

Intelligent Systems Reference Library 173

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IoT Sensor-Based Activity Recognition

Human Activity Recognition

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IoT Sensor-Based Activity Recognition

Human Activity Recognition

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*This book is dedicated to—our beloved
parents,
and our respected teacher (Late) Prof. Zahid
Hasan Mahmood, University of Dhaka.
M. Ahad would also like to dedicate this book
to his lovely daughter Rumaisa Fatima and
charming son Zubair Umar!*

Foreword

Human activity recognition and understanding have been explored in various domains for a long period. Vision-based and sensor-based activity analyses are progressing amazingly with the advent of various IoT sensors and video cameras. The impacts are very high for the present and the future of the world. There are very few genuine books on human activity recognition, and these are mainly in the vision-based field. There is a dire necessity for a comprehensive guideline for the researcher and practitioner in the arena of IoT sensor-based human activity recognition.

This book is filling the huge void by introducing 10 excellent chapters—from the basics of activity recognition to the advanced deep learning related strategies. The book has enriched itself by introducing a number of pragmatic challenges for future research issues. It has a great collection of important references at the end of the book so that readers can go through for further study. The chapters ended with some thought-provoking questions. The book will be very much valuable for now and in the coming years, especially for the undergrad (final year) and Master's course in universities as well as for researchers.

I know Prof. Md Atiqur Rahman Ahad for almost a decade. He has been engaged in research activities and promoting research extensively for a longer period. He has published two books as a single author on vision-based human action recognition in 2011 and 2013. The books are available in Springer. From the records of Springer, it is found that these are well-read and very useful until now. Introducing another book on *IoT Sensor-Based Activity Recognition* is a great move by him. Other co-authors are young and highly-promising researchers as well.

I am very delighted that the book is published by Springer and I am confident that it will get huge circulation in the academic and research communities. I thank Ahad, Antar, and Ahmed for their excellent efforts to produce such a magnificent book.

August 2019

Toshio Fukuda, Fellow IEEE
IEEE President-elect 2019 (President 2020)
Nagoya University, Japan
Meijo University, Japan
Waseda University, Japan
Beijing Institute of Technology, China
Nagoya, Japan

Comments from Experts

This timely book on sensor-based activity recognition will serve as an excellent overview of the state of the art and a roadmap for what is to come in this area. The authors have nicely presented the relevant problems, approaches, challenges, and opportunities in human activity recognition, identified the most relevant related research, and provided useful summaries and thought-provoking questions for each chapter. In reading this book, readers will gain from their combined expertise and learn important principles for approaching a range of related problems. I highly recommend it.

*Matthew Turk, IEEE Fellow, IAPR Fellow,
President, Toyota Technological Institute at Chicago.*

This compilation brings together successfully different aspects and use of IoT sensors in Human Activity Recognition (HAR) with applications in healthcare, elderly people monitoring, fitness tracking, working activity monitoring and more encompassing 150 or so benchmark datasets and dataset repositories for pattern recognition, machine learning, context awareness, and human-centric sensing. In addition to discussing and introducing multiple performance evaluation techniques for use in both video-based and sensor-based (environmental, wearable, and smartphone) HAR, the book highlights deep learning methods to solve the problem of shallow learning using hand-crafted features in conventional pattern recognition approaches.

*Mohammad Karim, IEEE Fellow, OSA Fellow, SPIE Fellow,
Provost, Executive Vice Chancellor, University of Massachusetts Dartmouth.*

It is many years now since I first wondered whether people could be recognised by their gait. Then, computers were slow, memory was expensive and accelerometers were enormous. Rolling on 20 years, we find that computers are fast, memory is cheap and the notion that gait is individual to each person is widely accepted. There has also been tremendous progress in sensors and in their analysis

and there is now a rich selection of techniques to enable recognition by this. We also now have the IEEE Transactions on Biometrics Behavior and Identity Science. And now we have a book on Sensor-based Activity Recognition. Enjoy!!

*Mark Nixon, IET Fellow, IAPR Fellow,
BMVA Distinguished Fellow 2015, University of Southampton.*

The book has comprehensive coverage on an increasingly important topic as we start to see more and more wearable devices. The chapters are structured well, with excellent illustrations and activities for use in a graduate or upper-level undergraduate course.

*Sudeep Sarkar, AAAS Fellow, IEEE Fellow, AIMBE Fellow, IAPR Fellow,
University of South Florida.*

The book is a timely, badly needed, and important treatise on IoT and sensors. Well exposed concepts and algorithms supporting ways of realizing processes of recognition and classification of human activities. Thorough discussions on algorithms, sensing devices and tools as well as benchmark data sets are a genuine asset of this monograph.

*Witold Pedrycz, IEEE Fellow,
University of Alberta.*

Great work! I especially like the multifaceted approach that includes the design of experiments and the use of available tools, hardware, and methods specifically tailored to activity recognition research.

*Kristof Van Laerhoven, Professor,
University of Siegen.*

It is one of the most comprehensive, easy-to-read books about the human activity recognition in this modern IoT and Big Data era. Technologies mentioned in this book are up-to-date. Both researchers and practitioners should read this book to grasp its critical ideas and recent advancement.

*Atsushi Inoue, Professor,
Eastern Washington University.*

This is a cutting-edge collection of theories, technologies, and views on digital human activity recognition. The book is a must-read for students and researchers in

the field of IoT sensor-based human activity recognition and its applications. No other book has presented results of this research in a more convincing way.

*Anton Nijholt, Professor
University of Twente.*

The elaborate explanations and benefits of utilizing deep learning over conventional pattern recognition approach in the field of human activity recognition with sensor modalities will be beneficial to the research community. Besides, comfortable and straightforward approach of representing benchmark datasets, device information, data collection protocol, and other solution of existing and possible challenges has made this book a must-read.

*Mahbub Hassan, Professor
University of New South Wales.*

An excellent book that provides an overview of human activity recognition based on wearable and smartphone sensors.

*Vishal M. Patel, Asst. Professor
Johns Hopkins University.*

Small Internet-connected devices with sensors have spread widely to many different application domains. This has left a distinct need for an in-depth look at this emerging field. Developers and researchers who are new to the IoT world will greatly benefit from this comprehensive volume, which helps satisfy that need.

*Walter J. Scheirer, Asst. Professor
University of Notre Dame.*

In this book, the authors systematically discuss various components of a sensor-based activity analysis system starting from preprocessing up to performance evaluation. The book provides a clear idea about the purpose and necessity of each component through well-written texts, clean illustrations, and nice data-visualization. The exercises in the ‘Think Further’ sections at the end of each chapter are well formulated. The book will be a very good first read for any newcomer in the activity analysis domain. On the other hand, the chapters on recent trends and future challenges can provide foods for thought to the experts.

*Upal Mahbub, Senior Engineer
Qualcomm Technologies, Inc.*

Preface

The accelerometer was invented in 1783. Though the initial purpose of using accelerometer was to validate the principles of Newtonian physics, with the advancement of the technology, it has become a popular component in the domain of IoT sensor-based Human Activity Recognition (HAR) in the present days. However, inventions of other sensors (e.g., gyroscope, magnetometer, pressure sensor) enrich this domain a lot. These sensors carry a lot of information, but they are in the form of raw data. There is a plenty of useful information and pattern underneath these raw data, but we need to extract some meaningful inherent information from the data and decipher some patterns. Therefore, we aim to present the tools and techniques, step by step, in this book so that one can acquire the idea of the primary approaches for HAR and progress thereafter. This book cuts through the basic concept of sensor-based human activity classification and demonstrates exactly how and from where to begin with, if someone is a newcomer in this research arena.

We can divide this book into three parts:

- At the beginning, we discuss different approaches of HAR, different types of filters for removing noises from the raw data, various parameters of those filters, and their effects, and different types of windowing techniques. Following these aspects, we amass several essential features in the time, frequency and other domains that are conventionally explored by the researchers. We enlighten on how to select important features, deduce surplus features, prepare them for the classification, and classify various activities using those features.
- In the next part of this book, we scrutinize distinctive issues and factors that we have to consider while designing a new dataset related to sensor-based human activity analysis. Moreover, we introduce different tools and applications that

are exploited for data collection. In this book, we summarize about 150 benchmark datasets and categorize them with some important features.

- In the final section of the book, we present more information about classification and evaluation strategies. We bestow on deep learning concepts and how this extremely flourishing domain can solve the problems of classification faced by the conventional statistical classifiers. Finally, we demonstrate a number of future challenges that one can ponder on for further developments.

We introduce some thought-provoking questions at the end of each chapter. We strongly recommend that a reader explore the entire book to get a comprehensive exploration of sensor-based human activity recognition and analysis.

We are delighted to present this book for the students of upper level of undergrad and postgraduate, as well as, researchers in academia and industry—in the domain of IoT, sensor, HAR, healthcare, machine learning and related fields. We firmly anticipate that this book will be a genuine companion on the *IoT Sensor-based Human Activity Recognition* journey. We have been engaged ourselves for this book for about three years' period, and we kept on polishing the book for a longer period to enrich the content and the clarity.

We are indebted to **Toshio Fukuda**, *Fellow IEEE, IEEE President 2020* for his time to write the 'Foreword' of this book. We would like to offer our sincere gratitude to a panel of great researchers who poured their valuable time and comments to enrich the book. We would like to mention them with our sincerest gratefulness: **Matthew Turk** (*IEEE Fellow, IAPR Fellow, President, Toyota Technological Institute at Chicago*), **Mohammad Karim** (*IEEE Fellow, OSA Fellow, SPIE Fellow, Provost, Executive Vice Chancellor, University of Massachusetts Dartmouth*), **Sudeep Sarkar** (*AAAS Fellow, IEEE Fellow, AIMBE Fellow, IAPR Fellow, Professor, University of South Florida*), **Witold Pedrycz** (*IEEE Fellow, Canada Research Chair, University of Alberta*), **Mark Nixon** (*IET Fellow, IAPR Fellow, BMVA Distinguished Fellow 2015, Professor, University of Southampton*), **Diane J. Cook** (*IEEE Fellow, FTRA Fellow, NAI Fellow, Huie-Rogers Chair Professor, Washington State University*), **Kenichi Kanatani** (*IEEE Fellow, Professor Emeritus, Okayama University*), **Atsushi Inoue** (*Professor, Eastern Washington University*), **Kristof Van Laerhoven** (*Professor, University of Siegen*), **Anton Nijholt** (*Professor, University of Twente*), **Mahbub Hassan** (*Professor, University of New South Wales*), **Vishal M. Patel** (*Asst. Professor, Johns Hopkins University*), **Walter J. Scheirer** (*Asst. Professor, University of Notre Dame.*), and **Upal Mahbub** (*Senior Engineer, Qualcomm Technologies, Inc.*).

We want to thank everyone who encouraged and assisted us to accomplish this book. Finally, we are grateful to the Springer and Prof. Lakhmi Jain for their

endorsements and publishing the book. We will be delighted to have your valuable feedback on this book. Enjoy the book!

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Mohammad Karim (*IEEE Fellow, OSA Fellow, SPIE Fellow*, Provost, Executive Vice Chancellor, University of Massachusetts Dartmouth)

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