Automated modeling and reasoning approach for context in smart homes based on stochastic analysis of sensory data

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Purpose The primary goal of smart homes is to fulfil convenient life for human residents by providing needed services and proper applications. The key for the smart home technology is to build an intelligent context-awareness computing (CAC) system which fascinates to recognize a current context. It proceeds in two processes: 1) modeling contexts and 2) reasoning contexts based on modeled contexts. As Bettini *et al*. have shown in their survey (2010), various modeling/reasoning approaches have been proposed. However, most approaches required manual configurations for context models, which needed a human-aided context reasoning process. The lack of automation degrades usability of CAC systems and increases the occurrence rate of errors in modeling and reasoning contexts due to possibility of mistakes by humans. Therefore, we proposed an approach to automate modeling and reasoning contexts by stochastically analyzing sensor data. **Method** In the prior phase of the approach, sensor data is derived to context models by using three machine learning techniques. This approach precedently needs to define a couple of components for contexts. First, Lee and Helal defined a state space to describe status of a smart space by using status of sensors and IoT (2022). A context represents a meaningful state space among a set of state spaces. To automatically define such contexts, all state spaces are clustered by the K-means clustering method. Since a centroid of each cluster has the minimum average distance to other state spaces, it is representative and considered as a context. This method requires the number of contexts(K), which is obtained by statistical analysis. In our current proposed approach, we utilized conditional probabilities of all state spaces, which enable to estimate how many contexts may happen with a high probability. Then, sensors which are significant in each context are determined by applying the Principal Component Analysis (PCA). With the sensors, context models finally are defined and used for next reasoning phase. In the reasoning process, a most similar context to a current status of space is discovered. For this purpose, two computational methods for similarity - Euclidean distance and Cosine similarity, are applied. **Results and Discussion** This approach achieves to fully automate modeling and reasoning contexts by analyzing sensor data. To validate it, we examined that the approach consistently showed as good results as a non-automated approach did. For the comparison, data were collected from the Gator Tech Smart House (Figure 2). The contexts modeled/reasoned by applying the automated approach were compared contexts manually configured in Persim 3D (Lee *et al.*, 2015). The experiential validation showed that the proposed approach was acceptable with positive results. Based on the meaningful progress, we will enhance the approach, which can 1) figure impermissible contexts, 2) find unknown contexts, and 3) map the present context to the most relevant services for human residents in a smart space.

References

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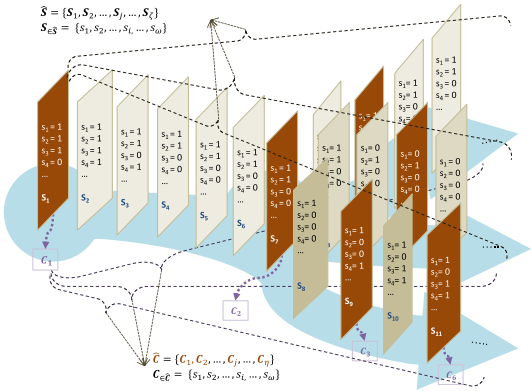

Figure 1. State Space S_j consists of status of sensors s_i. $\hat{S}$ stands for all collection of state spaces. Context C_j is a representative and meaningful state space, and a collection of contexts is defined as $\hat{C}$.

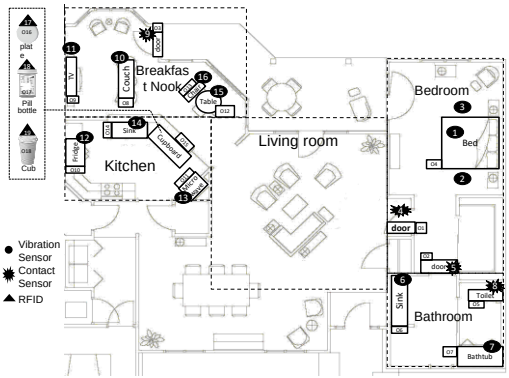

Figure 2. For this experience, 19 sensors have been attached on 18 objects in the Gator Tech Smart House (GTSH). Sensor data have been collected in four rooms – bedroom, bathroom, dining room and kitchen. In this space, 8 activities have been performed and 4 to 6 contexts have been modeled and recognized.