

---

# Static and Dynamic Interpretations of Hand Specific Body Language Cues for HCI

---

**Dissertation**

zur Erlangung des akademischen Grades

**Doktoringenieur**

**(Dr.-Ing.)**

von M.Sc. Omer Rashid Ahmad

geb. am 20.03.1983 in Riad, Saudi-Arabien

genehmigt durch die Fakultät für Elektrotechnik und Informationstechnik

der Otto-von-Guericke-Universität Magdeburg

Gutachter:

Prof. Dr.-Ing. habil. Ayoub Al-Hamadi

Prof. Dr. rer. nat. Andreas Wendemuth

Prof. Dr. rer. nat. Heiko Neumann



**EIT**

**FAKULTÄT FÜR  
ELEKTROTECHNIK UND  
INFORMATIONSTECHNIK**

Promotionskolloquium am 07.12.2015

# Contents

<b>List of Figures</b>	<b>xix</b>
<b>List of Tables</b>	<b>xxiii</b>
<b>Glossary</b>	<b>xxiv</b>
<b>Nomenclature</b>	<b>xxvii</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	2
1.2 Concept Definition . . . . .	3
1.3 Contributions . . . . .	6
1.4 Organization of the Thesis . . . . .	7
<b>2 Literature Review</b>	<b>9</b>
2.1 Fundamental Concepts . . . . .	9
2.2 Vision-based Hand Cues . . . . .	10
2.2.1 Model based Approaches . . . . .	11
2.2.2 Appearance based Approaches . . . . .	11
2.2.3 Discussion . . . . .	13
2.3 Gesture Recognition . . . . .	13
2.3.1 Discussion . . . . .	16
2.4 Posture Recognition . . . . .	18
2.4.1 Discussion . . . . .	21
2.5 Augmented Reality . . . . .	23
2.5.1 Augmentation . . . . .	24
2.5.2 Discussion . . . . .	25
2.6 Summary and Conclusion . . . . .	26
<b>3 Segmentation</b>	<b>27</b>
3.1 Context Description . . . . .	27
3.1.1 Context for Gesture and Posture Scenario . . . . .	28
3.1.2 Context for Augmented Reality Scenario . . . . .	29
3.2 Skin Color Segmentation . . . . .	29

3.3	Blob Detection . . . . .	31
3.3.1	Face Blob . . . . .	32
3.3.2	Hand Blobs . . . . .	34
3.4	Refinement using Distance Transformation Descriptor . . . . .	35
3.5	Experimental Results and Analysis . . . . .	37
3.5.1	Gesture and Posture Recognition Scenario . . . . .	38
3.5.2	Augmented Reality Scenario . . . . .	40
3.5.3	Analysis . . . . .	40
3.6	Summary and Conclusion . . . . .	41
<b>4</b>	<b>Feature Extraction and Tracking</b>	<b>43</b>
4.1	Features . . . . .	43
4.2	Gesture Features . . . . .	44
4.2.1	Bezier Descriptors . . . . .	44
4.2.2	Features Binning . . . . .	48
4.3	Fingertip Detection . . . . .	49
4.4	Posture Features . . . . .	53
4.4.1	Statistical Feature Vectors . . . . .	55
4.4.2	Geometrical Feature Vectors . . . . .	57
4.4.3	Categorization based on Fingertip Detection . . . . .	58
4.4.4	Experimental Results . . . . .	59
4.5	Feature-Level Fusion for Posture Features . . . . .	61
4.6	Tracking . . . . .	62
4.7	Summary and Conclusion . . . . .	67
<b>5</b>	<b>Classification</b>	<b>68</b>
5.1	Hidden Markov Models . . . . .	68
5.1.1	Elements of HMM . . . . .	68
5.1.2	HMM Topologies . . . . .	70
5.1.3	Problems of HMM . . . . .	72
5.1.4	Solution to Problems . . . . .	72
5.1.5	Experimental Results . . . . .	76
5.2	Support Vector Machines . . . . .	82
5.2.1	Categorization Results and Analysis . . . . .	84
5.2.2	Experimental Results . . . . .	86
5.3	Summary and Conclusion . . . . .	89

---

<b>6</b>	<b>Integration and Inferences</b>	<b>95</b>
6.1	Concept . . . . .	95
6.2	Particle Filter System . . . . .	96
6.2.1	Initialization . . . . .	97
6.2.2	Selection . . . . .	98
6.2.3	Prediction . . . . .	98
6.2.4	Updation . . . . .	98
6.3	Interpretation and Inferences . . . . .	100
6.4	Experimental Results and Analysis . . . . .	104
6.5	Summary and Conclusion . . . . .	106
<b>7</b>	<b>Content Augmentation over Hand Postures</b>	<b>109</b>
7.1	Hand Skeleton Formation . . . . .	109
7.2	Hand Posture Geometry . . . . .	111
7.2.1	Patch Detection . . . . .	111
7.2.2	Content Augmentation . . . . .	113
7.3	Experimental Results and Analysis . . . . .	114
7.4	Summary and Conclusion . . . . .	117
<b>8</b>	<b>Summary and Future Directions</b>	<b>118</b>
8.1	Summary . . . . .	118
8.2	Future Directions . . . . .	120
<b>A</b>	<b>Appendix</b>	<b>122</b>
A.1	Orthogonal Moments . . . . .	122
A.1.1	Zernike Moments: . . . . .	123
A.2	Experimental Setup . . . . .	124
	<b>Bibliography</b>	<b>125</b>