

# Criminal Identification using Partial Fingerprint Reconstruction Method

Priya Chhajer<sup>1</sup>, Omkar Kadam<sup>2</sup>, Deepali Agarwal<sup>3</sup>, Nehal Pandey<sup>4</sup>, Prof. Soumitra Das<sup>5</sup>,  
Prof. Sunil D Rathod<sup>6</sup>.

B. E Student, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun, Pune, India<sup>1</sup>

B. E Student, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun, Pune, India<sup>2</sup>

B. E Student, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun, Pune, India<sup>3</sup>

B. E Student, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun, Pune, India<sup>4</sup>

Head of the Department, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun, Pune,  
India<sup>5</sup>

Assistant Professor, Department of Computer Engineering, Dr. D Y Patil School of Engineering, Lohegaun,  
Pune, India<sup>6</sup>

**ABSTRACT:** Sometimes during crime investigations police detectives find partial fingerprint at the crime scene which makes it difficult to identify the criminal. Thus we need to implement this paper to reconstruct a fingerprint from its partial print, which will later on help to identify the criminal through minutia points. In the proposed system a reconstruction algorithm that utilizes prior knowledge of two kinds of dictionaries, orientation patch and continuous phase patch dictionaries to improve the reconstructed fingerprint. The orientation field is reconstructed from a particular minutia set produced, with help of orientation patch dictionary and the ridge pattern is reconstructed by continuous phase patch dictionary. We used two public domain fingerprint databases which are FVC\_2002 and NIST SD4. The main objective of our project is to develop an efficient criminal identification system. The novel approach is used towards reconstruction which will increase the efficiency of reconstructed fingerprint image. The reconstructed fingerprint image can be used for criminal identification which can be efficiently done by applying classification algorithm, which will in turn improve the identification of the criminal through reconstruction of partial fingerprint found at the crime scene. This project will lead to innovation in different fields like Biometrics and Forensics.

**KEYWORDS:** Orientation Patch Dictionary, Continuous Phase Patch Dictionary, minutiae, FVC\_2002, NIST SD4, Criminal Identification System.

## I. INTRODUCTION

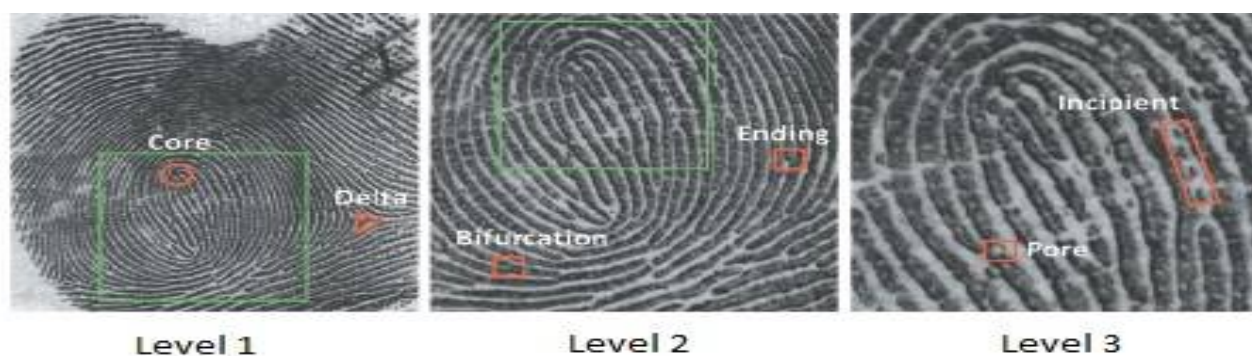
Fingerprints are nothing but different lines marked on individual's fingertip. Who knew that a criminal could be easily identified from a partial print he/she left at crime scene. Every individual has its own set of unique fingerprint that could easily help the detectives to identify the criminal and save an innocent's life from getting accused for a crime he/she not even committed. Even a partial fingerprint is considered as an important clue to lead an investigation and help the police detectives to differentiate between suicides from a homicide and to bring justice for the people. To remove some workload off our detective shoulders we suggested a proposed reconstruction algorithm that increases the accuracy of getting a restored original fingerprint. Each fingerprint consists of unique features which are divided into various levels. (As shown in Fig1) Level 1 contains global features called as singular points (core and delta). Level 2 contains ridge ending, bifurcation, and short ridge. Level 3 contains pores, dots and incipient ridges. So, all the above levels define set of minutiae.

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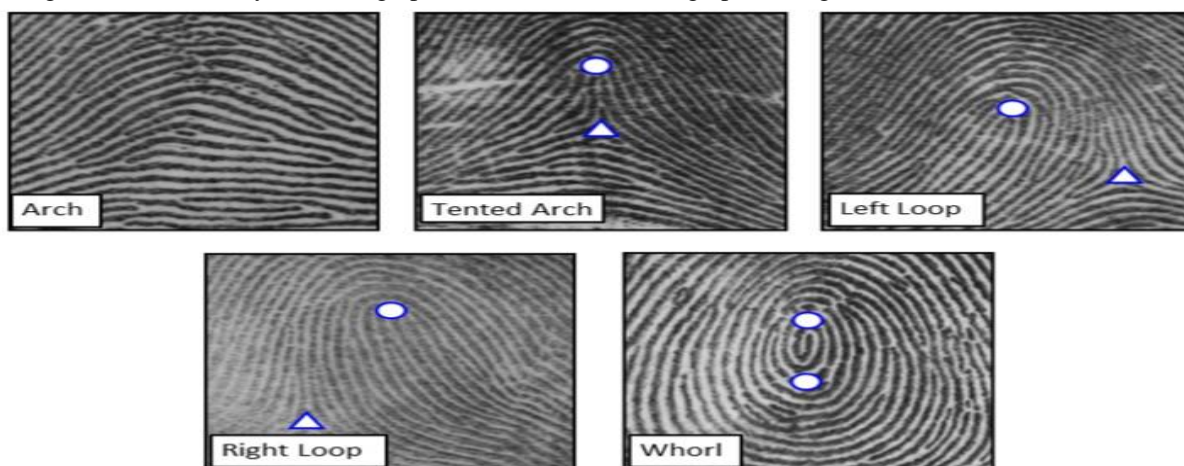
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[Jianjiang Feng , Anil K. Jain ,Karthik Nandakumar (Feb 2010),Fingerprint Matching Retrieved from : <https://www.computer.org/csdl/mags/co/2010/02/mco2010020036-abs.html>]

Fig.1It depicts various levels present on a fingerprint which contributes to set of minutiae.

The need for calculating singular points is for reconstruction and for fingerprint classification. During calculation of singular points: core, which is the topmost point of innermost curving ridge and delta which is centre of triangle where three different directions flow meets, helps us to classify any fingerprint into any one of the following classes: Arch, Left Loop, Right Loop, Tented Arch and Whorl. (As shown in Fig. 2).The proposed algorithm can be also used for the matching of reconstructed synthetic fingerprint and restore latent fingerprint images.



[Ali Ismail Awad,Kensuke Baba(Jan 2012), Global structure of fingerprint images with different classes and different singular points locations. Retrieved From: [https://www.researchgate.net/figure/230772912\\_fig1\\_Figure-1-Global-structure-of-fingerprint-images-with-different-classes-and-different](https://www.researchgate.net/figure/230772912_fig1_Figure-1-Global-structure-of-fingerprint-images-with-different-classes-and-different)]

Fig.2 Five classes present to classify a fingerprint with their Global Features.

The work in this paper is divided as follows: Section 2 consists of Literature Survey, Section 3 consists of Existing System, Section 4 consists of Proposed System, Section 5 consist of Criminal Identification System and its System modules Section 6 consists of Experimental Results, Section 7 consists of Conclusion and Section 8 consists of Acknowledgements.

## II. RELATED WORK

Previous reconstruction algorithms essentially consist of two main steps: i) orientation field reconstruction and ii) ridge pattern reconstruction. The orientation field determines the ridge direction through reconstructing minutiae. Fingerprint

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reconstruction is completed in ridge pattern construction through reconstructed orientation field. There are several fingerprint reconstruction algorithms been proposed for matching performance of reconstructed fingerprint with original fingerprint image it is not adequate as shown in Fig.4 This paper will implement an efficient algorithm that utilizes the prior knowledge of two dictionaries, Orientation patch dictionary and Phase patch dictionary which increases the matching performance of reconstructed partial fingerprint with respect to original fingerprint found in the database and makes sure to protect the system from spoofed fingerprints . The proposed system will work on extracting both global and local features from a given gray scale input image of partial fingerprint. The comparative results of the previously implemented reconstruction algorithm is as shown in the table.1

Comparitive Results Of Previously Implemented Reconstruction Algorithms

Algorithm	Orientation field reconstruction	Ridge pattern reconstruction	Performance evaluation	Comments
Hill	Zero-pole model	Partial skeleton reconstruction	N/A	Only partial skeleton of a fingerprint is obtained
Ross <i>et al.</i>	Minutiae triplets	Streamlines and line integral convolution	Type-I attack: 23% rank-1 identification rate on NIST SD4	Only partial fingerprint is reconstructed
Cappelli <i>et al.</i>	Modified zero-pole model	Gabor filtering	Type-I attack: 81.49% TAR <sup>a</sup> at 0% of FAR <sup>b</sup> on FVC2002 DB1 (average of eight matchers)	Many spurious minutiae appear in the reconstructed fingerprint
Feng and Jain	Nearest minutiae in eight sectors	AM-FM model	Type-I attack <sup>c</sup> : TAR=94.12% at FAR=0.1% on FVC2002 DB1_A and 99.70% rank-1 identification rate on NIST SD4; Type-II attack <sup>d</sup> : TAR=45.89% at FAR=0.1% on FVC2002 DB1_A and 65.75% rank-1 identification rate on NIST SD4 by Verifinger SDK 4.2.	Spurious minutiae and blocking effect appear in the reconstructed fingerprint.
Li and Kot	Nearest minutiae in eight sectors	AM-FM model	Type-II attack: TAR=86.48% at FAR=0.01% <sup>e</sup> on FVC2002 DB1_A by Verifinger SDK 6.3.	Ridge flow and ridge frequency may change in the continuous phase compared to the original fingerprint.
Cao and Jain	Orientation patch dictionary	Continuous phase patch dictionary	Type-I attack: TAR=100% at FAR=0.01% on both FVC2002 DB1_A and FVC2002 DB2_A and 100% rank-1 identification rate on NIST SD4; Type-II attack: TAR=85.23% and TAR=90.29% at FAR=0.01% on FVC2002 DB1_A and FVC2002 DB2_A, respectively, 80.55% rank-1 identification rate on NIST SD4 by Verifinger SDK 6.3.	Requires learning orientation field and ridge pattern

a TAR means true accept rate.

b FAR means false accept rate.

c Type-I attack refers to matching the reconstructed fingerprint against the same impression from which the minutiae set was extracted.

d Type-II attack refers to matching the reconstructed fingerprint against a different impression of the same finger.

e Only minutiae position and direction were used in the matching experiments. Texture information, such as ridge frequency and curvature around minutiae, were ignored.

[Kai Cao and Anil K. Jain(Jan 2015), A comparison of fingerprint reconstruction algorithms proposed in the literature Retrieved from: <http://ieeexplore.ieee.org/document/6928426/>]

Table 1: Comparative results of Previously Implemented Reconstruction Algorithms

### III. EXISTING SYSTEM

The existing system mainly focuses on reconstruction algorithm and it is a step-by-step process which takes place as follows:

Input: Gray Scale Fingerprint Image.

Step 1: Identifying singular points.

Step 2: Extraction of minutiae set.

Step 3: Conversion of minutiae to orientation field using orientation patch dictionary. Orientation density value is interpolated using Delaunay Triangulation.

Step 4: Reconstruction of orientation field using orientation patch dictionary and context based optimization. Gaussian filtering is used to preserve the orientation around minutiae.

Step 5: Reconstruction of ridge pattern using continuous phase patch dictionary.

Step 6: In Fingerprint image reconstruction we find different values for initial fingerprint patch and measure the differences between orientation field and frequency field of initial fingerprint patch for reconstructed fingerprint.

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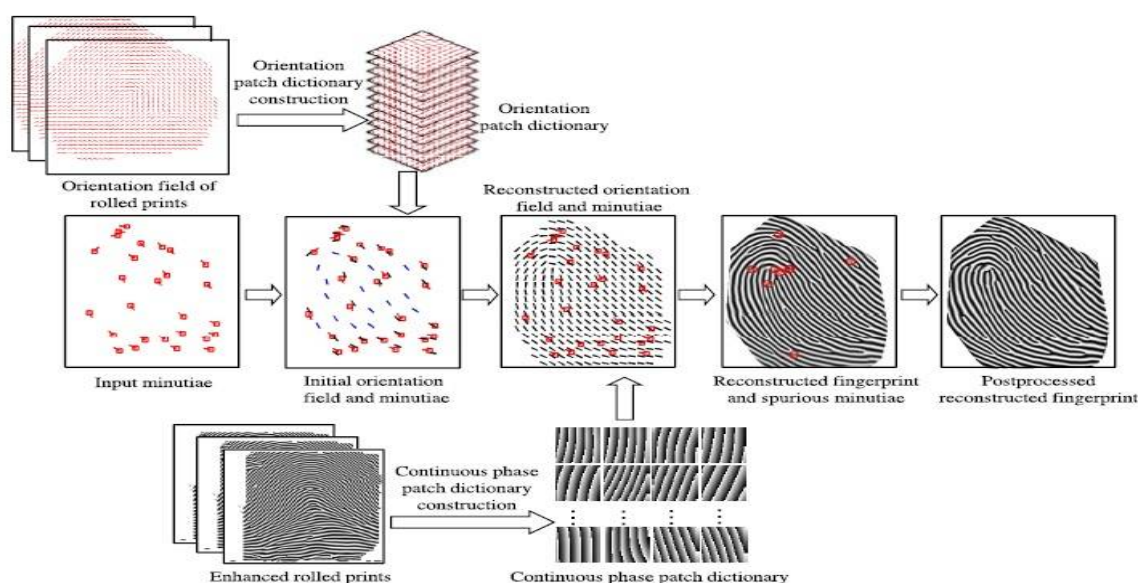
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Step 7: Generation of spurious minutiae in reconstructed fingerprint introduced by overlapping regions.

Step 8: Fingerprint image refinement: Removal of spurious minutiae using Global AM-FM Model. Gabor filtering is used to remove discontinuity segments and smooth the fingerprint region. After Gabor filtering demodulation is used to obtain the final reconstructed image.

Final Step: Reconstructed fingerprint image.



[Kai Cao and Anil K. Jain(Jan 2015), Flowchart of the proposed reconstruction algorithm. Retrieved from: <http://ieeexplore.ieee.org/document/6928426/>]

Fig.3 Existing System Architecture

## IV. PROPOSED SYSTEM

The proposed system mainly focuses on increasing the accuracy of matched fingerprint to the reconstructed fingerprint and to provide Security by preventing unauthorized access for spoofed fingerprints and increasing efficiency by implementing classification technique. Thus Criminal Identification System implements partial fingerprint reconstruction and matching in the following way: In the first step the system performs averaging on the input fingerprint image to convert it to gray scale image. Enhancement is done on the gray scale image to remove noise. Now through Binarization and Thinning minutia is extracted. Then conversion of minutiae to orientation field is done by using orientation patch dictionary. With the help of orientation field generated by the previous step, helps in reconstruction of ridge pattern through continuous phase patch dictionary. After the output generated by the previous step is refined then it is sent for matching with the database and efficiency for matching has been increased by the use of classification technique.

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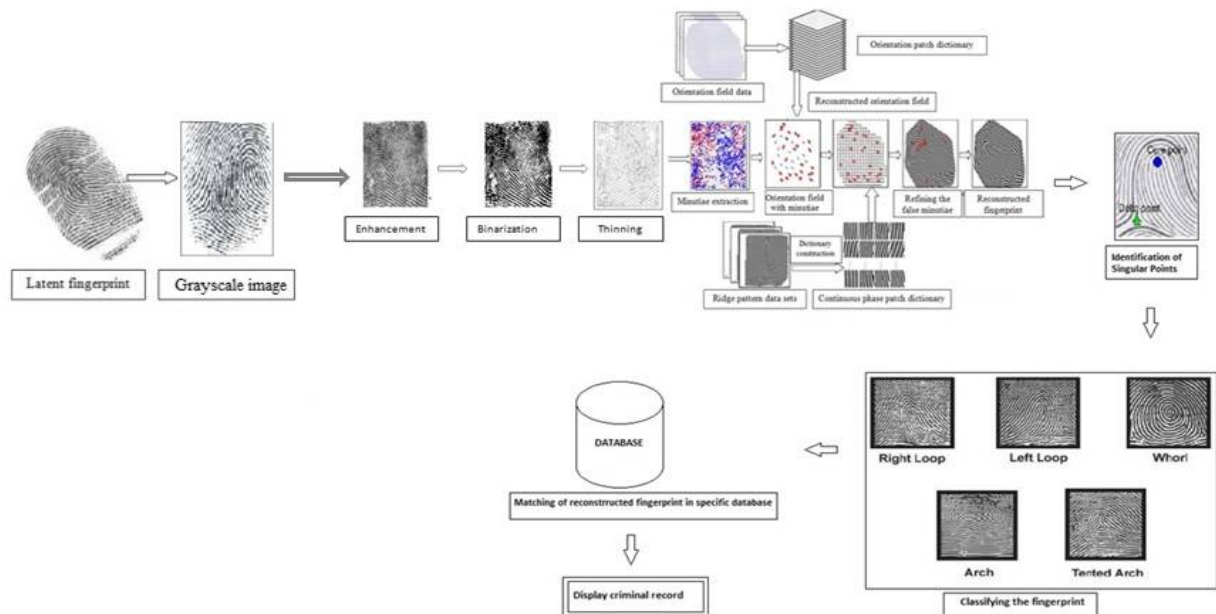


Fig.4 Proposed System Architecture

## V. CRIMINAL IDENTIFICATION SYSTEM

It consists of two system modules:

### I. RECONSTRUCTION

The partial fingerprint found at the crime scene is reconstructed during the reconstruction process which is as follows: (Fig 5)

- Step 1: Any partial fingerprint image (latent, colour, black/white) can be given as an input image to the system.
- Step 2: Averaging is performed to convert the input image into gray scale image.
- Step 3: Enhancement is done on the gray scale image to remove noise.
- Step 4: After enhancement, Otsu Binarization is done to get a binarized image.
- Step 5: Binarized image is thinned through Zang-Suen Thinning Algorithm.
- Step 6: After the above procedure it becomes easier to extract minutiae.
- Step 7: Orientation field is reconstructed through minutiae extraction and Orientation Patch Dictionary.
- Step 8: Ridge flow reconstructed through orientation field and Continuous phase patch Dictionary.
- Step 9: Partial Fingerprint is reconstructed.

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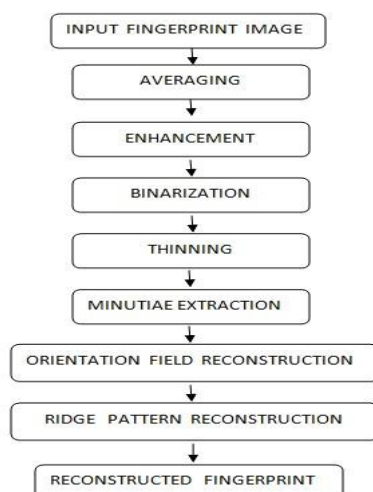


Fig.5 Implementation Process: Reconstruction.

## I. MATCHING

The Identification of the criminal can be easily done during the matching process, when the reconstructed fingerprint generated by reconstruction process is matched with the known fingerprints present in the database. The matching process is explained as follows: (Fig 6)

Step 1: Calculation of singular points i.e.Core and delta are done for Reconstructed Fingerprint.

Step 2: Classification technique through singular points is used to classify the reconstructed fingerprint into one of the five fingerprint classes. (Arch, Left Loop, Right Loop, Tented Arch and Whorl)

Step 3: After the fingerprint has been classified, matching process starts between the reconstructed fingerprint and database (FVC 2002 and NIST SD4)

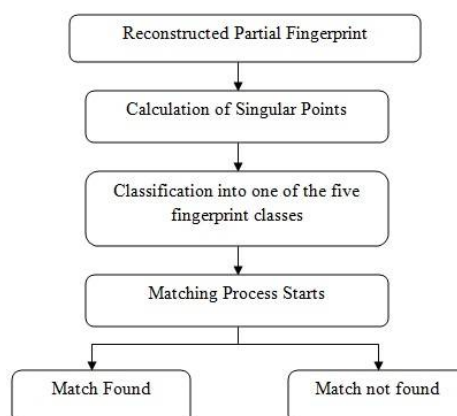


Fig.6 Implementation Process: Matching.

## VI. EXPERIMENTAL RESULTS

For our Criminal Identification System we have experimented in two ways firstly we modified the existed system and added our classification technique to increase the overall performance of the system. The result produced our efficient and less time consuming. Secondly, we are using two public databases NIST SD4 and FVC 2002, both these databases

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contains multiple fingerprints. The output generated when a fingerprint from NIST SD4 database is passed to our Criminal Identification System: (Fig 7)

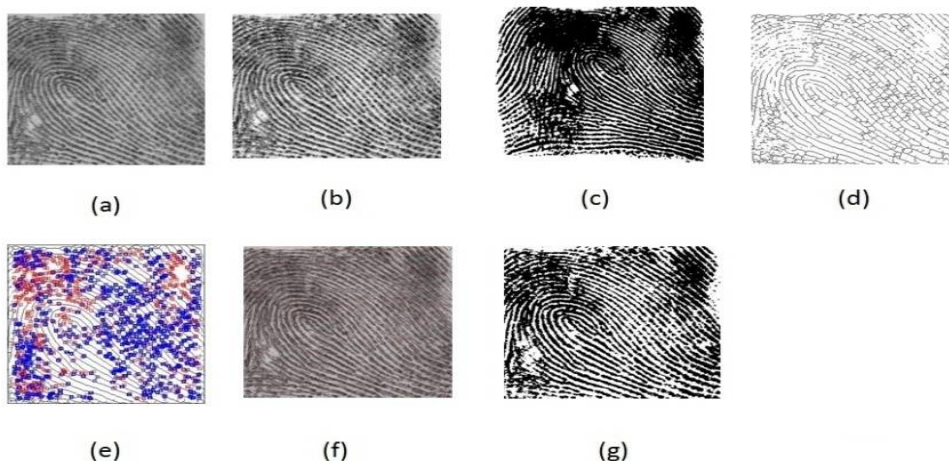


Fig 7: (a)Input Image from NIST SD4 database,(b)Gray Scale Image,(c)Enhanced Image,(d)Thinned Image,(e)Extracted Minutiae,(f)Ridge pattern reconstructed with orientation field.(g)final reconstructed fingerprint.

The output generated when a fingerprint from FVC 2002 database is passed to our Criminal Identification System: (Fig 8)

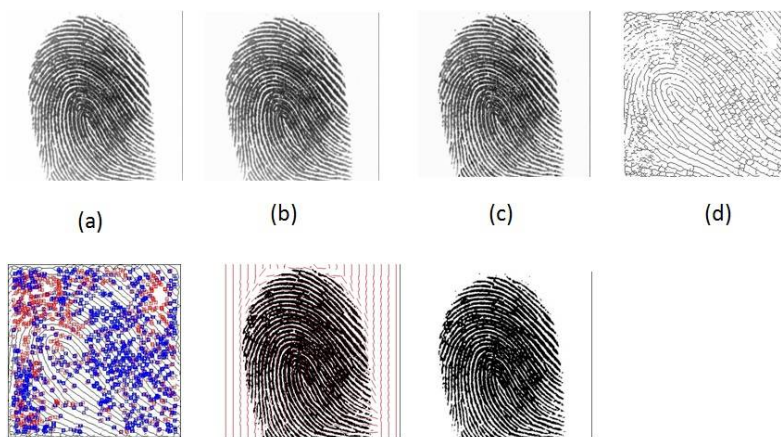


Fig 8: (a)Input Image from FVC 2002 database,(b)Gray Scale Image,(c)Enhanced Image,(d)Thinned Image,(e)Extracted Minutiae,(f)Ridge pattern reconstructed with orientation field.(g)final reconstructed fingerprint.

The difference between the final reconstructed outputs can be clearly seen in the above figures. Output generated by FVC 2002 database fingerprint is more refined when compared it with NIST SD4 database fingerprint. The Classification technique mentioned above generates the following output as follows: (Fig 9 & 10)

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Fig 9 Singular Points Detection (i.e. Core & Delta) did for (a) NIST SD4 Fingerprint (b) FVC 2002 Fingerprint.

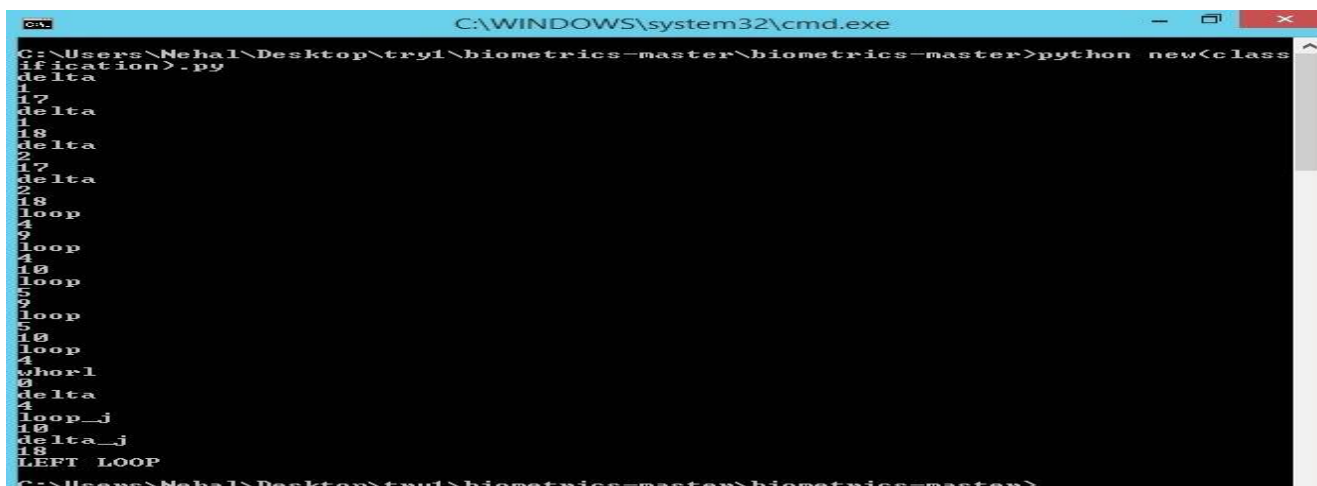


Fig 10. Classification Results for both NIST SD4 fingerprint and FVC 2002 fingerprint.

The classification technique classifies the fingerprint reconstructed into one of the five fingerprint classes. Therefore makes it easier and faster to match the fingerprint from the respective database once its type is known.

## VII. CONCLUSION

In this paper, we used finger print reconstruction algorithm which is efficient and secured for successfully identifying the criminal using his/her partial fingerprint from an input of minutiae set.

## VIII. ACKNOWLEDGEMENTS

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