

**Dedicated to my parents**

*Dr. R.K. Sanatomba Singh and Dr. Y. Momon Devi*

**And my beloved wife and daughters**

*Ksh. Nirmala Devi, Kuina Rajkumari and Langlen Rajkumari*

## **Declaration**

I , **Raju Rajkumar**, bearing Registration Number PHD/854/2009 dated 24/08/2009, hereby declare that the work presented in this thesis entitled “**Fingerprint Recognition System**” is the record of work done by me under the guidance of **Prof. K. Hemachandran**, Department of Computer Science , Assam University, Silchar, Assam. I further declare to the best of my knowledge that no part of the thesis has been submitted for the award of any degree to any other University or Institution.

Place	(Raju Rajkumar)
Date	Research Scholar

## Acknowledgement

First of all, I am very grateful to almighty for inspiring and spiritual will generated within me to complete this thesis.

I would like to address a grateful thanks to my supervisor **Prof. K. Hemachandran** for giving me valuable guidance, constant monitoring and encouragement during my research work. I consider myself very lucky for having worked with such a gentle person like him.

I wish to thank my research colleagues of Assam University, Silchar for their help and moral support throughout my stay here.

On the family side, my sincere thanks go to my parents for their unconditional love and support. And last but not least, I am most thankful to my wife for providing her unfailing support, understanding and love in pursuing PhD.

# Table of Contents

<b>List of Figures.....</b>	<b>ix</b>
<b>List of Tables.....</b>	<b>xi</b>
<b>List of Abbreviation.....</b>	<b>xii</b>
<b>Abstract.....</b>	<b>xiv</b>
<b>1. Introduction.....</b>	<b>1</b>
1.1 Motivation behind the present work .....	2
1.2 Objective of the thesis.....	3
1.3 Thesis contribution.....	3
1.4 Thesis outline.....	4
<b>2. Literature Review.....</b>	<b>6</b>
2.1 Scan Fingerprint Image.....	6
2.2 Latent Fingerprint Image.....	8
2.3 Fingerprint Matching.....	10
2.4 Fingerprint Indexing.....	11
2.1 Chapter Summary.....	14
<b>3. Overview of Fingerprint.....</b>	<b>15</b>
3.1 History of fingerprint.....	15
3.2 Different fingerprint patterns.....	16
3.3 Fingerprint features.....	18
3.4 Requirement of fingerprint recognition system.....	22
3.5 Chapter Summary.....	23
<b>4. Fingerprint Recognition System.....</b>	<b>24</b>
4.1 Previous systems.....	24
4.2 Proposed fingerprint recognition system.....	27
4.2.1 Preprocessing and post processing stages.....	29
4.2.2 Construction of distance feature.....	29
4.2.3 Heap based fingerprint matching.....	29
4.2.4 Fingerprint registration and fingerprint template database..	29

4.2.5	Fingerprint database indexing.....	30
4.3	Chapter Summary.....	30
<b>5.</b>	<b>A Preprocessing Stage and Postprocessing Stage.....</b>	<b>31</b>
5.1	Fingerprint enhancement.....	31
5.1.1	Directional filter.....	32
5.2	Proposed fingerprint enhancement.....	33
5.2.1	Primary enhancement.....	33
5.2.2	Secondary enhancement.....	34
5.3	Necessity of secondary enhancement after primary enhancement.	35
5.4	Minutiae extraction.....	37
5.5	Purifying minutiae.....	38
5.6	The different stage of preprocessing and post processing.....	39
5.7	Chapter summary.....	39
<b>6.</b>	<b>Fingerprint Matching based on MinHeap.....</b>	<b>40</b>
6.1	Introduction.....	40
6.2	Heap based fingerprint matching.....	41
6.3	Orientation independent.....	44
6.4	hFPM test cases.....	44
6.5	Chapter Summary.....	45
<b>7.</b>	<b>Indexing of Fingerprint Database.....</b>	<b>46</b>
7.1	Fingerprint database.....	46
7.2	Fingerprint distance feature.....	48
7.3	Distance feature indexing technique.....	49
7.3.1	Indexing value.....	50
7.3.2	Candidate selection.....	50
7.4	Chapter summary.....	52
<b>8.</b>	<b>Experimental Results and Discussions.....</b>	<b>53</b>
8.1	Database.....	53
8.2	Experimental results of preprocessing and post processing stage..	54
8.3	Experimental results of hFPM fingerprint matching.....	56
8.4	Comparison on fingerprint matching.....	61

8.5	Experimental results on fingerprint database indexing.....	61
8.5.1	Experimentation on DB1.....	62
8.5.2	Experimentation on DB2.....	64
8.5.3	Experimentation on DB3.....	66
8.5.4	Experimentation on DB4.....	67
8.6	Comparison on database indexing.....	70
8.7	Chapter summary.....	70
9	<b>Conclusion and Future Work.....</b>	<b>71</b>
	<b>Bibliography.....</b>	<b>72</b>
	<b>Appendix A Heap Short.....</b>	<b>80</b>
	<b>Appendix B List of Publications.....</b>	<b>81</b>
	<b>Appendix C List of Conference/Seminar/Workshop attended.....</b>	<b>82</b>

# List of Figures

3.1	Different fingerprint patterns.....	17
3.2	Fingerprint Singular point .....	19
3.3	Fingerprint minutiae.....	20
3.4	Fingerprint ridge dimensional features.....	21
4.1	Proposed fingerprint recognition system.....	28
5.1	Orientation of fingerprint ridge flow.....	32
5.2	Two-dimensional Gaussian with $\sigma = 1.5$ .....	34
5.3	Enhancement Image.....	35
5.4	A 32 x 32 block pixel of 4 X 6.....	36
5.5	Skeleton image with and without secondary enhancement.....	36
5.6	Illustration of Crossing Number properties .....	38
5.7	A preprocessing and post processing stages.....	39
6.1	Showing Construction of Minimum heap from minutiae points....	43
6.2	Showing error tolerance $\epsilon$ .....	44
7.1	The two fingerprint images from same finger.....	48
8.1	The different steps of fingerprint implementation.....	55
8.2	Showing original image, core point and minutiae points.....	56
8.3	Showing graph of FNMR and FMR against matching threshold using FVC2002 database.....	58
8.4	Showing graph of different quality of images at different degree of rotation.....	60
8.5	Showing original image and false core point of the fingerprint Image.....	60
8.6	Showing error tolerance ‘K’.....	62
8.7	DB1 Sample images.....	62
8.8	Performance on rotation, noise and scaling test using DB1 FVC 2002 Dataset.....	63
8.9	DB2 Sample images.....	64
8.10	Performance on rotation, noise and scaling test using DB2 FVC 2002 Dataset.....	65
8.11	DB3 Sample image.....	66
8.12	Performance on rotation, noise and Scaling test using DB3	

FVC 2002 Dataset.....	67
8.13 DB4 Sample images.....	68
8.14 Performance on rotation, noise and scaling test using DB4 FVC 2002 Dataset.....	69
8.15 Performance of proposed indexing algorithm on FVC2002 Database.....	69

# List of Tables

2.1	Types of some fingerprint matching algorithm found in the literature.....	12
2.2	Types of some fingerprint indexing technique found in the literature.....	14
7.1	Proposed template database model for fingerprint recognition System.....	47
7.2	Distance feature.....	49
8.1	Description of the FVC 2002 fingerprint dataset.....	53
8.2	The performance evaluation of the proposed method using different fingerprint images.....	54
8.3	Comparison with respect to EER.....	61
8.4	Comparison for indexing performance: Penetration rate at 95% and 100% hit rate.....	70

# List of Abbreviation

FFT	Fast Fourier Transformation
FMR	False Matching Rate
FNMR	False Non Matching Rate
EER	Equal error rate
M <sub>T</sub>	True Minutiae
M <sub>E</sub>	Extract Minutiae
M <sub>F</sub>	False Minutiae
M <sub>D</sub>	Dropped Minutiae
M <sub>TE</sub>	Type-exchange Minutiae
DB	Database
hFPM	Heap based fingerprint matching
PIN	Personal Identification Number
CN	Crossing Number
ROI	Region of Interest
DMF	Directional Median Filter
SPR	Small Particle Reagent
BiPS	Binarised Phase Spectrum

STFT	Short Time Fourier Transformation
FVC	Fingerprint Verification Competition
NBS	National Bureau of Standard
AFIS	Automatic fingerprint Identification System