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Fuzzy Ontology Based Activity Recognition for Assistive Health Care Using Smart Home

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ABSTRACT

Assistive health care system is a viable solution for elderly care to offer independent living. Such health care systems are feasible through smart homes, which are intended to enhance the living quality of the occupant. Activities of daily living (ADL) are considered in the design of a smart home and are extended to abnormality detection in the case of health care. Abnormality in occupant behavior is the deviation of ongoing activity with that of the built activity model. Generally, supervised machine learning strategies or knowledge engineering strategies are employed in the process of activity modeling. Supervised machine learning approaches incur overheads in annotating the dataset, while the knowledge modeling approaches incur overhead by being dependent on the domain expert for occupant specific knowledge. The proposed approach on the other hand, employs an unsupervised machine learning strategy to readily extract knowledge from unlabelled data using contextual pattern clustering and subsequently represents it as ontology activity model. Ontology offers enhanced activity recognition through its semantically clear representation and reasoning, it has restriction in handling temporal data. Hence, this article in addition to unsupervised modeling focuses at enabling temporal reasoning within ontology using fuzzy logic. The proposed fuzzy ontology activity recognition (FOAR) framework represents an activity model as a fuzzy temporal ontology. Fuzzy SWRL rules modeled within ontology aid activity recognition and abnormality detection for health care. The experimental results show that the proposed FOAR has better performance in abnormality detection than that of the existing systems.

KEYWORDS

Activity Recognition, Health Care, Ontology, Pattern Clustering, Smart Home, Temporal Reasoning

1. INTRODUCTION

Smart homes endeavor at integrating intelligence into home surroundings to provide services that enable better quality living to its occupant. In general, smart home refers to a digital environment that proactively, but sensibly, assists people in their daily lives to increase safety and comfort (Cook et al., 2009; Cook & Das, 2007; Alam et al., 2012). Autonomy is its primary objective that enables

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and empowers independence to the occupant towards meeting their social, emotional and rational needs. Ambient intelligence and assistive living offered via smart home aid its integration to various socially relevant applications that have profound impact on the future of society (Woznowski et al., 2017; Augusto et al., 2010). Thus, this paper aims at modeling reasoning and decision support system which intend to offer ambient assistive living (Augusto, 2012).

Ambient Assistive Living (AAL) (Peek et al., 2017) via smart home has turned out to be an essential research area as it can be utilized in various application domains like health care, elderly care, energy efficiency, surveillance, offices, hospitals, agriculture and disaster assessment (Cortés et al., 2007; Hanratty et al., 2016). The impact of the global demographic change has made elderly care critical, which needs to address issues both from a societal and economic perspective (de la Concepcion et al., 2017), (Sow et al., 2013). AAL also offers assistive solutions for people affected by a wide variety of physical and cognitive challenges (Lotfi et al., 2012). Ambient Intelligence in hospital environment augments the effectiveness of hospital services.

Internet of Things (IoT) is the paradigm employed in AAL, where sensors are embedded in objects or in the environment to endorse wellbeing, augment comfort, and to maintain an independent living of occupants. Captured sensor data is evaluated to recognize activity and deduce knowledge concerned to the physical or cognitive status of monitored occupant. The reasoning system within smart home is characterized to recognize activity, classify patterns, discover trends, and detect abnormal or anomalous behavior of the occupant. Moreover, the reasoning framework intelligently computes, proficiently learns, adapts to a wide variety of needs and requirements of the occupant to offer assistive living environment.

Activity monitoring, activity modeling, activity recognition and decision making are the series of procedures involved in the design of reasoning system (Cook & Das, 2007). Activity modeling and recognition is the key process in smart home that aims to recognize the actions and goals of occupant from a series of observations on the occupants events. The essential task in the design of activity recognition system involves the construction of activity model to represent the activity pattern of the occupant which is later utilized to automate various services in the home environment.

Activity recognition is extended to anomaly detection in the case of health care applications (Augusto, 2012). Anomaly detection is the process of identifying patterns in data that do not conform to normal or expected behavior of the occupant. The process of modeling anomaly detection system involves two steps, where the usual or normal behavior of the occupant is modeled at first and any deviation from that of the built activity model is recognized to be abnormality. The ongoing activity of the occupant is recognized dynamically by employing machine learning and artificial intelligence strategies over the real time data attained from the environment (Chen et al., 2012b).

The proposed activity recognition and anomaly detection smart home for elderly care focuses on:

- Building an contextual activity recognition system for smart homes for elderly care using contextual pattern clustering;
- Ontology a unified representation language is used to represent activity models;
- A novel approach to represent temporal information in ontology is proposed and constructed using fuzzy logic;
- An efficient reasoning algorithm is developed to work over fuzzy ontology to recognize the abnormality in occupant behavior.

2. RELATED WORK

Activity recognition is categorized as vision and sensor based on type of sensor used for monitoring (Chen et al., 2012b). Vision based activity recognition monitors the occupant through video cameras whereas sensor-based activity recognition monitors through miniature sensors. The privacy and