Preface ix
List of Figures xi

1. Introduction 1

2. Activities 5
   2.1 Definitions / 5
   2.2 Classes of Activities / 7
   2.3 Additional Reading / 8

3. Sensing 11
   3.1 Sensors Used for Activity Learning / 11
      3.1.1 Sensors in the Environment / 12
      3.1.2 Sensors on the Body / 15
   3.2 Sample Sensor Datasets / 17
   3.3 Features / 17
      3.3.1 Sequence Features / 21
      3.3.2 Discrete Event Features / 23
      3.3.3 Statistical Features / 25
      3.3.4 Spectral Features / 31
      3.3.5 Activity Context Features / 34
CONTENTS

6.2 Sequence Mining / 110
   6.2.1 Frequency-Based Sequence Mining / 111
   6.2.2 Compression-Based Sequence Mining / 112

6.3 Clustering / 117

6.4 Topic Models / 119

6.5 Measuring Performance / 121
   6.5.1 Expert Evaluation / 121

6.6 Additional Reading / 124

7. Activity Prediction / 127
   7.1 Activity Sequence Prediction / 128
   7.2 Activity Forecasting / 133
   7.3 Probabilistic Graph-Based Activity Prediction / 137
   7.4 Rule-Based Activity Timing Prediction / 139
   7.5 Measuring Performance / 142
   7.6 Additional Reading / 146

8. Activity Learning in the Wild / 149
   8.1 Collecting Annotated Sensor Data / 149
   8.2 Transfer Learning / 158
      8.2.1 Instance and Label Transfer / 162
      8.2.2 Feature Transfer with No Co-occurrence Data / 166
      8.2.3 Informed Feature Transfer with Co-occurrence Data / 167
      8.2.4 Uninformed Feature Transfer with Co-occurrence Data Using a Teacher–Learner Model / 168
      8.2.5 Uninformed Feature Transfer with Co-occurrence Data Using Feature Space Alignment / 170
   8.3 Multi-Label Learning / 170
      8.3.1 Problem Transformation / 173
      8.3.2 Label Dependency Exploitation / 174
      8.3.3 Evaluating the Performance of Multi-Label Learning Algorithms / 179
   8.4 Activity Learning for Multiple Individuals / 180
      8.4.1 Learning Group Activities / 180
      8.4.2 Train on One/Test on Multiple / 183
CONTENTS

8.4.3 Separating Event Streams / 185
8.4.4 Tracking Multiple Users / 188

8.5 Additional Reading / 190

9. Applications of Activity Learning 195

9.1 Health / 195
9.2 Activity-Aware Services / 198
9.3 Security and Emergency Management / 199
9.4 Activity Reconstruction, Expression and Visualization / 201
9.5 Analyzing Human Dynamics / 207
9.6 Additional Reading / 210

10. The Future of Activity Learning 213

Appendix: Sample Activity Data 217
Bibliography 237
Index 253