4th Workshop on Human Activity Sensing Corpus and Applications: Towards Open-Ended Context Awareness

Nobuo Kawaguchi
Nagoya University
kawaguti@nagoya-u.jp

Nobuhiko Nishio
Ritsumeikan University
nishio@cs.ritsumei.ac.jp

Daniel Roggen
University of Sussex
daniel.roggen@ieee.org

Sozo Inoue
Kyushu Institute of Technology
sozo@acm.org

Susanna Pirttikangas
University of Oulu
susanna.pirttikangas@ee.oulu.fi

Kristof van Laerhoven
University of Freiburg
kristof@ese.uni-freiburg.de

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Abstract
Current motion sensors in wearable devices are primarily used for simple orientation and motion sensing. They provide however signals related to more complex and subtle human behaviours which will enable next-generation human-oriented computing in scenarios of high societal value. This requires large scale human activity corpuses and improved methods to recognise activities and their context. This workshop deals with the challenges of designing reproducible experimental setups, running large-scale dataset collection campaigns, designing robust activity and context recognition methods and evaluating systems in the real world. As a special topic, we wish to reflect on the challenges and approaches to recognise activities outside of a pre-defined set to achieve an open-ended activity and context awareness. Following the success of previous years, this workshop is the place to share experiences on human activity corpus and their applications and to discuss the future of activity sensing, in particular towards open-ended contextual intelligence.

Author Keywords

Large Scale Human Activity Sensing Corpus, Activity Recognition, Wearable Computing, Open-Ended Activity/Context Recognition; Mobile Sensor; Participatory Sensing.

ACM Classification Keywords

H.1.2 Models and Principles: User/Machine Systems; I.5.4 Pattern recognition**:** Applications**;** H.5.m Miscellaneous:HCI

Rationale and Objective of the Workshop

The objective of the workshop is to bring together researchers and practitioners both from academia and industries with the goal to discuss, identify and share experiences surrounding the construction of human activity sensing corpuses and their applications. Similarly to other human-related information processing areas, such as speech recognition and image recognition, real-world activity recognition requires large scale corpuses of data. Some initiatives set reference datasets for the use by the community, such as OPPORTUNITY [1] and HASC [2], but more work on larger scale and richer datasets are clearly required. Scenarios of high societal value - such as a memory prosthesis for people with dementia - are likely to require a more complete and subtle understanding of the user's activities and the context in which they occur, beyond what is currently available in "off the shelf" datasets. Similarly, activity recognition methods will have to be further improved to tackle real-world challenges.

This year, we wish to give a special consideration on how to address a common limitation faced by most activity recognition systems: by the nature of using supervised machine learning they are limited to recognizing a narrowly pre-defined "closed" set of activities/context for which training data is available. In practice the rich complexity of activities and context in which a person may engage is unbounded and it is not possible to foresee it entirely at design-time. The action-motor strategies of a person may evolve (e.g. due to injuries, changing preferences), new activities may be performed, or old ones lost (e.g. changing job). In a scenario of high societal value it may not be feasible to enumerate every single activity that is potentially relevant at design time to collect training data, or it may be too costly or time consuming to do so.

In this workshop we are interested in recent advances that may allow - in isolation or combination - to pave the way towards "*open-ended contextual intelligence*". In other words, we believe that next generation recognition system may well be "seeded" with some pre-defined activities or contexts, but that they will then have to be able to expand their repertoire of activities and contexts as they encounter new situations. Some approaches illustrate how this may be envisioned.

Online data sources can be used to avoid the data collection phase [12, 13]. Transfer learning supports dataset reuse by adapting datasets to different but related modalities [8,10]. The cost of acquiring precise annotations can be reduced algorithmically [16] or using crowd-sourcing platforms [17,18]. Pattern recognition can be made more robust to boundary jitter [11] and boundaries may be detected by structure discovery [20]. Social media can provide implicit information about activities [21]. Mobile phone experience sampling can be used to self-report activities [15]. Recent wearables (e.g. smartwatches, Google Glass) further support this through micro-interactions [6]. This can be used to collect minimalistic feedback, as even a binary feedback is sufficient to learn multi-class problems [14]. Semi-supervised learning [19] or self-taught learning [7] can exploit partially labelled data which is easily collected to improve accuracy. These approaches could combine in a framework allowing open-ended learning [9].

Topics of the Workshop

The objective of this workshop is to share the experiences among current researchers around the challenges of real-world activity recognition, the role of datasets and tools, and breakthrough approaches towards open-ended contextual intelligence

We expect the following domains to be relevant contributions to this workshop (but not limited to):

1. *Data collection / Corpus construction:* Experiences or reports from data collection and/or corpus construction projects, such as papers describing the formats, styles or methodologies for data collection. Cloud-sourcing data collection or participatory sensing also could be included in this topic.
2. *Effectiveness of Data / Data Centric Research:* There is a field of research based on the collected corpus, which is called “Data Centric Research”. Also, we solicit of the experience of using large-scale human activity sensing corpus. Using large-scape corpus with machine learning, there will be a large space for improving the performance of recognition results.
3. *Tools and Algorithms for Activity Recognition:* If we have appropriate and suitable tools for management of sensor data, activity recognition researchers could be more focused on their research theme. However, development of tools or algorithms for sharing among the research community is not much appreciated. In this workshop, we solicit development reports of tools and algorithms for forwarding the community.
4. *Real World Application and Experiences:* Activity recognition “in the Lab” usually works well. However, it is not true in the real world. In this workshop, we also solicit the experiences from real world applications. There is a huge gap/valley between “Lab Environment” and “Real World Environment”. Large scale human activity sensing corpus will help to overcome this gap/valley.
5. *Sensing Devices and Systems:* Data collection is not only performed by the “off the shelf” sensors. There is a requirement to develop some special devices to obtain some sort of information. There is also a research area about the development or evaluate the system or technologies for data collection.

In light of this year's special emphasis on *open-ended contextual awareness*, we wish cover these topics as well:

6. *Mobile experience sampling, experience sampling strategies*: Advances in experience sampling approaches, for instance intelligently querying the user or using novel devices (e.g. smartwatches) are likely to play an important role to provide user-contributed annotations of their own activities.
7. *Unsupervised pattern discovery:* Discovering meaningful repeating patterns in sensor data can be fundamental in informing other elements of a system generating an activity corpus, such as

inquiring user or triggering annotation crowd sourcing.

8. *Dataset acquisition and annotation through crowd-sourcing, web-mining:* A wide abundance of sensor data is potentially in reach with users instrumented with their mobile phones and other wearables. Capitalising on crowd-sourcing to create larger datasets in a cost effective manner may be critical to open-ended activity recognition. Online datasets could also be used to bootstrap recognition models.

9. *Transfer learning, semi-supervised learning, lifelong learning:* The ability to translate recognition models accross modalities or to use minimal supervision would allow to reuse datasets accross domains and reduce the costs of acquiring annotations.

These topics can be described with the following Keywords.

- Human Activity Sensing Corpus
- Large Scale Data Collection
- Data Validation
- Data Tagging / Labeling
- Efficient Data Collection
- Data Mining from Corpus
- Automatic Segmentation
- Performance Evaluation
- Man-machine Interaction
- Noise Robustness
- Non Supervised Machine Learning
- Sensor Data Fusion
- Tools for Human Activity Corpus/Sensing
- Participatory Sensing
- Feature Extraction and Selection
- Context Awareness
- Pedestrian Navigation
- Social Activities Analysis/Detection
- Compressive Sensing
- Sensing Devices
- Lifelog Systems
- Route Recognition/Detection
- Wearable Application
- Gait Analysis
- Health-care Monitoring/Recommendation
- Daily-life Worker Support

Estimated outcomes

We hope, the workshop will contribute in establishing a research community in the human activity sensing corpus area. The expected outcomes are:

1. Survey of the state of the art of “Human Activity Sensing Corpus.” This includes the overview of the data collection methods, tools and algorithms.

2. Practical knowledge of the data collection methodologies for human activity sensing.

3. Recognition of the potential and the importance of the large-scale corpus for human activity recognition.

These outcomes also will be shown on the workshop websites.

Post-Workshop activities

On the workshop website (http://hasca2016.hasc.jp) and affiliated websites (e.g. on http://har-dataset.org) we will list the current data collection activities and the information about public corpora.

Organisers

Nobuo Kawaguchi is a Professor of Department of Computational Science and Engineering, Graduate School of Engineering, Nagoya University since 2009. He received Ph.D. in Computer Science from Nagoya University, Japan, in 1997. During 1999-2004, he was working with CIAIR (Center for Integrated Acoustic Information Research), and made a major contribution on its large scale in-car speech database which includes speech dialog with car-driving information for more than 500 subjects in the real-world driving environment. His research interest is in the areas of Human Activity Recognition and Ubiquitous Communication Systems. He is now serving a chairperson of the Human Activity Sensing Consortium (HASC), Japan.

Nobuhiko Nishio is a professor of the College of Information Science and Engineering, Ritsumeikan University. He got his PhD at Keio University in 2000. Since 1993 till 2003, he had worked at Keio University SFC. His current research interests are ubiquitous computing and long term human activity recognition. He is was a general chair of HASC Challenge 2013.

Daniel Roggen is Associate Professor (Reader) in Sensor Technology at the University of Sussex. He received his MSc in microengineering in 2000 from the EPFL (Swiss Federal Institute of Technology) in Lausanne, Switzerland. He received his PhD degree from EPFL in 2005. Since then his activities include context recognition algorithms, embedded wearable systems, sensor fusion, and learning and adaptivity in wearable systems. He has coordinated the EU-funded FP7 project OPPORTUNITY on opportunistic activity recognition. He is leading the UK EPSRC-funded project "Lifelearn: Unbounded activity and context awareness" (2016-2018).

Sozo INOUE is an associate professor in Kyushu Institute of Technology, Japan. His research interests include human activity recognition with smart-phones, and healthcare application of web/pervasive/ubiquitous systems. Currently he has gathered 40,000 activity information of 250 people with accelerometer data using smart phones and servers. Inoue has a Ph.D of Engineering from Kyushu University. He is a member of the IEEE Computer Society, the ACM, the Information Processing Society of Japan (IPSJ), the Institute of Electronics, Information and Communication Engineers (IEICE), and the Database Society of Japan(DBSJ).

Susanna Pirttikangas Susanna Pirttikangas finished her doctoral studies on embedded systems at 2004 and works as a researcher at the Center for Ubiquitous Computing, University of Oulu. Her post-doctoral visits were to Japan (Waseda University, 2004-2005 and Tokyo Denki University, 2008) and China (Tsinghua University, 2011). Her research interests are machine learning and data science, with the focus on situation awareness.

Kristof van Laerhoven is Professor for Embedded Systems at the University of Freiburg, Germany. His research activities include (wearable) sensing systems, activity recognition, wireless sensor networks, machine learning, signal processing. He was technical program commitee chair of the Internatl Symposium on Wearable Computers in 2013. Previously he was Emmy Noether Research Group (DFG) Leader of Embedded Sensing Systems at TU Darmstadt.

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