



CONTENTS

THESIS	i
APPROVAL PAGE	ii
STATEMENT	iii
ACKNOWLEDGMENTS	iv
CONTENTS.....	v
List of Figures	viii
List of Tables	xi
INTISARI	xii
ABSTRACT.....	xiii
CHAPTER I INTRODUCTION	1
1.1 Motivation	1
1.2 Research Problem.....	3
1.3 Problem Formulation.....	4
1.4 Research Objectives	4
1.5 Research benefits.....	4
1.6 Research Contributions	5
1.7 Thesis Overview.....	5
CHAPTER II LITERATURE REVIEW	7
CHAPTER III THEORETICAL THESIS	11
3.1 Biometric	11
3.1.1 Biometric Recognition.....	11
3.1.2 Biometric System.....	12
3.2 Fingerprints	14
3.2.1 Fingerprint Representation.....	15
3.2.2 Fingerprint Impressions	15



3.3	Fingerprint Databases.....	17
3.3.1	Introduction of Fingerprint Verification Competition 2002	17
3.3.2	Database collection	18
3.3	Evaluation of Fingerprint System	19
3.3.1	System Performance by fixed threshold (t)	20
3.4	Segmentation and Finding ROI (Region of Interest)	22
3.5	Fingerprint Enhancement	25
3.5.2	Filtering using Gabor Filter.....	25
3.5.3	Image binary transformation.....	26
3.6	AKAZE FEATURE	27
3.6.1	Nonlinear Diffusion Filtering	27
3.6.2	Building a Nonlinear Scale Space with Fast Explicit Diffusion (FED)	28
3.6.3	Feature Detection using Hessian Response	30
3.6.4	Feature Description using Modified-Local Difference Binary (M-LDB) 30	30
3.7	Feature Matching using Brute Force.....	32
3.8	Artificial Neural Network	33
3.8.1	Architecture of Multilayer Perceptron	34
3.8.2	Activation Function of Rectified Linear Units (ReLU).....	35
3.8.3	Training Procedure (forward propagation and backpropagation).....	36
3.8.4	Optimizer	37
CHAPTER IV RESEARCH METHODOLOGY	41	
4.1	System Analysis	41
4.2	Tools and Materials.....	42
4.2	Research Procedures	43
4.3	General System Design	44
4.3.1	Dataset Preparation Design.....	47



4.3.2 Feature Extraction Design.....	48
4.3.4 Decision Scoring Design.....	50
4.4 Evaluation Design	51
CHAPTER V RESULTS AND ANALYSIS.....	53
5.1 Description of Partial Fingerprint Datasets.....	53
5.2 Baseline Performance using Full Image Recognition	54
5.3 Performance of Proposed Method.....	56
5.3.1 Analysis of Preprocessing Approach	56
5.3.2 Analysis of Decision Scoring Approach.....	60
5.4 Reliability of Proposed method.....	63
5.4.1 Analysis of Various Resolution	64
5.4.2 Analysis of Various Orientation	69
CHAPTER VI CONCLUSIONS	74
6.1 Research Summaries	74
6.2 Research Limitations.....	75
6.3 Future Research.....	75
Bibliographies	76
APPENDIX.....	81
A. Data Acquisition.....	81
B. Image Segmentation and ROI	82
C. Feature Representation	83



List of Figures

Figure 3. 1 Example of biometric traits	12
Figure 3. 2 Enrollment, verification, and identification process.....	13
Figure 3. 3 Fingerprint impression.....	16
Figure 3. 4 Fingerprint level category.....	16
Figure 3. 5 Sample fingerprint image of each database.....	19
Figure 3. 6 FNMR and FMR for a given threshold (t) value.....	20
Figure 3. 7 Example graph of (a) DET and (b) ROC curve.....	21
Figure 3. 8 An example of FMR(t) and FNMR(t) curves.....	22
Figure 3. 9 The morphological process.....	24
Figure 3. 10 Sample of contour extraction (b) from source image (a).....	24
Figure 3. 11 Illustration of LDB extraction	31
Figure 3. 12 Brute force matching process	32
Figure 3. 13 Brute force K-NN algorithm	33
Figure 3. 14 Basic models of neural network	34
Figure 3. 15 Multilayer perceptron architecture	35
Figure 3. 16 ReLU curve	35
Figure 3. 17 Working procedure of a sliding window architecture (Pal et al. 2014)..	39
Figure 3. 18 The sample of (a) partial image and (b) full image with same finger ID but difference impression and orientation.....	40
Figure 3. 19 Iterative Orientation Algorithm	40
Figure 4. 1 General design of training stages	45
Figure 4. 2 General design of testing stages	46
Figure 4. 3 Dataset preparation	47
Figure 4. 4 AKAZE feature extraction flow	49
Figure 4. 5 Brute force process	50
Figure 4. 6 Neural network architecture	51
Figure 5. 1 The process of making (a) a full image into (b) a partial image	54