Analytical Review on Ontological Human Activity Recognition Approaches

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ABSTRACT

New advancements in pervasive computing technology have turned smart homes into a daily living monitoring tool increasingly used for elderly. Recently, using knowledge driven approaches such as ontology to introduce semantic smart homes has received attention due to their flexibility, reasoning and knowledge representation. Due to the vast number of ontological human activity recognition methods, the proposed ontological human activity recognition framework can be effective in analyzing and evaluating different methods in different applications and dealing with various challenges. Also, due to numerous challenges involved in different aspects of ontology-based human activity recognition in smart homes, this paper offers a classification for challenges in human activity recognition in ontology based systems. Then the proposed ontological human activity recognition framework is evaluated based on the proposed classification and ontology-based techniques which are thought to solve some of the challenges are examined and analyzed.

KEYWORDS

Ambient Assisted Living, Context Awareness, Healthcare, Human Activity Recognition, Ontology, Semantic Web, Smart Homes

INTRODUCTION

Smart home has made it possible to empower people and us technologies to facilitate independent living of the elderly or the disabled equipped with sensors, actuators and devices. Semantic Smart Homes (SSH) provide strong capacity to create and manage large-scale semantic information along with intelligent high-level abilities based on ontological approaches to modeling data for entities, including inhabitants, their activities, environments, devices and services (Chen, Nugent, Mulvenna et al., 2009). Particularly, smart homes are used as appropriate tools to provide monitoring of daily activities and cognitive assessment, especially for the elderly (Wemlinger & Holder, 2014). These models must be able to recognize the condition of users and their activities effectively and accurately (Wemlinger & Holder, 2014).

Activity recognition is the process of activity inference from a series of data observation from sensor readings. This area has attracted much attention in recent years due to a growing demand for intelligent and customized support for user tasks, among the various application areas from healthcare and surveillance to activity-aware services and entertainment (Chen, Hoey, Nugent, Cook, & Yu, 2012). In this regard, some research has been conducted to evaluate ontology-based frameworks for modeling and reasoning about contexts (Chen, Nugent, & Wang, 2012; Chen, Nugent, & Okeyo, 2014). The idea is mapping low-level information and activity models onto ontologies which make
inferring high-level activities possible using domain knowledge and ontology reasoning (Rodríguez, Cuéllar, Lilius, & Calvo-Flores, 2014). Generally, ontologies are the key elements of Semantic Web (SW) and semantics which exist in SW can be transferred by ontology.

There have been vast numbers of ontological approaches on human activity recognition in smart homes but there is no effort on representing a classification, which covers all existing ontology-based human activity recognition approaches in smart homes. Therefore, providing the overall structure seems to be necessary to analyze each of the proposed approaches. In this paper, we proposed an all-around classification framework for existing ontology-based human activity recognition methods into two general groups i.e. Naïve Smart Context Modeling (NSCM) and Complex Smart Context Modeling (CSCM), and review these methods for each class. We compare different methods with appropriate evaluation criteria in term of qualitative assessment, and indicate which method is suitable for which kind of requirements.

In addition, by considering a variety of existing challenges in ontology-based human activity recognition in smart homes and due to many obstacles and challenges in this field, a classification of challenging issues as a systematic structure for ontology-based activity recognition in smart homes is then proposed. We compare well-known methods in such systems to represent which method is appropriate for which kind of challenges.

The remainder of this paper is organized as follows: The next section reviews activity recognition based on ontology in semantic smart homes to introduce basic concepts in this field. The general process of human activity recognition in smart homes is then described. The proposed ontology-based human activity recognition approaches classification is represented in the section related to ontological human activity recognition framework. In classification of challenges in ontology-based activity recognition, the proposed classification for ontology-based human activity recognition challenges using sensor readings is presented. In the section on evaluation a comparative analysis of the proposed framework based on the proposed measures is presented. The last section concludes the paper.

**ONTOSTY-BASED HUMAN ACTIVITY RECOGNITION IN SSH**

The nature of SSH is to have data definition within and across smart homes and linked in a way that they can be used for discovery, processing, automation, integration and reuse across different applications effectively (Chen, Nugent, Mulvenna et al., 2009).

In this regard, the common task in SSH is ontology-based Activity of Daily Living (ADL) recognition. Ontological approaches to human activity modeling include knowledge engineering tasks to define formal semantics of activities (Riboni, Pareschi, Radaelli et al., 2011; Rodríguez, Cuéllar, Lilius et al., 2014). The core of ontology in the field of activity recognition in smart homes can be expressed with three major entities as user, activity, and environment (Meditskos, Dasiopoulou, & Kompatsiaris, 2015). These entities can collect concepts from the basic subdomains and recognize that “What activity” by “Who” in “Where” is done.

The inherent characteristics of ubiquitous environments in real world situations are incomplete information, and noisy and inaccurate dependencies. The key challenge to solving human activity recognition in smart homes environment is the ability to detect a context which represents complex activities. Approaches such as time windows, time slices, domain knowledge about order or duration of activities define strict dependencies and assume that all information is available which leads to failure to capture environment characteristics (Riboni, Pareschi, Radaelli et al., 2011; Juan & Graeme, 2013; Meditskos, Kontopoulos, & Kompatsiaris, 2014). In majority of cases, these approaches require prior domain knowledge including maximum duration of activities or window length and they face
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