Using Non-Intrusive Environmental Sensing for ADLS Recognition in One-Person Household

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ABSTRACT

This article describes how pervasive sensing technologies are promising for increasing one-person household (OPH), where a system monitors and assists a resident to maintain healthy life rhythm. Automatic recognition of activities of daily living (ADLS) has been a hot research topic in pervasive computing. However, most existing methods have limitations in development cost, privacy exposure, and inconvenience for residents. To cope with the limitations, this article presents a new ADL recognition system especially for OPH. To minimize the development cost as well as intrusions to user and house, the system exploits an IoT-based environment sensing device, called autonomous sensor box (sensorbox) which can autonomously measure 7 kinds of environment attributes. The system then applies machine-learning techniques to predict 7 kinds of ADLS. Finally, this article conducts an experiment within an actual apartment of a single user. The result shows that the proposed system achieves the average accuracy of ADLS recognition with about 88%, by carefully developing the features of environment attributes.

KEYWORDS

Activities of Daily Living, ADLS Recognition, Feature Engineering, Machine Learning, Non-Intrusive Environment Sensing, One-Person Household

INTRODUCTION

The growing number of unmarried people and late marriages in developed countries leads to a social issue of one-person household (OPH). In Japan, the number of OPH increasing rapidly. It is estimated that 37.4% households will become OPH in 2030 (Ministry of Health, Labour and Welfare, 2010). In seven states of USA, the percentage of OPH exceeds 30.3% in 2015 (Statista, 2017). In China, there are more than 60 million people currently living alone (Yeung & Cheung, 2015). According to Asaoka, Fukuda & Yamazaki (2004) and Fujino et al. (2006), people in OPH easily lose control healthy life rhythm, since no one else can take care of the living in OPH. Since the loss of healthy life rhythm often leads to health deterioration, it is essential to maintain the life rhythm especially in the context of OPH. In general, a life rhythm is characterized by activities of daily living (ADLs, for short). Typical ADLs in OPH include eating, taking bath, sleeping, etc. If the cycle of ADLs

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becomes very different from the one in a healthy life rhythm, the resident is losing his/her life rhythm. To maintain the life rhythm, one has to keep a regular record of ADLs. However, keeping manual recording requires strong mind and patience.

To automate the ADL recording in OPH, pervasive sensing technologies combined with machine learning are quite promising, because they can recognize ADLs from automatically measured data. There have been many studies for ADL recognition. Some approaches (e.g., Fiore, Bodor, Drenner, Somasundaram & Papanikolopoulos, 2008; Ouchi & Doi, 2013) try to directly capture the living using camera, or microphone. However, such systems are too intrusive of the user in the sense that the daily living is exposed as it is. There are many studies using wearable sensors, and/or indoor positioning system to recognize ADLs (e.g., Kusano, Muro, Hayashi, Harada & Shimakawa, 2011; Pei et al., 2013). However, the wearable sensor is intrusive to human body, as the user always has to wear the sensor device at home. Indeed, the home is a place where the user is free from tedious things. The indoor positioning is intrusive to a house, in the sense that sensors and beacons must be installed into the house and objects. This usually causes expensive cost for deployment and maintenance.

To overcome the limitations, we propose a new system that recognizes ADLs of OPH based on non-intrusive environmental sensing with machine learning. In the proposed system, we exploit an IoT-based environment-sensing device, called autonomous sensor box (we simply call SensorBox, hereinafter). SensorBox has been developed in our previous work (Sakakibara, Saiki, Nakamura & Matsumoto, 2016), and is designed to minimize the effort of deployment and operation. Once a power cable is connected, SensorBox autonomously measures seven types of environment attributes (temperature, humidity, light, sound, vibration, gas pressure and motion) around the box, and then periodically uploads the data to a cloud server. Thus, all the operations for deployment and maintenance are performed without human intervention, or expensive infrastructure.

As SensorBox is measuring the environment in OPH, the proposed system also requires the initial training, where the resident manually records ADLs using a designated lifelog tool. The initial training is supposed to be performed in several days, to associate labels of ADLs with the sensor data. In the proposed system, we define seven basic ADLs (cooking, working, cleaning, taking bath, sleeping, eating, absence), which are the most typical ADLs for maintaining the life rhythm. For the labeled dataset, we apply supervised learning algorithms to construct a model of ADL recognition for the house. For this, we perform careful feature engineering to determine essential predictors that well explain ADLs in OPH. Furthermore, we try several different classification algorithms to compare the performance.

To evaluate the proposed system, we have deployed one SensorBox in an actual apartment of a single person, and conducted an experiment for ten days. Experimental results show that the average accuracy of all the seven ADLs was around 87% with Decision Forest supervised learning. The accuracy of some specific ADLs achieved over 90%. From this result, we confirmed that the proposed system achieves non-intrusive and practical ADL recognition in OPH, using SensorBox.

PRELIMINARY

Activities of Daily Living (ADL)

ADL is a professional word originally used at hospital. It is the minimum action required for daily life such as sleeping, meal, taking bath, etc. it is used as an indicator of the aging and degree of disability. The discovery and recognition of ADL is an essential function of the system that provides necessary assistant to the residents of OPH. Based on the results of this process, the intelligent system can decide which action to take in order to support the residents’ well-being and understand residents’ life rhythm based on the regular record of ADLs.
Model-Driven Applications: Using a Model-Driven Mechanism to Bridge the Gap between Business and IT
Tong-Ying Yu (2014). Advances and Applications in Model-Driven Engineering (pp. 53-72).
www.igi-global.com/chapter/model-driven-applications/78610?camid=4v1a

Knowledge Integration in Problem Solving Processes: A Case Study - Perceptions of Workers
www.igi-global.com/article/knowledge-integration-in-problem-solving-processes/119656?camid=4v1a