Contents

1 Introduction and Preliminaries on Biometrics and Forensics Systems 1
1.1 Introduction 1
1.2 Definition of Biometrics 1
1.2.1 Biometric Characteristics 2
1.2.2 Biometric Modalities 2
1.3 Recognition/Verification/Watch-List 5
1.3.1 Verification: Am I Who I Claim to Be? 5
1.3.2 Recognition: Who Am I? 5
1.3.3 The Watch-List: Are You Looking for Me? 6
1.4 Steps of a Typical Biometric Recognition Application 6
1.4.1 Biometric Data Localisation 6
1.4.2 Normalisation and Pre-processing 7
1.4.3 Feature Extraction 8
1.4.4 Matching 9
1.4.5 Databases 9
1.5 Summary 9
References 10

2 Data Representation and Analysis 11
2.1 Introduction 11
2.2 Data Acquisition 12
2.2.1 Sensor Module 13
2.2.2 Data Storage 14
2.3 Feature Extraction 15
2.4 Matcher 16
2.5 System Testing 17
2.6 Performance Evaluation 17
2.7 Conclusion 18
References 19

3 Improving Face Recognition Using Directional Faces 21
3.1 Introduction 21

3.2 Face Recognition Basics 22
3.2.1 Recognition/Verification 22
3.2.2 Steps of a Typical Face Recognition Application 23
3.3 Previous Work 26
3.3.1 Principal Component Analysis (PCA) 26
3.3.2 Independent Component Analysis (ICA) 27
3.3.3 Linear Discriminant Analysis (LDA) 28
3.3.4 Subspace Discriminant Analysis (SDA) 29
3.4 Face Recognition Using Filter Banks 31
3.4.1 Gabor Filter Bank 31
3.4.2 Directional Filter Bank: A Review 33
3.5 Proposed Method and Results Analysis 37
3.5.1 Proposed Method 37
3.5.2 PCA 38
3.5.3 ICA 39
3.5.4 LDA 41
3.5.5 SDA 41
3.5.6 FERET Database Results 43
3.6 Conclusion 45
References 45

4 Recent Advances in Iris Recognition: A Multiscale Approach 49
4.1 Introduction 49
4.2 Related Work: A Review 51
4.3 Iris Localisation 52
4.3.1 Background 52
4.3.2 Iris Segmentation 52
4.3.3 Existing Methods for Iris Localisation 53
4.4 Proposed Method for Iris Localisation 55
4.4.1 Motivation 55
4.4.2 The Multiscale Method 57
4.4.3 Results and Analysis 65
4.5 Texture Analysis and Feature Extraction 67
4.5.1 Wavelet Maxima Components 68
4.5.2 Special Gabor Filter Bank 68
4.5.3 Proposed Method 70
4.6 Matching 71
4.7 Experimental Results and Analysis 72
4.7.1 Database 72
4.7.2 Combined Multiresolution Feature Extraction Techniques . . 72
4.7.3 Template Computation 73
4.7.4 Comparison with Existing Methods 73
4.8 Discussion and Future Work 74
4.9 Conclusion 75
References 75

5 Spread Transform Watermarking Using Complex Wavelets 79
5.1 Introduction 79
5.2 Wavelet Transforms 80
5.2.1 Dual Tree Complex Wavelet Transform 80
5.2.2 Non-redundant Complex Wavelet Transform 83
5.3 Visual Models 86
5.3.1 Chou's Model 87
5.3.2 Loo's Model 93
5.3.3 Hybrid Model 94
5.4 Watermarking as Communication with Side Information 94
5.4.1 Quantisation Index Modulation 96
5.4.2 Spread Transform Watermarking 97
5.5 Proposed Algorithm 98
5.5.1 Encoding of Watermark 99
5.5.2 Decoding of Watermark 100
5.6 Information Theoretic Analysis 100
5.6.1 Decoding of Watermark 101
5.6.2 Parallel Gaussian Channels 102
5.6.3 Watermarking Game 105
5.6.4 Non-iid Data 110
5.6.5 Fixed Embedding Strategies 111
5.7 Conclusion 113
References 113

6 Protection of Fingerprint Data Using Watermarking 117
6.1 Introduction 117
6.2 Generic Watermarking System 119
6.3 State-of-the-Art 123
6.4 Optimum Watermark Detection 124
6.5 Statistical Data Modelling and Application to Watermark Detection 127
6.5.1 Laplacian and Generalised Gaussian Models 128
6.5.2 Alpha Stable Model 129
6.6 Experimental Results 130
6.6.1 Experimental Modelling of DWT Coefficients 132
6.6.2 Experimental Watermarking Results 135
6.7 Conclusions 138
References 139

7 Shoemark Recognition for Forensic Science: An Emerging Technology 143
7.1 Background to the Problem of Shoemark Forensic Evidence 143
7.1.1 Applications of a Shoemark in Forensic Science 144
7.1.2 The Need for Automating Shoemark Classification 146
7.1.3 Inconsistent Classification 147

7.1.4 Importable Classification Schema 148
7.1.5 Shoemark Processing Time Restrictions 149
7.2 Collection of Shoemarks at Crime Scenes 149
7.2.1 Shoemark Collection Procedures 150
7.2.2 Transfer/Contact Shoemarks 150
7.2.3 Photography of Shoemarks 151
7.2.4 Making Casts of Shoemarks 152
7.2.5 Gelatine Lifting of Shoemarks 153
7.2.6 Electrostatic Lifting of Shoemarks 153
7.2.7 Recovery of Shoemarks from Snow 154
7.2.8 Recovery of Shoemarks using Perfect Shoemark Scan 154
7.2.9 Making a Cast of a Shoemark Directly from a Suspect's Shoe 155
7.2.10 Processing of Shoemarks 155
7.2.11 Entering Data into a Computerised System 157
7.3 Typical Methods for Shoemark Recognition 157
7.3.1 Feature-Based Classification 158
7.3.2 Classification Based on Accidental Characteristics 159
7.4 Review of Shoemark Classfication Systems 160
7.4.1 SHOE-FIT 160
7.4.2 SHOE© 160
7.4.3 Alexandre's System 161
7.4.4 REBEZO 161
7.4.5 TREADMARK ™ 162
7.4.6 SICAR 162
7.4.7 SmART 162
7.4.8 De Chazal's System 163
7.4.9 Zhang's System 163
References 163

8 Techniques for Automatic Shoeprint Classification 165
8.1 Current Approaches 165
8.2 Using Phase-Only Correlation 166
8.2.1 The POC Function 166
8.2.2 Translation and Brightness Properties of the POC Function 168
8.2.3 The Proposed Phase-Based Method 168
8.2.4 Experimental Results 170
8.3 Deployment of ACFs 172
8.3.1 Shoeprint Classification Using ACFs 173
8.3.2 Matching Metrics 175
8.3.3 Optimum Trade-Off Synthetic Discriminant Function Filter 176
8.3.4 Unconstrained OTSDF Filter 177
8.3.5 Tests and Results 178

8.4 Conclusion . . . 179
References . . . 180

9 Automatic Shoeprint Image Retrieval Using Local Features . . . 181
9.1 Motivations . . . 181
9.2 Local Image Features . . . 181
9.2.1 New Local Feature Detector: Modified Harris–Laplace Detector . . . 182
9.2.2 Local Feature Descriptors . . . 186
9.2.3 Similarity Measure . . . 188
9.3 Experimental Results . . . 189
9.3.1 Shoeprint Image Databases . . . 189
9.4 Summary . . . 199
References . . . 200

Index . . . 203