Ain Shams University
Faculty of Computer
& Information Sciences
Computer Science Department

Developing a Multimodal Biometric System Based on Single Camera

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By:

Ahmed Salah ELDin Mohammed ELSayed

Ms.C in Computer Science,
Faculty of Computer and Information Sciences,
Ain Shams University.
Cairo, Egypt

Supervised By:

Prof. Dr. Mohamed Roushdy
Prof. in Computer Science Dept., Faculty of Computer and Information Sciences, Ain Shams University

Prof. Dr. Zaki Taha
Prof. in Computer Science Dept., Faculty of Computer and Information Sciences, Ain Shams University

Dr. Hala Moushier
Assoc. Prof. in Scientific Computing Dept., Faculty of Computer and Information Sciences, Ain Shams University

Faculty of Computer and Information Sciences
Ain Shams University
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Abstract

Multimodality is often seen as a way to solve some of the problems raised by the use of single biometric. Indeed, combining two or more modalities can significantly improve the overall accuracy, address the non-universality problem, resist to spoof attacks and help searching a large database in a computationally efficient manner. However, multimodal systems may require using many sensors and additional time for user enrollment especially when using contact-based sensors (e.g. fingerprint) or intrusive sensors (e.g. iris). This makes them more expensive and less convenient to the user.

This thesis aims to fuse two hand modalities, palmprint and inner-knuckle-prints (IKPs) of fingers. These modalities can be extracted from the hand using a traditional camera in contactless manner. Using a single camera can facilitate the enrollment process and make it more convenient for users. In addition, due to the low cost, compact size and the widespread availability of such cameras in most laptops and mobiles, it allows the system to be used by large number of users in wide-range of applications (e.g. personal accounts over the web, e-voting, electronic identity in the e-government applications). Moreover, being contactless help addressing the hygiene issue, avoid the possibility of copying the latent hand prints for illegitimate use and avoid the problem of contaminating the device surface in harsh environments.

However, many challenges arise from using contactless camera in unconstrained and guideless environment. First, geometric transformations, existence of hand wrist, connected fingers, finger rings and other hand accessories can highly affect the extraction of palm and knuckles region-of-interests (ROIs). Second, pose and illumination variations can affect the layout and visibility of palm and knuckle lines. In addition, different ways of holding out the hand can lead to extra wrinkles and false line-like features. These can affect the performance of some contact-based methods and raise the need to develop special algorithms to cope with contactless conditions.

This thesis proposes a complete multibiometric system to cope with the above challenges. The main contributions can be summarized as follows; first, propose a simple method for checking the hand existence and extracting the palm and knuckles ROIs from unconstrained contactless environment. The method is based on blob analysis, morphological and geometrical operations without a need to pre-train or parameter adjustment. The method copes with hand scale, rotation, connected fingers and the existence of finger rings, hand wrist and other false objects. It's tested on four publicity available inner hand databases (DBs) that cover these challenges; namely, Sfax-Miracl, IITD, PolyU 3D/2D and HGC. Based on the proposed evaluation methodology, the method correctly extracts the palm ROI in more than 99% and the knuckles ROIs in more than 97.8% of each DB. For the hand existence checking, the method correctly identifies the absence of the hand in 99% of non-hand images from four skin-based DBs.

Second contribution; propose a new SIFT-based method for palmprint and inner-knuckle-print (IKP) recognition with three main modifications from the traditional SIFT. First, the regions with no significant lines/wrinkles are masked out to reduce the false features. A region with multi lines are then described by multi descriptors rather than a single one. Second, instead of matching all query keypoints with all target ones, only those with small rotation difference are matched together. This speedup the matching process and enhance the accuracy by reducing the wrong matches. Third, an align-based refinement is applied to filter out the incorrect matches. The method is tested on three contactless hand DBs; namely, IITD, PolyU 2D/3D and Sfax-Miracl. These DBs cover variations in image resolution, sensor type and capture environment. In verification scenario, for palmprint, the method achieves an equal error rate (EER) of 0.72%, 0.59% and 1.14% and a genuine accept rate (GAR) of 97.0%, 95.5% and 85.8% at false accept rate (FAR) of

0.001% on each DB, respectively. For index knuckleprint, it achieves an EER of 6.52%, 5.02% and 5.57% and a GAR of 62.1%, 55.3% and 65.9% at FAR of 0.001% on each DB, respectively. In identification scenario with one training image per subject, the method achieves a correct identification rate (CIR) of 98.9%, 99.4% and 98.7% for palmprint and 83.1%, 87.2% and 88.2% for index IKP on the three DBs, respectively.

Third contribution; the fusion of the palmprint and the fingers IKPs is compared at three different levels; score, decision and rank levels. The best results are achieved at score level fusion using the Hamacher method. In verification scenario, the score level fusion leads to enhance both the EERs and the GARs. It achieves an EER of 0.36%, 0.54% and 0.94% and a GAR of 98.4%, 97.1% and 96.2% at FAR of 0.001% on IITD, PolyU 2D/3D and Sfax-Miracl DBs, respectively. In identification scenario with one training image per subject, the score level fusion leads to a CIR of 99.7%, 99.5% and 99.0% for the three DBs, respectively. Moreover, compared with the five available literature works of fusing the hand biometrics on the same DBs (to the best of our knowledge), the proposed score fusion method gives the best results.

Fourth contribution; build a ground truth for the location of fingers tips, valleys and center knuckles of five public hand DBs (Sfax-Miracl, IITD, PolyU 3D/2D, HGC and BioChaves). These ground truth can help in the assessment of palm/knuckle ROI extraction methods and the IKP recognition methods (To the best of our knowledge, no public IKP database are available in the literature). These ground truth are made available for research.

Publications

1. A. S. ELSayed, H. M. Ebeid, M. Roushdy and Z. T. Fayed, "A method for contactless palm ROI extraction," in 11th International Conference on Computer Engineering & Systems (ICCES), IEEE, Cairo, Egypt, 2017.

2. A. S. ELSayed, H. M. Ebeid, M. Roushdy and Z. T. Fayed, "Robust Palm-Knuckle ROI Extraction in Unconstrained Environment," in IEEE International Conference on Identity, Security and Behavior Analysis (ISBA 2018), Singapore, 2018 [**ACCEPTED**].

3. A. S. ELSayed, H. M. Ebeid, M. Roushdy and Z. T. Fayed, " Masked SIFT with Align-Based Refinement for Contactless Palmprint Verification," in IEEE International Conference on Identity, Security and Behavior Analysis (ISBA 2018), Singapore, 2018 [**ACCEPTED**].

4. A. S. ELSayed, H. M. Ebeid, M. Roushdy and Z. T. Fayed, " Robust Palm and Knuckle ROIs Extraction in Unconstrained Environment," Pattern Analysis and Applications, 2018 [**UNDER REVIEW –** last check 7 MAR 2018].

5. A. S. ELSayed, H. M. Ebeid, M. Roushdy and Z. T. Fayed, " Masked SIFT with Align-Based Refinement for Contactless Palmprint Recognition," IET Biometrics, 2018 [**UNDER REVIEW –** last check 7 MAR 2018].

Presentation

The power point presentation of this thesis is available at the following link:

https://www.dropbox.com/s/noffimvbbjl10it/Thesis%20presentation.pptx?dl=0

It summarizes the main contributions of this thesis together with the proposed methods and their results.

Table of Contents

Acknowledgement ..... **I**

Abstract ..... **II**

Publications ..... **IV**

Presentation ..... **IV**

List of Tables ..... **VIII**

List of Figures ..... **X**

List of Abbreviations ..... **XV**

1. Introduction **1**

1.1. Biometrics 1
1.1.1 Definition *1*
1.1.2 Requirements *1*
1.1.3 Usage Principles *1*
1.1.4 Affected Factors *2*
1.2. Single vs. Multi Biometrics 3
1.2.1 Pros and Cons *3*
1.2.2 Sources and Processing Sequence *4*
1.2.3 Level of Fusion *5*
1.3. Contactless Hand Biometrics 8
1.4. Problem Definition 9
1.5. Thesis Contributions 10
1.6. Thesis Overview 11

2. Survey of Contactless Hand Biometrics **12**

2.1. Introduction 12
2.2. Devices and Databases 12
2.2.1 Devices *12*
2.2.2 Contactless Databases *17*
2.3. Segmentation 19
2.3.1 Hand segmentation *19*
2.3.2 Valleys and Tips *23*
2.3.3 ROIs Extraction *26*
2.4. Feature Extraction and Matching 29
2.4.1 Palmprint *29*
2.4.2 Inner Knuckle-Print (IKP) *35*
2.5. Fusion with other modalities 40
2.6. Discussion and Conclusion 40

3. Robust Palm-Knuckle ROIs Extraction in Unconstrained Environment **45**

3.1. Introduction 45
3.2. Literature Survey and Related Work 45
3.3. The Proposed ROIs Extraction Method 50
3.3.1 Skin-based Segmentation *50*
3.3.2 Hand Validation *51*
3.3.3 Estimation of Hand Measures *54*

3.3.4 Hand Wrist Removal *59*
3.3.5 Fingers Separation *60*
3.3.6 Finger Holes Fixation *62*
3.3.7 Hand Rotation Adjustment *65*
3.3.8 Detection of Hand Geometric Points *67*
3.3.9 Left/Right Determination *68*
3.3.10 Palm ROI Extraction *69*
3.3.11 Finger ROI Extraction *70*
3.3.12 Knuckle ROI Extraction *70*
3.3.13 Quality Assessment *71*
3.4. Experimental Setup 73
3.4.1 Databases Descriptions *73*
3.4.2 Performance Criteria *76*
3.4.3 Evaluation Methodologies *77*
3.5. Experimental Results 79
3.5.1 Testing Hand Validation *79*
3.5.2 Testing Hand Geometric Point Extraction *80*
3.5.3 Testing Robustness to Scale and Rotation *82*
3.6. Conclusions and Future Work 85

4. Palmprint Recognition 88

4.1. Introduction 88
4.2. Literature Survey and Related Works 89
4.3. Preprocessing 91
4.3.1 Circular Gabor (CG) *91*
4.3.2 CLAHE *91*
4.3.3 Circular Gabor CLAHE (CG-CLAHE) *92*
4.3.4 Local Histogram Equalization (LocalHE) *92*
4.3.5 Local Contrast Enhancement (LocalCE) *92*
4.3.6 GAMMA-HM-COMP (GMC) *92*
4.4. Method Description 93
4.4.1 Masked SIFT *94*
4.4.2 Selective Matching *98*
4.4.3 Align-based Refinement *99*
4.5. Experimental Setup 103
4.5.1 Databases *103*
4.5.2 Performance Criteria *104*
4.5.3 Evaluation Methodologies *105*
4.6. Experimental Results 105
4.6.1 Study1: Masked SIFT vs. traditional SIFT *105*
4.6.2 Study2: Align-based vs. RANSAC *108*
4.6.3 Study3: Benchmark with literature methods *109*
4.6.4 Analysis on Computational Complexity *114*
4.7. Conclusions and Future Work 115

.5 Inner-Knuckle-Print Recognition 116

5.1. Introduction 116
5.2. Literature Survey and Related Work 117
5.3. ROI Ground Truth 118
5.4. Method Description 119

5.4.1 Step1: Masked SIFT *120*
5.4.2 Step2: Selective Matching *124*
5.4.3 Step3: Align-based Refinement *126*
5.5. Experimental Setup 127
5.5.1 Databases *127*
5.5.2 Selected Methods *128*
5.6. Experimental Results 129
5.6.1 Study1: RANSAC vs. Align-Based *131*
5.6.2 Study2: Verification Accuracy Benchmark *133*
5.6.3 Study3: Identification Accuracy Benchmark *135*
5.6.4 Analysis on Computational Complexity *142*
5.7. Conclusions and Future Work 143

.6 Fusion of Palmprint and Inner-Knuckle-Prints 145

6.1. Introduction 145
6.2. Literature Survey 146
6.3. Multibiometric System Schemes 147
6.3.1 Score-Level Fusion *147*
6.3.2 Decision-Level Fusion *148*
6.3.3 Rank-Level Fusion *148*
6.4. Experimental Setup 150
6.4.1 Databases *150*
6.4.2 Evaluation Criteria *151*
6.5. Experimental Results 152
6.5.1 Individual Biometrics Results *152*
6.5.2 Score-level Fusion Results *153*
6.5.3 Decision-level Fusion Results *158*
6.5.4 Rank-level Fusion Results *159*
6.5.5 Comparison with Published Literature Results *161*
6.6. Conclusions 161

7. Conclusions and Future Research Directions 163

7.1. Conclusions 163
7.2. Future Research Directions 164

8. References 165

List of Tables

Table 2.1: Summary of different contactless devices that used to capture the hand biometrics 13
Table 2.2: Summary of contactless hand databases 18
Table 2.3: Top5 algorithms in the Hand Geometric Points (HGC) extraction competition 24
Table 2.4: Comparison between common approaches of palmprint recognition methods 30
Table 2.5: Summary of different contactless palmprint recognition methods in the literature 31
Table 2.6: Summary of different contactless inner-knuckle-print recognition methods in the literature 37
Table 2.7: Summary of literature works that fuse the hand biometrics together and with other biometrics . 41
Table 3.1: Literature methods of palm ROI extraction step and their supported features 47
Table 3.2: Literature methods of inner knuckles ROIs extraction and their supported features 49
Table 3.3: Four common cases of connected fingers and their conditions 58
Table 3.4: Five hand DBs with their existing variations, total number of images, resolution, number (percentage) of images with hand wrist, connected fingers, finger holes and background regions 74
Table 3.5: Number (and percentage) of not detected hands in each of the five hand DBs 79
Table 3.6: Number (and percentage) of wrongly detected hands in each of the four negative DBs 80
Table 3.7: Hand geometric points detection results of the proposed method on the five DBs 80
Table 3.8: Percentage of the misses in the thumb valleys and tips from the total misses in each DB. The detection rates are shown again after neglecting the thumb misses 80
Table 3.9: Testing set results of the TOP5 winners of the HGC competition together with the results of the proposed method 81
Table 3.10: Number (and percentage) of L/R determination error, palm extraction error before and after neglecting the acquisition errors 81
Table 3.11: Number (and percentage) of knuckle extraction error (%) for each DB 82
Table 3.12: Scale and Rotation effect: palm extraction error (max, mean and std) of 10 random runs and the difference from the original error 85
Table 3.13: Scale and rotation effect: knuckles extraction error (max, mean and std) of 10 random runs and the difference from the original error 85
Table 3.14: Average execution time (ms), palm and knuckles extraction errors of the proposed method on the four inner-hand DBs at moderate scale 86
Table 4.1: Comparison between common approaches of palmprint recognition methods 90
Table 4.2: Used parameters of each preprocessing method 92
Table 4.3: Average number of calculated distances and verification accuracy (EER %) of MaskedSIFT method using the original Lowe's matching and the selective matching in different databases 99
Table 4.4: Number of genuine and imposter matches for each hand in each database 104
Table 4.5: Parameters of each step in the proposed method together with their used values 105
Table 4.6: Average number of extracted keypoints using SIFT and MaskedSIFT in different databases 109
Table 4.7: The verification results for the proposed method and some literature methods using all 460 palms of the current version of IITD DB 110
Table 4.8: The verification results for the proposed method and some literature methods using the older version of IITD DB (2791 images) 110
Table 4.9: The verification results for the proposed method and some literature methods using the GPDS DB 111
Table 4.10: The identification results for the proposed method and some literature methods using the current version of IITD DB (all 460 palms – 5 images per palm) 112

Table 4.11: The identification results for the proposed method and some literature methods using the current version of IITD DB (459 palms – all images per palm) 113
Table 4.12: The identification results for the proposed method and some literature methods using the GPDS DB 113
Table 4.13: EER and CIR of the proposed method using different sets of the Sfax-Miracl DB 114
Table 4.14: Average execution time (ms) and EER (%) of the traditional SIFT method vs. the proposed method using the GPDS DB 114
Table 5.1: Average number of calculated distances and verification accuracy (EER %) of the proposed method using the original Lowe's matching and the selective matching for the index knuckle of different databases 125
Table 5.2. Parameters of each method, the set of values that are experimentally tried and the selected optimal value 130
Table 5.3. Number of genuine and imposter for each DB 131
Table 5.4. Parameters of each step in the proposed method together with their used values 131
Table 5.5: Verification EER (%) of all methods over each finger of the three DBs 133
Table 5.6: Published results of literature methods over publicly available DBs in comparison with the results of the proposed method using the same testing methodology 142
Table 5.7: Average execution time (ms) and EER (%) of the proposed method over the index finger knuckle of the three DBs 143
Table 6.1: Number of genuine and imposter for each DB 151
Table 6.2: Verification EER (%) of each individual biometric over the three DBs 152
Table 6.3: CIR (%) (mean and standard deviation) of each individual biometric over the three DBs with different number of training images 152
Table 6.4: Verification EER (%) for ten score-level fusion methods of the five biometric traits over the three DBs. The EER of the individual modality (palmprint and best knuckleprint) are shown for comparison 153
Table 6.5: CIR (%) (mean and standard deviation) for palmprint, index knuckleprint and Hamacher score fusion over the three DBs with different number of training images 157
Table 6.6: Verification FAR and FRR of the decision level fusion using weighted majority voting with two threshold selection methods over the three DBs. The FRRs of palmprint at the same FARs are shown for comparison 159
Table 6.7: CIR (%) (mean and standard deviation) for palmprint, score level and decision level fusion over the three DBs with different number of training images 159
Table 6.8: CIR (%) (mean and standard deviation) for the seven rank level fusion methods over the three DBs with different number of training images. The score level fusion is shown in the last row for comparison. (Top three results of rank-level fusion are shown in red, green and blue. Best overall results are shown in bold black) 160
Table 6.9: Published results of literature methods over publicly available DBs in comparison with the results of the Hamacher score fusion using the same testing methodology 162

List of Figures

Figure 1.1: Verification phases 2
Figure 1.2: Identification phases 2
Figure 1.3: Five sources of multibiometric system 4
Figure 1.4: Examples of the five level of fusions of multibiometric 5
Figure 1.5: Example on the amount of information at each level of fusion 5
Figure 1.6: Application examples of the contactless hand recognition 9
Figure 1.7: Proposed system architecture 10
Figure 1.8: Examples of different challenges that appear in contactless hand biometrics 10
Figure 2.1: Examples on special-made devices with lighting source and/or closed box 16
Figure 2.2: Examples on special-made devices with infrared camera together with normal camera 16
Figure 2.3: Examples on normal devices with constrained environments 17
Figure 2.4: Samples from some contactless hand databases that are publicity available 20
Figure 2.5: Examples on the test images and the segmentation results from Gaussian Multiscale Aggregation Method 22
Figure 2.6: Hand segmentation steps of [17]: (a) original image (b) detection result of skin color (c) hand image after morphological operations. 23
Figure 2.7: Nine keypoints to be extracted in the HGC'11 competition 23
Figure 2.8: Samples from BioStar hand database that is used in HGC'11 competition 24
Figure 2.9: The process of skeleton construction: (a) binary image; (b) boundary corridor and minimal perimeter polygon; (c) continuous skeleton of polygon, and (d) skeleton after pruning 24
Figure 2.10: Detection of (a) palm center and fingers branches, and (b) tips and valleys for each finger 25
Figure 2.11: Preprocessing steps to separate the touching fingers 26
Figure 2.12: Fingers isolation steps: (a) original segmented image, (b) result after applying opening (c) fingers after subtracting (b) from (a) 26
Figure 2.13: Square ROI extraction in (a) [7] and (b) [46] 27
Figure 2.14: Extracting max rectangular ROI proposed in [6] 27
Figure 2.15: Steps of extracting inner knuckle ROI in [59] 28
Figure 2.16: Steps of extracting finger surface ROIs in [57] 29
Figure 3.1: Proposed ROIs extraction steps 51
Figure 3.2: Examples of the hand segmentation results. First row: original images from the four DBs, second row: segmentation results 51
Figure 3.3: Objects separation steps 52
Figure 3.4: Examples of rejected hands at a) hand level, b) palm level and c) & d) finger level validations 52
Figure 3.5: Steps of extracting palm region (a, b) and fingers candidates (c, d) 53
Figure 3.6: Steps of detecting and filtering out a non-finger candidate 55
Figure 3.7: Same angle for a) correct case and b) up-side-down case, and c) detection of up-side-down case 56
Figure 3.8: Steps of hand wrist checking 57
Figure 3.9: Examples on the first three cases of the connected fingers and their satisfied conditions 57
Figure 3.10: Example on the 4th case (partially connected fingers) with the two conditions (a,b) of the palm peak 58
Figure 3.11: Steps of hand wrist removal 60
Figure 3.12: Fingers separation steps 61
Figure 3.13: Results of three passes from finger separation step with different Robert coefficients 61

Figure 3.14: Angle calculations a) before and b) after the morphological steps and rejected components by c) first six validations and d) seventh validation 63
Figure 3.15: Closing operation to fill the hole, a) the closing area around the hole, b) the region inside it, c) the SE and d) closing result 64
Figure 3.16: Results of hole filling after b) the first iteration and c) the second iteration..... 64
Figure 3.17: Examples of a) false rejected finger-parts hole length and b) false accepted component..... 64
Figure 3.18: Calculating hand angle a) with thumb finger and b) without it. Largest Eigen vector is shown, as a line, in both cases. 65
Figure 3.19: Steps of detecting thumb finger..... 66
Figure 3.20: Detection and correction of the adjustment angle in the up-side-down case 66
Figure 3.21: Example of rejecting the valley that is caused by a) false bridging a component to the hand using b) Refinement1..... 68
Figure 3.22: Effect of relaxing the condition after b) detecting three valleys using the original conditions in order to c) detect the fourth valley after relaxation..... 68
Figure 3.23: Using four valley points to determine left/right hand 69
Figure 3.24: Steps of extracting palm ROI. a) and b) are Fine orientation, c) palm width estimation and d) square ROI extraction..... 69
Figure 3.25: Steps of extracting fingers ROIs. a) original image, b) tips, valleys and two extra points, c) fingers separated from the hand and d) vertically aligned fingers. 70
Figure 3.26: Steps of extracting knuckle ROI from a) image with incomplete and skewed fingers. b) hor. edges, c) after removing strong & weak edges from b), d) binary image of c), e) hor. projection of d) together with search area (green) and selected peak (red), f) search area & peak on the finger image, g) extracted knuckles..... 71
Figure 3.27: Checking the brightness level of a) well-brighten palm and b) bad-brighten palm (A_{max} exceeds the right bound) 72
Figure 3.28: Example of calculating the low and high codes of Local Ternary Pattern..... 72
Figure 3.29: Steps of checking the visibility of the three palm principle lines in a good-quality palm image (1st row) and a bad-quality one (2nd row). 73
Figure 3.30: Different examples from the five hand DBs after hand segmentation step 75
Figure 3.31: Nine characteristic points on the hand: 5 finger tips and 4 valleys 75
Figure 3.32: User interface to select the ground truth of (a) tips and valleys and (b) knuckle-lines..... 76
Figure 3.33: Examples of (a) palm extraction error and (b) knuckle extraction error 77
Figure 3.34: Examples for the skin regions from the four DBs that represent negative examples for the open hand..... 78
Figure 3.35: Palm extraction error in IITD DB due to the incomplete hand in the acquisition step..... 81
Figure 3.36: Knuckles extraction error in IITD DB due to the incomplete fingers in hand segmentation step 82
Figure 3.37: Scale effect: palm extraction error at different scales of the a) first three DBs and b) HGC DB. Original extraction error of each DB is shown as reference 83
Figure 3.38: Scale effect: knuckles extraction error at different scales of the a) first three DBs and b) HGC DB. Original extraction error of each DB is shown as reference 83
Figure 3.39: Rotation effect: max, min and mean (red dash) extraction error of 10 runs for a) palm ROI extraction and b) knuckles ROI extraction over all DBs. Original extraction error of each DB is shown as reference 84

Figure 3.40: Scale and rotation effect: max, min and mean (red dash) extraction error of 10 runs for a) palm ROI extraction and b) knuckles ROI extraction over all DBs. Original extraction error of each DB is shown as reference 84
Figure 3.41: Input (1st row) and output (2nd row) of some successful examples over different challenges .. 86
Figure 3.42: Examples of failed cases due to the failure in fingers separation step because of a) blurred fingers, b) shadow inside the palm region, c) very small size and d) false object connected to the hand..... 86
Figure 4.1: Examples of how the hand pose and illumination affect the visibility of the palm lines and wrinkles (first row: two hand images from the same subject, second row: extracted palm ROIs) 89
Figure 4.2: Output of the five preprocessing methods on Palm ROI from the three DBs IITD (1st row), GPDS (2nd row) and Sfax-Miracl (3rd row) [Values are scaled to [0, 255] for illustration purpose]..... 91
Figure 4.3: Block diagram of GAMMA-HM-COMP method..... 92
Figure 4.4: Established coordinate system during the palm ROI extraction of two rotated images for the same hand. Extracted palm ROIs are shown on the top-right corner of each image with minor rotation difference between them 93
Figure 4.5: Three steps of the proposed method..... 93
Figure 4.6: OLOF-Based masking of palm image, a) OLOF gives large responses at lines/wrinkles (in red) and small responses at background (blue), b) masking result with threshold $\boldsymbol{TM}$ = 15.2..... 95
Figure 4.7: Keypoints of a) original SIFT and b) Masked SIFT. Line regions (in red) are correctly described in MaskedSIFT while not described in original SIFT. Non-line region (in blue) are described with many keypoints in original SIFT while few keypoints in MaskedSIFT 95
Figure 4.8: Regions with their orientation histograms and dominant orientations. Region 1 with single line and one dominant orientation (in blue), Region 2 with three lines and one dominant orientation, each line is represented by single location (in green), Region 3 with two lines and two dominant orientations (blue and yellow) 97
Figure 4.9: Two SIFT descriptors oriented at the dominant orientation of two different locations..... 98
Figure 4.10: Two wrong matches are detected by a) the original Lowe's matching while not detected by b) the Selective matching due to large angle difference. Four additional matches are correctly detected by the Selective matching while not detected by the Lowe's matching..... 99
Figure 4.11: Four false matches that appear in a) the all matches while removed in b) the refined matches 100
Figure 4.12: Illustration of align-based refinement, a) five original matches (3 are true (green), one is wrong (red) while one (orange) can be falsely rejected due to large position shifting), b) four refined matches after aligning the query keypoints with on the target one (x-trans. = -33, y-trans. = 26 and angle = 12°) (wrong match (red) is rejected while the orange one is accepted)..... 100
Figure 4.13: Pseudocode of the proposed align-based refinement..... 102
Figure 4.14: Samples of Palm ROI from the three DBs a)IITD, b) GPDS and c) Sfax-Miracl 104
Figure 4.15: EER (%) of the traditional SIFT with Lowe's matching and the masked SIFT with selective matching using each of the six preprocessing methods over GPDS DB. 106
Figure 4.16: EER (%) of the traditional SIFT with Lowe's matching and the masked SIFT with selective matching using each of the six preprocessing methods over (a, b) Sfax-Miracl DB and (c, d) IITD DB (2601 images). 106
Figure 4.17: Genuine and imposter scores distributions of the traditional SIFT (left column) and the proposed method (right column) at different databases. 107
Figure 4.18: EER (%) comparison between the RANSAC and the Align-based refinements on SIFT and MaskedSIFT methods over all databases. 108

Figure 4.19: Average matching time (ms) of the RANSAC and the Align-based refinements on SIFT and MaskedSIFT methods over all databases. 109
Figure 5.1: User interface to select the ground truth of (a) knuckle-lines and (b) tips and valleys 119
Figure 5.2: Samples of ground truth knuckle-lines (first row) and the extracted ROIs (second row) from the three contactless DBs 119
Figure 5.3: Established coordinate system during the knuckle ROI extraction of two rotated images for the same hand. Extracted knuckle ROIs are shown on the top-right corner of each image with minor rotation difference between them 120
Figure 5.4: Three steps of the proposed method 120
Figure 5.5: OLOF-Based masking of knuckle image, a) OLOF gives large responses at lines and ridges (in red) and small responses at background (blue), b) masking result with threshold $\boldsymbol{TM}$ = 12.9 122
Figure 5.6: Keypoints of a) original SIFT and b) Masked SIFT. Line and ridges regions (inside red ellipses) are correctly described in MaskedSIFT while not described in original SIFT 122
Figure 5.7: Regions with their orientation histograms and dominant orientations. Region 1 with single line and one dominant orientation (in blue), Region 2 with three lines and two dominant orientations (blue and yellow) 123
Figure 5.8: One dominant orientation with two groups of connected pixels (in blue), each group is represented by single location (in yellow) 124
Figure 5.9: Two SIFT descriptors oriented at the dominant orientation of two different locations 124
Figure 5.10: One additional match is correctly detected by a) the Selective matching while not detected by b) the original Lowe's matching 125
Figure 5.11: Seven false matches that appear in a) all matches (yellow lines) while removed in b) refined matches 126
Figure 5.12: Illustration of align-based refinement, a) five original matches (3 are true (green), one is wrong (red) while one (orange) can be falsely rejected due to large position shifting), b) four refined matches (green and orange) after aligning the query keypoints with on the target one (x-trans. = -5, y-trans. = 23 and angle = -10°) (wrong match (red)) 126
Figure 5.13: Samples from the three contactless hand databases 128
Figure 5.14: EER (%) comparison between the RANSAC and the Align-based refinements on MaskedSIFT with a) Lowe's matching and b) Selective matching methods over the index knuckle of all databases. 132
Figure 5.15: Average matching time (ms) of RANSAC and Align-based refinements on MaskedSIFT with a) Lowe's matching and b) Selective matching methods over the index knuckle of all databases. 132
Figure 5.16: ROC curves of all methods over Sfax-Miracl DB 134
Figure 5.17: ROC curves of all methods over PolyU 2D/3D DB 134
Figure 5.18: ROC curves of all methods over IITD DB 135
Figure 5.19: CIR (%) of all methods over Sfax-Miracl DB at different number of training images 136
Figure 5.20: CIR (%) of all methods over PolyU 2D/3D DB at different number of training images 137
Figure 5.21: CIR (%) of all methods over of IITD DB at different number of training images 138
Figure 5.22: CMC curves of all methods over Sfax-Miracl DB using three training images 139
Figure 5.23: CMC curves of all methods over PolyU 2D/3D DB using three training images 140
Figure 5.24: CMC curves of all methods over IITD DB using three training images 141
Figure 6.1: Score level fusion scheme 148
Figure 6.2: Decision level fusion scheme 149
Figure 6.3: Rank level fusion scheme 149
Figure 6.4: Samples from the three contactless hand databases 151