Enabling Cloud-Based and Personalized Sensors in Assisted Living Environments

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ABSTRACT

In this work, the authors combine the field of cloud computing with assisted living to improve activity classification. The proposed system addresses the challenge of enabling heterogeneous, cloud-based sensors in domestic environments. With a semantic and model-based approach, the authors seamlessly integrate web services as virtual sensors and, therefore, increasing the accuracy of human activity classifiers. They solve the most important compelling issue of interoperability, by using generated wrapper classes and semantically unify all heterogeneous sensor events within the system. Their approach is evaluated with a test installation by means of the requirements for Sensor Web Infrastructures combined with the one for assisted living environments.

Keywords: Activity Classification, Assisted Living Environments, Domestic Environments, Interoperability, Semantic

1. INTRODUCTION

Through this article we detail, update, and extend our approach for enabling virtual, cloud-based sensors in assisted living environments (M. Franke, Wuttig, & Schlegel, 2013) presented at the IEEE CloudCom 20131.

Demographic change yields many yet unsolved issues for the following decades, such as the rise of the expenditure of healthcare or the increased burden of caregivers (Bayer & Harper, 2000). As one solution, several kinds of Ambient Assisted Living (AAL) systems (Geisberger & Broy, 2012) have been proposed. This kind of system aims to assist users in their domestic environment assuring their independence as long as possible and improving overall life quality (Bayer & Harper, 2000). To achieve useful systems for real life applications, we argue that establishing cloud and ubiquitous computing in these assisted living environments is necessary.

On the one hand, cloud computing provides natural evolution of distributed, widespread resources according to the current needs, as every resource or service becomes accessible without requiring detailed knowledge about

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the underlying technology and can be maintained remotely. On the other hand, the idea of ubiquitous computing (Weiser, 1991) describes the ubiquity of computers in our daily living environments without the demand of intrusive or even visible system components.

According to these requirements, these systems are suited for management tasks in the daily surrounding (Friedewald, Raabe, Georgieff, Koch, & Neuhäusler, 2010). Chaouchi (2010) describes the availability of such ubiquitous computers and information as any place, any time, anything, which are goals similar to those of cloud computing.

In addition, AAL environments pose also special challenges (Kleinberger, Becker, Ras, Holzinger, & Müller, 2007). These challenges can be summarized as: being low-cost and on low-battery consumption (regarding to the domestic environment); high acceptance rate, e.g., by means of wearable and non-disturbing sensors; high accuracy; and privacy, e.g., with the help of only non-visual sensors.

Our test environment is a domestic living environment, equipped with stationary Indoor Sensor Devices. In our case Tinkerforge\(^2\) weather stations. These stations measure luminance, humidity, temperature and sound level of each room. Due to the fact that the general idea of Ambient Assisted Living is not fixed to indoor environments but also domestic outdoor environments, like a garden next to a house, our approach should give the possibility to determine activities indoors and outdoors. For this purpose, we have to establish a procedure for sensors that are available in both environmental settings, which is mentioned in this work. That implies that we have to tackle the requirements of both fields AAL and cloud computing, without demanding or shorten the abilities for user assistance.

This article is structured as follows: Sect. II gives an overview of the state of the art of assisted living environments and cloud-based sensors. Sect. III shows an architecture overview of our Sensor Web Infrastructure. Sect. IV gives one particular example of the Wunderground weather services and how to model it as cloud-based sensor. Sect. V illustrates our scenario, which enables concrete sensors to improve the accuracy of activity classifiers. Sect. VI concludes the paper and outlines future work.

2. STATE OF THE ART

We identified multiple approaches related to our work, classifying activities in assisted living environments as well as enabling virtual, cloud-based sensors as a global sensor web. However, none of these approaches combine both fields.

2.1. Activity Classification in AAL

The work of (Yin & Bruckner, 2010, 2012) shows an approach of activity analysis based on Hidden Markov Models (HMM). This approach combines multiple sensors (e.g., motion detector sensors) to HMM chain on a day-to-day basis. In contrast to other approaches, these models consist not only of a correlation of sensor values to activities, but also on assigning activities to daily routines. Thereby, a HMM training set classificatory system deduces the current human activity from sensor readings. The work concludes the recognition of activities could be improved by adding more sensors or different sensor types.

In Chernbumroong, Cang, Atkins, and Yu (2013), Chernbumroong et al. describe an elderly-activity recognition system based on wearable sensors and supervised Support Vector Machines (SVM) classification. They mainly focus on a system that is low cost, works on low energy and with a high acceptance rate according to the AAL requirements (Kleinberger et al., 2007). For this purpose, they decided to use non-visual, non-stigmatizing wearable sensors, such as altimeter, accelerometer and temperature sensors. Furthermore, they combined all sensors in one wristband, which gathers the temperature values by a skin contact sensor. With this approach, it is possible to distinguish between 11 different activities, such as walking, dressing or sleeping. After a training time, the SVM system was able to classify an activity
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