Table of contents

Acknowledgements **3**

Abstract **5**

Zusammenfassung **8**

Table of contents **10**

1 Introduction **13**
1.1 Fundamental concepts 14
1.1.1 Ubiquitous computing 15
1.1.2 Machine learning and time-series classification 16
1.1.3 Deep learning 18
1.2 Motivation 23
1.2.1 Context 23
1.2.2 Example 1: *ELISE* - sensor-based emotion recognition 25
1.2.3 Example 2: *PainMonit* - sensor-based pain recognition 37
1.3 Thesis contributions 48
1.4 Overview 49

2 Deep learning for sensor-based human activity recognition **51**
2.1 Problem statement 51
2.1.1 Motivation 51
2.1.2 Human activity recognition 53
2.1.3 Pattern recognition chain 54
2.2 Related work 60
2.2.1 Feature engineering 60
2.2.2 Deep feature learning 62
2.3 Comparative study of feature learning approaches 65
2.3.1 Comparative framework 65
2.3.2 Feature learning approaches 66
2.3.3 Datasets 73
2.4 Experimental results on *OPPORTUNITY* 76
2.4.1 Implementation details 76
2.4.2 Comparative study results 78
2.4.3 Impact of input sensor channel variation 80
2.4.4 Impact of segmentation parameters 81

2.5 Experimental results on *Uni-MiB SHAR* . . . 82
2.5.1 Implementation details . . . 82
2.5.2 Comparative study results . . . 83
2.6 Overall analysis . . . 84
2.7 Summary . . . 85

3 Deep transfer learning based on sensor modality discrimination 87
3.1 Problem statement . . . 87
3.1.1 Motivation . . . 87
3.1.2 Transfer learning . . . 90
3.2 Related work . . . 94
3.2.1 Deep transfer learning for image modalities . . . 94
3.2.2 Deep transfer learning for time-series . . . 96
3.3 Sensor modality discrimination for deep transfer learning . . . 97
3.3.1 Methodology . . . 98
3.3.2 Implementation details . . . 99
3.4 Experiments . . . 103
3.4.1 *CogAge* dataset . . . 103
3.4.2 *DEAP* dataset . . . 111
3.4.3 Analysis of transfer robustness to variations in training data quantity . . . 113
3.4.4 Analysis of transfer interpretability . . . 115
3.5 Summary . . . 120
3.6 Complementary experiments . . . 122
3.6.1 *ELISE* - transfer for sensor-based emotion recognition . . . 122
3.6.2 *PainMonit* - transfer for sensor-based pain recognition . . . 123

4 Conclusion 127
4.1 Summary . . . 127
4.2 Limitations . . . 129
4.3 Future work . . . 132

Bibliography 132

List of own publications 146

List of abbreviations 148

List of tables 149

List of figures 151

Curriculum Vitae 152