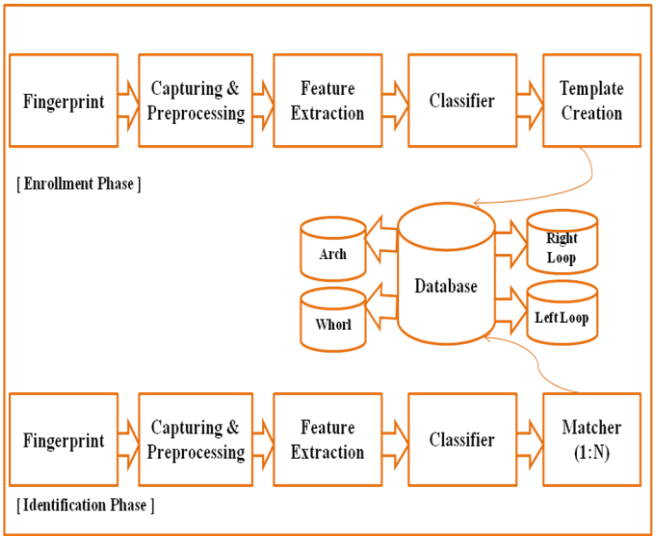
In classification approach the whole database is divided into no. of bins. The bins are made based on Galton Level features like whorl, loop, arch class etc. The classes are identifying on no. of Core points and on Delta points in finger image. If there are 2 core points and 2 delta points then its whorl class. If there is no core and no delta point then its arch class. And if only one core and one delta point is there then it can be left-loop, right-loop or tented arch. In this check the Relative position (R). If relative position, R of delta with respect to symmetry axis is R = 1 means the delta is on the right side of symmetry axis then it will be left loop otherwise it will be right loop [10].

[I. Classification types of fingerprint and corresponding delta point.]

Class	Core Point	Delta Point
Whorl	2	2
Arch	0	0
Left Loop	1	1
Right Loop	1	1

The above features are extracted and classify at Enrollment phase and make the template. Then the templates are stored in individual bins depend on classification information. At the time of Identification process the features are extracted then matcher will match the template with only the specific bins depend on classification. So instead of matching will done on whole database it will do on specific bin. Therefore it reduces the time of user match.

See the below Fig. 11. Which show that the database is divided into mainly in four bins based on whorl, arch, left loop and right loop classes.



[Fig. 11. Classification Approach]

A. *Performance of Classification Approach*

For the First Template, The time required =1 X 1 = 1 ms

Based on study 60-65% population has loops, 30-35% has whorl and 5% has arch. Here, we consider 2, 40,000 templates, According to classification there will be
72000 whorls (30%) + 76800 left loop (32%) + 79200 right loop (33%) + 12000 arch (5%) templates in each bins
Now calculate the time taken for each classification
For whorl = 1ms X 72000 = 72000ms = 72 sec = 1.2 min
For left loop = 1ms X 76800 = 76800ms = 76.8 sec = 1.28 min
For right loop = 1ms X 79200= 79200ms = 79.2 sec = 1.32 min
For arch = 1ms X 12000= 12000ms =12 sec =0.2 min
Average time = 240 sec./4= 60 sec =1 min.
So, the average time is required for 2, 40,000 templates is approximately 1 min.
Based on the comparisons of this two approach classification approach is better.

VI. CONCLUSION

In this paper we have seen that Fingerprint authentication is done in three phases like Enrollment, Verification (1:1 match), and Identification (1: N match). In traditional approach at the time of Identification the matching will be done on whole database therefore it will take long time to match. While in classification approach, which split the database in nos. of bins based on the Galton Level features like whorl, loop, arch etc. reduce the processing time and improve the performance. This paper also shows the comparison of performance of traditional and classification approach. Based on the comparison it prove that the classification approach is 3 time faster than the traditional approach.

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