

Nalini Ratha Ruud Bolle
Editors

Automatic Fingerprint Recognition Systems

With 135 Figures



Springer

Contents

Preface	v
Contributors	xv
1. History of Fingerprint Pattern Recognition	
<i>Simon A. Cole</i>	1
1.1 Introduction	1
1.2 The Development of Fingerprint Classification Systems	2
1.3 Forensic Fingerprint Identification	10
1.4 Diffusion of Fingerprint Systems	14
1.5 Demand for Automation	15
1.6 Automation of Fingerprint Systems	17
1.7 Considerations for the Future	19
References	21
2. Advances in Fingerprint Sensors Using RF Imaging Techniques	
<i>Dale R. Setlak</i>	27
2.1 Introduction	27
2.2 A Taxonomy of Fingerprint Sensing Methods	28
2.3 Intrinsic Advantages of Electric Sensing	30
2.4 History of Electrical Fingerprint Sensing	30
2.5 Commercial Capacitive Sensor Implementations	33
2.6 Capacitive Fingerprint Sensor Performance	34
2.7 RF Imaging	35
2.8 The RF Electric Field Model	41
2.9 The Circuit Model	46
2.10 Types of Fingers	48
2.11 Conclusions and Future Directions	51
References	52

3. Fingerprint Quality Assessment	
<i>Michael Yi-Sheng Yao, Sharath Pankanti, and Norman Haas</i>	55
3.1 Introduction	55
3.2 Assessing Fingerprint Quality	56
3.3 Nonuniform Contact	57
3.4 Inconsistent Contact	60
3.5 Experiments	62
3.6 Conclusions and Future Research	65
References	66
4. Dynamic Behavior in Fingerprint Videos	
<i>Chitra Dorai, Nalini Ratha, and Ruud Bolle</i>	67
4.1 Introduction	67
4.2 MPEG Compression	69
4.3 Distortion Detection in Fingerprint Videos	70
4.4 Experimental Results	78
4.5 Dynamic Behavior Modeling	80
4.6 Conclusion	85
References	86
5. Computer Enhancement and Modeling of Fingerprint Images	
<i>B.G. Sherlock</i>	87
5.1 Introduction	87
5.2 Enhancing Fingerprint Images by Directional Fourier Filtering	89
5.3 A Mathematical Model of Fingerprint Ridge Topology	101
5.4 Conclusions	110
References	110
6. Image Filter Design for Fingerprint Enhancement	
<i>Toshio Kamei</i>	113
6.1 Introduction	113
6.2 Fingerprint Filter Design	114
6.3 Image Enhancement	119
6.4 Results and Discussion	122
6.5 Conclusions	125
References	125
7. Fingerprint Enhancement	
<i>Lin Hong and Anil Jain</i>	127
7.1 Introduction	127
7.2 Spatial Domain Filtering Algorithm	131
7.3 Frequency Decomposition Algorithm	135
7.4 Evaluation of Fingerprint Enhancement Algorithms	139
7.5 Summary	141
References	142

8. Feature Extraction in Fingerprint Images

<i>Weicheng Shen and M.A. Eshera</i>	145
8.1 Introduction and Background	145
8.2 Foreground Detection	149
8.3 Ridge Flow and Ridge Width	152
8.4 Enhancement	158
8.5 Minutiae Detection	165
8.6 Minutiae Detection in Gray-Scale Images	169
8.7 Conclusions	177
8.8 Appendix	178
References	180

9. The State of the Art in Fingerprint Classification

<i>R. Cappelli and D. Maio</i>	183
9.1 Introduction	183
9.2 Literature Review	184
9.3 An MKL-based Fingerprint Classifier	192
9.4 Summary	202
References	203

10. Fingerprint Classification by Decision Fusion

<i>Andrew Senior and Ruud Bolle</i>	207
10.1 Introduction	207
10.2 Previous Work	209
10.3 Ridge Extraction	210
10.4 Fingerprint Recognition by Hidden Markov Models	212
10.5 Decision Tree Classifiers	214
10.6 Fingerprint Classification by Decision Trees	215
10.7 Postprocessing and Classifier Combination	218
10.8 Classifier Efficiency	219
10.9 Results	221
10.10 Previous Results	223
10.11 Conclusions	226
References	226

11. Fingerprint Matching

<i>Salil Prabhakar and Anil K. Jain</i>	229
11.1 Introduction	229
11.2 Fingerprint Verification System	230
11.3 Fingerprint Representation	232
11.4 Fingerprint Matching	236
11.5 Experimental Performance Evaluation	242
11.6 Conclusions	245
References	246

12. Fingerprint Matching Using Distortion-Tolerant Filters	
<i>Craig Watson and David Casasent</i>	249
12.1 Introduction	249
12.2 Filter Types	251
12.3 Data Set Processing	253
12.4 Results	258
12.5 Conclusions	261
References	261
13. Fingerprint Preselection Using Eigenfeatures for a Large-size Database	
<i>Toshio Kamei</i>	263
13.1 Introduction	263
13.2 Fingerprint Preselection	265
13.3 Adaptive Discriminant Distance with Confidence	266
13.4 Feature Extraction	270
13.5 Matching	275
13.6 Experiment and Discussion	277
13.7 Conclusions	280
References	281
14. Systems Engineering for Large-Scale Fingerprint Systems	
<i>Rajiv Khanna</i>	283
14.1 Introduction	283
14.2 Fingerprint Systems Engineering	285
14.3 Performance Evaluation and Benchmarking	288
14.4 Summary and Conclusions	303
References	303
15. Multifinger Penetration Rate and ROC Variability for Automatic Fingerprint Identification Systems	
<i>James L. Wayman</i>	305
15.1 Introduction	305
15.2 Test Data	306
15.3 Vendor Testing	306
15.4 Finger Dependency of Penetration Rate	307
15.5 Penetration Rates of Multifinger Systems	308
15.6 ROC Curves for Communicating and Noncommunicating Impostor Comparisons	310
15.7 Finger Dependency of ROC	311
15.8 Impostor Distribution Variation Across Test Samples	313
15.9 Conclusions	315
References	315

16. Latent Fingerprint Analysis Using an AM-FM Model

<i>Marios Pattichis and Alan Bovik</i>	317
16.1 Introduction	317
16.2 An AM-FM Model for Fingerprints	319
16.3 Extracting the Dominant AM-FM Fingerprint Component	321
16.4 AM-FM Analysis of Minutiae Points	327
16.5 Conclusion	336
References	338

17. Error Rates for Human Latent Fingerprint Examiners

<i>Lyn Haber and Ralph Norman Haber</i>	339
17.1 Introduction	339
17.2 Forensic Science of Fingerprint Comparison	340
17.3 Anecdotal FBI Evidence of a Courtroom Zero Error Rate	343
17.4 Crime Laboratory Consensus Accuracy	344
17.5 Individual Proficiency and Certification Tests	352
17.6 Experimental Test Results	357
17.7 Summary	358
References	359

18. Generation of Synthetic Fingerprint Image Databases

<i>Davide Maltoni</i>	361
18.1 Introduction	361
18.2 Fingerprint Anatomy	363
18.3 How SFINGE Works	365
18.4 Master-Fingerprint Generation	366
18.5 Generation of Synthetic Fingerprint Impressions	374
18.6 Experimental Results and Validation	378
18.7 Conclusions	383
References	383

19. Fingerprint Image Compression and the Wavelet Scalar Quantization Specification

<i>Remigius Onyshczak and Abdou Youssef</i>	385
19.1 Introduction	385
19.2 The General Framework of Wavelet Compression	386
19.3 Choices and Trade-offs in Wavelet Compression	391
19.4 Fingerprint Image Compression: The WSQ Specification	396
19.5 Implementation of WSQ	403
19.6 Summary	411
References	411

20. Security Considerations for the Implementation of Biometric Systems

Colin Soutar 415

20.1 Introduction 415

20.2 API Discussions 417

20.3 General System Design 421

20.4 Relationship with Privacy Principles 425

20.5 Common Criteria 427

20.6 Conclusions 430

References 430

21. Fingerprint Interoperability Standards

R. Michael McCabe 433

21.1 Background 433

21.2 Introduction 434

21.3 Fingerprint Format Standard 435

21.4 FBI Modernization and Image-based Systems 439

21.5 Image Quality Specifications 447

21.6 Fingerprint Research Databases 448

21.7 Future Directions and Trends 448

References 450

Index 453