Recent Trends in Sensor-based Activity Recognition

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***Abstract*—This seminar introduces recent trends in sensor-based activity recognition technology. Technology to recognize human activities using sensors has been a hot topic in the field of mobile and ubiquitous computing for many years. Recent developments in deep learning and sensor technology have expanded the application of activity recognition to various domains such as industrial and natural science fields. However, because activity recognition in the new domains suffers from various real problems such as the lack of sufficient training data and complexity of target activities, new solutions have been proposed for the practical problems in applying activity recognition to real-world applications in the new domains. In this seminar, we introduce recent topics in activity recognition from the viewpoints of (1) recent trends in state-of-the-art machine learning methods for practical activity recognition, (2) recently focused domains for human activity recognition such as industrial and medical domains and their public datasets, and (3) applications of activity recognition to the natural science field, especially in animal behavior understanding.**

***Index Terms*—Activity recognition, sensors, deep learning, datasets**

I. Introduction

Activity recognition technology is a technology that uses sensors observing a target person to estimate what activity the target person is performing [1], [2]. Because the movements of a person's body parts reflect the activity the person is performing, IMU sensors attached to body parts of the person are often used for activity recognition. Because of its diverse real-world applications such as home automation, health management, and life-logging [3], [4], activity recognition has been a hot topic in the mobile and ubiquitous computing field for many years.

II. Motivation and Scope

Until now, activity recognition technology has been studied mainly for everyday human activities. With the recent development of machine learning technology and sensor technology, the target of activity recognition technology is expanding to various domains such as industrial fields and natural science fields [5], [6]. In addition, several datasets for these new domains have been publicly available in recent years [7]. However, unlike daily activity recognition, activity recognition in the new real domains suffers from various practical problems. For example, the cost of collecting labeled data is problematic for building real-world applications in the new domains such as the industrial domains. With recent advances in machine learning technology, studies have been conducted from various perspectives to solve this problem, including pre-training techniques, transfer learning techniques, data augmentation, and unsupervised learning. In addition, techniques have been studied to solve practical problems of building activity recognition systems such as supporting techniques for efficient labeled data collection.

The scope of this seminar includes state-of-the-art techniques for practical activity recognition in the new domains.

III. Summary of Seminar

This seminar introduces recent topics in activity recognition from the viewpoints of (1) recent trends in state-of-the-art machine learning methods for practical activity recognition, (2) recently focused tasks for human activity recognition technology and their public datasets, and (3) applications of activity recognition to the natural science field, especially in animal behavior understanding.

IV. Seminar Outline

A. Background and Basics of Activity Recognition

The seminar begins with the background and brief introduction to recently focused domains in activity recognition,

followed by the basics of activity recognition. In the basics of activity recognition, we will explain commonly used problem settings for activity recognition and commonly used sensors with external sensory information such as location information [8]–[10].

B. State-of-the-art Techniques for Practical Activity Recognition

Here we present state-of-the-art techniques for practical activity recognition. First, we introduce deep learning techniques that are commonly used in activity recognition, followed by an introduction to the problems that hinder the realisation of practical activity recognition, such as costs of the preparation of labelled training data. We then introduce techniques to address the problems from different perspectives. Specifically, self-supervised learning, weakly supervised learning, and transfer learning studies for activity recognition are introduced [11], [12]. In addition, recent techniques to build practical activity recognition systems are introduced such as supporting techniques for labeled data collection and explainable AI for sensor-based activity recognition.

C. Recently Focused Tasks for Human Activity Recognition

Here we introduce types of activities that have been the subject of recent activity recognition research in detail such as work activities in the industrial and medical domains. Then, the characteristics of these activities and the difficulties in recognising them are explained. Furthermore, state-of-the-art activity recognition methods tailored to these domains are introduced [13], [14]. Finally, public datasets commonly used for daily activity recognition and recently published public datasets for complex and work activity recognition are presented.

D. Applications of Activity Recognition to Animal Behavior Understanding

Here we present applications of activity recognition technology for animal behavior recognition and understanding. Specifically, applications in behavioural biology and in the field of livestock production will be presented, including how offline and online activity recognition are used in behavioural biology research and state-of-the art technologies used to realize online behaviour recognition [5]. We also explain what applications the results of behaviour recognition can be used for in the field of livestock production and what kind of technology is being developed. Finally, publicly available datasets for animal behaviour recognition are introduced.

V. Biographies of presenters

The research group of the presenters have many years of experience in activity recognition studies [5], [6], [13]–[17].

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Takuya Maekawa received his B.S., M.S., and Ph.D. degrees from Osaka University, Japan, in 2003, 2004, and 2006, respectively. From 2006 to 2012, he was a researcher at NTT Communication Science Laboratories in Japan. He is currently an associate professor at Osaka University. His research interests include ubiquitous and mobile sensing, web data mining, and information retrieval, and he is now mainly engaged in human activity recognition and indoor positioning research using ubiquitous and wearable sensor data based on machine learning techniques. He has published 26 full papers in top conferences of the mobile/ubiquitous computing research community (PerCom, Ubicomp, IMWUT, ISWC, etc).

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Ryoma Otsuka received his B.S., M.S., and Ph.D. degrees from Kyoto University, Japan, in 2016, 2018, and 2021, respectively. He was originally trained in biology and conservation science. His current interest is the integration of behavioral ecology and information science. More specifically, he is developing custom-made bio-logging devices that can perform real-time behavior classification. He also studies behavior classification techniques for various wild animals. He has published papers in journals such as PLoS One and Journal of Ecotourism, etc.

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Naoya Yoshimura received his B.S. and M.S. degrees from Osaka University in 2018 and 2020, respectively. His research interests include ubiquitous computing and mobile sensing. Specifically, he studies human activity recognition using wearable sensor data in the industrial site based on supervised frameworks such as neural networks. He has published papers in top conferences of the mobile/ubiquitous computing research community, such as IMWUT, PerCom, etc.

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Kei Tanigaki received his B.S. degrees from Osaka University in 2022. His research interests include ubiquitous computing and mobile sensing. Specifically, he is interested in supporting techniques for building real-world human activity recognition systems.

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