Introduction to the Special Issue on Activity Recognition for Interaction

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This editorial introduction describes the aims and scope of the *ACM Transactions on Interactive Intelligent Systems* special issue on Activity Recognition for Interaction. It explains why activity recognition is becoming crucial as part of the cycle of interaction between users and computing systems, and it shows how the five articles selected for this special issue reflect this theme.

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1. INTRODUCTION

Automatic recognition of human activities has emerged as a key area of research for intelligent interactions between humans, computers, and robots. One goal of activity recognition is to provide information on users' behavior and intentions that allows computing systems to assist users proactively with their tasks. Over the last 20 years, researchers have investigated a large number of methods, techniques, and sensors for automatic recognition of activities. The success of activity recognition has led to activity-aware applications, the commercial launch of a variety of products in the entertainment sector, and wearable technology that measures and analyses human activity.

Advances in activity recognition have opened up many new forms of interaction, most of which have barely been explored to date. This special issue helps fill this gap by publishing a set of "binocular" articles on interactive systems that include activity

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recognition as a key component and part of a cycle of interaction between users and computing systems. The first two articles, by de Carolis et al. and Ye et al., respectively, study smart environments as an important usage scenario but also as a problem setting for both activity recognition and human-computer interaction. The third article, by Cooney et al., studies interactions between humans and robots with the specific focus on enabling affectionate interactions by leveraging automatic recognition of touch events. Caramiaux et al. focus on real-time gesture recognition for human-computer interaction and present a novel algorithm that, in addition to gesture recognition, characterizes the movement execution. Finally, Dim and Kuflik present a holistic approach to the automatic detection of social behaviors in a human-human interaction setting, namely one involving interaction between museum visitors. Together, these five articles illustrate how activity recognition can play an increasingly important role in interactive intelligent systems, allowing for richer and more diverse interactions with the environment, robots, and other humans.

2. THE FIVE ARTICLES

2.1. Incremental Learning of Daily Routines as Workflows in a Smart Home Environment

Smart home environments—homes augmented with sensors and computing systems to track users' behavior, proactively support them in their activities, and anticipate their needs—have emerged as an important application area for both activity recognition and human-computer interaction. In their article, de Carolis, Ferilli, and Redavid present a method that relies on first-order logic learning in a process mining framework to model users' daily routines from their behavior and to incrementally adapt the model to reflect the subtle dynamics in everyday routines. Their method adopts a flexible representation that can handle routines of any complexity. It can learn complex pre- and postconditions, and it learns efficiently from a small number of examples. The method represents an important advance toward smart homes that better understand user context and that are able to exhibit richer interaction capabilities.

2.2. USMART: An Unsupervised Semantic Mining Activity Recognition Technique

Smart environments are also studied in the second article in this special issue. Ye, Stevenson, and Dobson present USMART, a method for unsupervised activity recognition and routine discovery that is based on a novel ontology model to represent domain knowledge that can be reused across different environments and users. Their model represents human activities and different key domain concepts, such as objects, locations and sensors. It is combined with a semantic online data segmentation algorithm that is based on the temporal, spatial, and object semantics of sensor events. The authors highlight the potential of their method for designing and implementing interactive systems with improved capabilities to predict user behavior for the purpose of providing services.

2.3. Affectionate Interaction with a Small Humanoid Robot Capable of Recognizing Social Touch Behavior

Activity recognition also plays an increasingly important role in facilitating the integration of robots into everyday environments and supporting the interaction between humans and robots. A good example is provided by Cooney, Nishio, and Ishiguro, who studied how people perform and perceive affectionate interactions with a small robot. The authors present and evaluate three affectionate interaction strategies that vary the level of affection shown by the robot depending on how the person interacts with it. In this work, activity recognition is fundamental to the approach in that it facilitates the affectionate interactions by enabling the robot to recognise different types

of touches; it is therefore tightly integrated into the interaction cycle between human and robot.

2.4. Adaptive Gesture Recognition with Variations Estimation for Interactive Systems

When we interact physically with our environment, we use gestures to manipulate objects. It is a natural step to extend the principle of motion-based manipulation to continuous human-computer interaction. For example, in health care, gesture recognition in 3D space can benefit rehabilitation and motor learning. Much as when speaking in a dialect, users express their gestures in different ways. Some users are slower, others are more intense; and depending on the context gestures can be executed in various forms. Caramiaux, Montecchio, Tanaka, and Bevilacqua address this problem and develop a model that continuously recognises gestures with low latency. By adapting to signal variations during gesture execution, the algorithm is able not only to improve recognition rates but also to measure the variation as a gesture parameter. The gesture intensity can be used to update parameter estimates incrementally during gesture execution.

2.5. Automatic Detection of Social Behavior of Museum Visitor Pairs

Places can have different meanings for us and can lead to different experiences depending on the people who surround us. With the goal of enabling an intelligent interactive system to recognize and take into account the social context of museum visitors, Dim and Kuflik investigated the recurrent patterns of social behavior exhibited by pairs of museum visitors. By analyzing low-level, sensor-detectable variables such as proximity to other visitors and to points of interest in the museum, the authors identified automatically recognizable social behavior patterns of visitor pairs.