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Fingerprint Analysis Using Graph Theory

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Abstract: In this paper we are trying to classify finger prints through identifying the core of the fingerprint. The fingerprint is taken as an input in an image format. Then it involved for necessary processing and we make a graph with ridge endings, bifurcations, deltas considering as vertices. The idea is to calculate the weight of the edge between the pair of vertices and to make an adjacency table with the values. An efficient classification method is necessary for automatic fingerprint recognition system. Colouring technique is applied to compare graph with the model graphs in order to classify fingerprints. In classification the number of subclasses is increased with acceptable accuracy and faster processing in fingerprints recognition, which makes this system superior.

Keywords — bifurcations, deltas, ridge endings

I. INTRODUCTION

Fingerprint Analysis has been used to identify criminals for a longer period of time. Human fingerprints are different from one another, difficult to change. One can identify a person not only when he is alive also after his death using fingerprints. It's a biometric technique to compare scanned images of prints. Identifying fingerprints is important for criminal investigation and legal actions.

1.1 FINGERPRINT ANALYSIS:

Fingerprint Analysis has been used to identify criminals for a longer period of time. Human fingerprints are different from one another, difficult to change. One can identify a person not only when he is alive also after his death using fingerprints. It's a biometric technique to compare scanned images of prints. Identifying fingerprints is important for criminal investigation and legal actions.

1.2 DELTAS AND CORES

There are 2 types of patterns used to differentiate one major kind from another in fingerprints that is Deltas and Cores

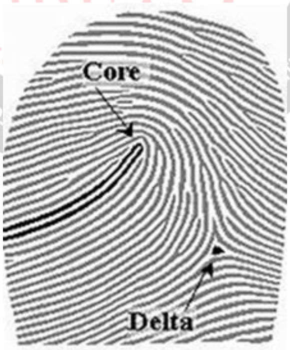

Fig 1.1 – Represents Core and Delta

Deltas and cores are unit shaped by ridge patterns. A delta is triangular formed ridge pattern that seems at the middle of 3 intersectant ridge flows. A core is that the termination of the innermost ridge that seems within the interior of a coaxial set of the ridges. A fingerprint ridge could be a slightly raised, long, narrow line of curve that seems on the surface of the skin.

II. PRIMARY CLASSIFICATION

A fingerprint classification algorithm is presented in this paper. Fingerprints are classified into five categories: arch, tented arch, left loop, right loop and whorl.

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2.1 Types of Fingerprints:

2.1.1 ARCH:

Fig 1.2(a)

Fig 1.2(b)

• Plain Arch - High hills reflect this pattern and starts from one side of the finger to the opposite during a time of continuous fashion. This pattern makes just five hitters for everyone, making it an unusual type. [Fig (1.2(a)]

• Tented Arch - almost like a plain arch, a tent arch has it too raised ridges flow within the same fashion. A different difference is coming inside the pitch of the raised ridge. The arch with the tent covers the deceiver edge compared to the plain arch, which forms a tent-like form. [Fig (1.2(b)]

2.1.2 WHORL:

Fig 1.3 - Whorl

Not like arch, it's a central pocket kind of fingerprint pattern. This type of pattern matches 30-35% of people in entire population. This type has 2 deltas and one core inside the pattern.

2.1.3 LOOP:

Fig(1.4 a) -

Left Loop

Fig(1.4 b)

Right Loop

This is usually the most common fingerprint pattern. Indeed, with 60-70% of most people have this pattern, inside the loop pattern, there should be a minimum of one core and a delta.

III. SECONDARY CLASSIFICATION

It is true that first classification is not enough to find out criminals. The secondary classification is about how of mensuration the difference in size of the final pattern and also the direction (left or right) of the final pattern.The fact that 2 prints could each be (1,1) loops, they will still be visibly totally different. For instance, the quantity of ridges that fall between the core and also the delta on a loop may well be totally different for distinct prints.

To carry out the secondary classification method, begin by drawing a line from the centre of every core to the middle of every delta. For a (1, 1) print, that's only 1 line, except for other primary classifications we will have to draw many lines. The middle

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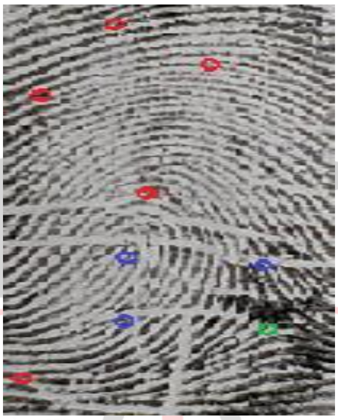
of a core is that the centre ridge ending at the guts of the core. The middle of a delta is the ridge ending or the "fork" of a ridge that happens among the delta.

Fig (1.5) - Fork

IV. VERTEX COLORING

The nodes or vertices of the graph are going to be bifurcations, ridge endings and deltas within the fingerprints. To differentiate one variety of point characteristic from another the nodes are going to be color-coded. This is often named as vertex coloring. **Fig(1.6).**



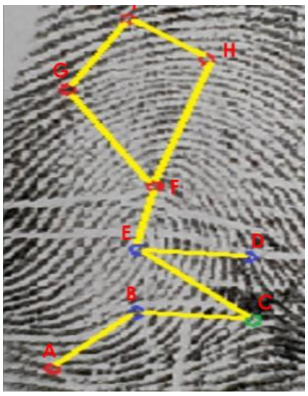
Fig(1.6) – Vertex Colouring

The color red represents bifurcation. The color blue represents ridge ending. The color green represents delta

V. CONNECTING THE VERTICES

The next step is to feature edges change of integrity the vertices. Not all vertices are going to be joined by a grip. The rule for change of integrity 2 vertices with a grip is as follows:

A combine of vertices is going to be joined (be adjacent) if the edge drawn can "cross" the ridges during a nearly perpendicular fashion. If the sting seems to be almost "parallel" (that is, follows the final flow of the ridges), then it will not be adscititious to the graph. The edge can then be "labelled" with this variety (count). This variety is named as the weight of the sting.



Fig(1.7) – Vertices Integrity

Note that the graph adscititious to the higher than fingerprint is simply one example of an attainable graph on this print. There are several alternative ridge characteristics that might are accustomed produce a graph associated with the fingerprint.

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VI. NUMERICAL REPRESENTATION OF GRAPHS

As humans we can compare the characteristics of two prints with the benefit of our eyesight. However, comparing graph diagrams by visually at the vertices and edges is not the best way to check if two graphs are isomorphic.

It is necessary to find a way to represent graphs numerically. That is to represent graphs is with an adjacency matrix. An adjacency matrix for a graph compares which vertices are adjacent to each other and which are not. The vertices are labelled and placed at the left of each row as well as at the top of each column.

The entries in each row and column represent the graph's edges with entries

of 1 and 0. The adjacency matrix Xij, defined by,

Xij ={ 1, if the vertices i and j are adjacent

0, if the vertices i and j are not adjacent}

The adjacency matrix below represents the graph constructed for the fingerprint.

	A	B	C	D	E	F	G	H	I
A	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
B	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
C	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
D	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
E	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**0**
F	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**0**
G	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
H	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**
I	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**

Table 1 – Represents the adjacency Matrix

Note, for example, the 1 at row A and column B means that vertices A and B are adjacent .This matrix can be altered to include some additional information. For example, the 1's in the matrix can be replaced with the edge weights for the corresponding edges to produce this new matrix, indicating that vertices A and B have 3 ridges between them. Instead of placing a 1 where two vertices are adjacent, the following matrix puts the edge weight in the row and column of two adjacent vertices.

	A	B	C	D	E	F	G	H	I
A	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
B	**3**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**0**
C	**0**	**7**	**7**	**0**	**12**	**0**	**0**	**0**	**0**
D	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**0**	**0**
E	**0**	**0**	**12**	**10**	**0**	**4**	**0**	**0**	**0**
F	**0**	**0**	**0**	**0**	**4**	**0**	**13**	**15**	**0**
G	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**0**	**5**
H	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**0**	**4**
I	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**4**	**0**

Table 2 – Represents the vertex colouring for the graph

It is possible to represent the vertex colouring numerically in the matrix. Let

- The color red be represented by 1,
- Blue represented by 2 and
- Green represented by 3.

Each vertex will be named with a 1, 2, or 3 to identify its color. Each matrix entry will be a triple order with the first coordinate the edge weight, the second coordinate the row vertex color and the third coordinate the column vertex color. This new matrix will be called the expanded adjacency matrix for the graph. The new matrix shows that vertices A and B have 3 ridges between them, and that vertex A is red and vertex B is blue.

	A	B	C	D	E	F	G	H	I
A	**0**	**(3,1,2)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
B	**(3,2,1)**	**0**	**(7,2,3)**	**0**	**0**	**0**	**0**	**0**	**0**
C	**0**	**(7,3,2)**	**0**	**0**	**12**	**0**	**0**	**0**	**0**
D	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**0**	**0**
E	**0**	**0**	**(12,2,3)**	**(10,2,2)**	**0**	**4**	**0**	**0**	**0**

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F	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**15**	**0**
G	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**0**	**5**
H	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**0**	**4**
I	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**4**	**0**

Table 3 – Represents the expanded adjacency Matrix for the graph

VII. CONCLUSION

It is now possible to compare two "expanded" adjacency matrices for two fingerprint graphs numerically. If the matrices have same numerical values in their rows and columns, the corresponding graphs can be said to be isomorphic. Suppose that there are still two suspects and the fingerprint graphs are to be compared numerically to find which one is the suspect. Fingerprint analysis makes investigators job easy by linking one crime to another crime involving the same person. This helps investigators to track a criminal's record, their previous arrests and convictions, to aid in parole and pardoning decisions. Finally, in order to use these graphs alone for fingerprint matching, the distinctiveness of the ridge topology in general must be investigated. We have argued in this paper that in certain cases, it can distinguish between different fingerprints. But its overall distinciveness remains to be further investigated.

REFERENCES

[1] Fingerprint Authentication Using Graph Theory,CSE,VIT University,Vellore India.

[2] Minutiae Based Fingerprint Verification using Graph Model : Sonali Sen,Deyashini Bhattacharya,Soumili Dey,Sabsarna Nandy.

[3] Department of Justice Federal Bureau of Investigation. Classification Codes.

[4] Fingerprint identification Chapter 10 fingerprint classification systems. (2005). San

[5] Srinivasan S et al./ Elixir Comp. Sci. & Engg. 73 (2014) 26158-26160

[6] Xudong Jiang and Wei-Yun Yau. "Fingerprint Minutiae Matching Based on the Local And Global Structures".

[7] Werner Ölz and Walter G. Kropatsch. Graph Representation of Fingerprint Topology. In Danijel Skocaj, editor, Computer Vision - CVWW'04, pages pp. 51–58, Ljubljana, Slovenija, February 2004. Slovenien Pattern Recognition Society.

[8] Leong Chung Ern, Dr. Ghazali Sulong, "Fingerprint classification approaches", 6 th International, Symposium on Signal Processing and its Applications, vol. 1 , pp. 347 - 350 , Aug. 2001.

[9] D. Maio, D. Maltoni, "An efficient approach to online fingerprint verification", proc. VIII Int. Symposium on Artificial Intelligence, 1995. [4] D. Maio, D. Maltoni, "Direct gray-scale minutiae detection in fingerprints", tech. Report n. 105, DEIS-Universita di Bologna, 1995.

[10] Jain.A.K, Prabhakar.S, Hong.L, "A Multichannel Approach to Fingerprint Classification", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.21, no.4, pp.348-358,1999.

[11] Wang.S, Zhang .W, "Fingerprint Classification by Directional Fields", Proc. 4th IEEE Int. Conf. Multimodal Interface, Pittsburgh, pp.395-398, 2002.

[12] Shen Wei, Chen Xia, Jun Shen, "Robust detection of singular points for fingerprint recognition", 2003. Proceedings. 17th Int. Symposium on Signal Processing and its Applications, vol. 2, pp. 439 - 442, July 2003.

[13] Hassan Ghassemian, "A Structural Fingerprint Restoration", International Journal of Engineering, vol. 10, no. 4, pp. 181-190, November 1997.

 DOI : 10.35291/2454-9150.2022.0437