SensHome: Towards A Corpus for Everyday Activities in Smart Homes

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Abstract

We present our planned efforts within the SensHome project in building a corpus of daily activities in smart environments. The recordings consisting of measurable events as provided by the instrumentation along with video and audio recordings. SensHome foresees a three-step development where the instrumentation is verified in a dual-reality setting followed by recording in controlled environments. Finally, the recordings will be done under real circumstances. We extend previous work on activities as formulated by (Leontiev, 1978) and (Stahl, 2009) with the notion of partial orders of ontologically represented events denoted *episodes* that constitute fundamental building block for annotations.

1. Introduction

Worldwide, considerable efforts are invested in research and development for accessible and user-friendly technology for the sake of coping with the demographic change. In Europe, the European Union alone or possibly in combination with domestic initiatives, e.g., the AAL Joint Programme, fund projects that target different aspects on living or being as a person with special needs. A big part of these efforts include providing different users with intuitive and accessible user interfaces for interacting with appliances and services in the smart home.

The SensHome project, see SensHome.dfki.de, is an effort in creating an infrastructure and a methodology for recording, modeling, annotating and analysing activities in Smart Environments where we initially focus on Smart Homes.

SensHome is one of the projects emerged from the i2home project. Here, the main focus was to inject an ecosystem around the Universal Remote Console (URC) standard, see (Zimmermann and Vanderheiden, 2007; ISO, 2008; Rich, 2009). The URC technology provides an approach called *pluggable user interfaces* that allows for interfacing arbitrary networked appliances or services with personalized and perhaps most important accessible and adaptable user interfaces. Both projects are step stones toward the long-term vision of intelligent and pro-active smart home environments where a person can not only control the environment, the environment even pro-actively supports the person in his/her daily life. To this end, we are particularly interested in the recognition of irregularities.

2. The SensHome Project

SensHome aims at finding an optimal instrumentation of the Smart Home implementing a flexible architecture and infrastructure for recognizing and analyzing everyday activities and thus offering proactive help.

Following the GOAL development methodology (Stahl, 2009) we start with pure virtual modeling of the environment to ensure that, firstly, there is a sufficient instrumentation and, secondly, the SensHome corpus is suitable for recording, annotating and analyzing the relevant activities.

The infrastructure will then be installed in the following controlled environments: I) SensHome Smart Suitcase; ii) DFKI's intelligent kitchen; and iii) Bremen Ambient Assisted Living Lab (BAALL).

To build up a corpus with realistic everyday activities the SensHome System will in the final step be used to instrument a real flat.

3. Activity Modeling

To start with, we will annotate our corpus with two levels of annotations: *activities* and *episodes*. However, we consider additional annotations, such as gestures, emotions, spoken language etc.

Our modeling of activities emerges from the Activity Theory by (Leontiev, 1978). Activity Theory provides a hierarchical model for dividing human interactions into *activities*, *actions* and *operations*. A single activity consists of actions which can again be decomposed into operations. Activities are motivated by primary goals or human needs, whereas actions and operations are directed towards secondary goals to achieve these needs. The boundary between actions and operations is represented by a user's specific knowledge and experience which can change over time, that is, an action that requires concentration can be internalized by transforming it into an unconscious operation and externalized vice versa. Activity Theory can be seen as a holistic framework for thinking about human activity and modeling user interaction as it is expressed in the use of technology (Kaptelinin and Nardi, 2006).

Previously, activity modeling has been extended in subject, artifact and object. For instance, (Stahl, 2009) extends the work of (Leontiev, 1978) with location and time point thus answering the question where the activity took place etc.

In SensHome, we include a temporal modeling in the sense that we explicit the details of the activities and their parts by adding the notion of *episodes*. Episodes are partial orders of ontological entities ordered by temporal and locational changes. The ontological entities—concepts and/or instances—stem from an ontology which are relevant to some activity as provided by the smart environment. Con-

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sequently, depending on the detail of the models, some sub entities of an episode can occur in parallel. Entities can be associated with a subject, an artifact, location as in (Stahl, 2009). In our model, we additionally can associate an entity with a time point or a time span (Allen, 1984) which might be absolute or just related, e.g. before/after/simultaneously. Examples of episodes are "Turn-around; Open-cupboard; take-a-cup; turn-around; go-to-location-*cooking-area*; ..." and "switch-on-water-tap; fill-glass; switch-off-water-tap". The latter example can, however additionally be annotated as "fill-glass-with-water". All of these entities are tuples built up from entities in on ontology or even other episodes. Currently, we are looking into the UbisWorld (Heckmann, 2006) ontology as a starting point for our modeling, see also `http://www.ubisworld.org/`

4. The SensHome Corpus

There are several possibilities to created and annotate the corpus. Among the current approaches, we are currently considering several options.

One possibility is to follow the approach used in the AMI/AMIDA projects: NTX `http://groups.inf.ed.ac.uk/nxt/`, (Kilgour and Carletta, 2006). There, meetings were recorded with cameras and microphones, the recordings were then annotated with different levels, such as transcriptions, dialogue acts, disfluencies etc. Drawback of NXT is that there is no standard tool for annotating but there is a set of previous tools, e.g. `http://www.amiproject.org`. Consequently, new tools will have to be developed.

There are a number of other alternatives: clearly, ANVIL has become an important tool for corpus creation and annotation. Other tools are ELAN, EXMARaLDA and MacVisSTA, see (Kipp, 2010) for a comparison of these tools.

5. The SensHome Technical Infrastructure

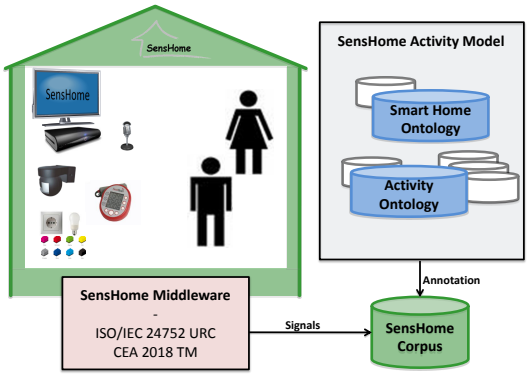

Figure 1: The SensHome Architecture. Activities in the smart home is mediated by the URC middleware through which not only video but also interactions with the environment is captured and piped to the corpus. The Corpus is the annotated with the SensHome Activity Model—a composition of different ontologies.

The SensHome architecture is built upon a new series of industry standards (ISO/IEC 24752 Universal Remote Console & ANSI/CEA 2018 Task Model Description) for interfacing networked appliances by means of a Universal Remote Console (URC) (Zimmermann and Vanderheiden, 2007) and for adding to the UIs, support for interaction, see (Rich, 2009). The implementation thereof is a middleware called universal control hub (UCH) that supports up-to-date prominent communication standards and allows for controlling multiple devices at the same time, see (Zimmermann and Vanderheiden, 2007). The combination of the UCH and the activity management module allows for the implementation of scenarios like leaving home: as a person leaves his house and locks the door, some running appliances should be turned off—TV, hood, oven the heating should depending on the situation be lowered—and the alarm system should be activated.

The SensHome Activity Model is a combination of a number of ontologies. Currently identified ontologies are

Smart Home Ontology In this ontology we basically model the appliances and signals included into the smart home, such as, Lamp, Stove, SwitchOne(lamp), ...

Activity Ontology Here, we model activities of daily living (ADL) and other higher order annotations

Dialogue Acts We will adapt the draft standard "ISO 24617-2 Semantic annotation framework, Part 2: Dialogue acts", e.g., (Bunt et al., 2010).

Temporal Ontology Activities are dependent on temporal information, e.g., (Allen, 1984).

Locational Ontology Modelling location will be based on an extension of the UBISWORLD ontology, see (Heckmann, 2006)

The UCH gateway-based architecture implementing the URC standard managing the communication between controllers and targets: a **Controller**, that is any device for rendering the abstract user interface, e.g., TV, touch screen or the smartphone presented in this paper; a **Target**, which is any networked device or service intended to be controlled or monitored, such as kitchen appliance, home entertainment or security devices; and, finally, a **Resource Server**, a global service for sharing user interfaces and other resources necessary for interacting with the targets. The benefit of this approach is that it is possible to deploy consistent and, particularly, accessible user interfaces which are tailored to particular users.

The URC technology has so far been envisioned as a middleware for interacting with smart environments as in the i2home[1] (Alexandersson, 2008) and VITAL[2] (Zinnikus et al., 2009) projects. Other running projects have started applying this technology for other scenarios, such as health care, smart grid/energy etc. In these projects, the main motivation has been the creation of accessible user interfaces. In SensHome, we will for the first time apply this technology for the creation of a corpus.

[1] `http://www.i2home.org`
[2] `http://www.ist-vital.org`

6. Conclusion and Outlook

We have presented our efforts within the SensHome project in creating a corpus for activities within a Smart Home scenario. The SensHome corpus builds on previous efforts, such as the NETCARITY corpus. There, purely controlled experiments with pre-defined activities are within the corpus. In addition to its annotations with visual features extracted from the video material only, the SensHome corpus will contain higher-order activities like our episodes and explicit temporal annotations, speech and dialogue acts (Bunt et al., 2010).

7. References

Jan Alexandersson. 2008. i2home—Towards a Universal Home Environment for Elderly and Disabled. *KI*, 3/08:66–68.

James F. Allen. 1984. Towards a general theory of action and time. *Artificial Intelligence*, 23:123–154.

Harry Bunt, Jan Alexandersson, Jean Carletta, Jae-Woong Choe, Alex Chengyu Fang, Koiti Hasida, Kiyong Lee, Volha Petukhova, Andrei Popescu, Claudia Soria, , and David Traum. 2010. Towards an iso standard for dialogue act annotation. In *Proceedings of the 7th International Conference on Language Resources and Evaluation — LREC 2010*, Malta, May.

Dominikus Heckmann. 2006. *Ubiquitous User Modeling*. Akademische Verlagsgesellschaft Aka GmbH, Berlin. ISBN 3-89838-297-4 and ISBN 1-58603-608-4.

ISO. 2008. *ISO/IEC 24752: Information Technology — User Interfaces — Universal remote console — 5 parts*. "International Organization for Standardization".

Victor Kaptelinin and Bonnie A. Nardi. 2006. *Acting with Technology - Activity Theory and Interaction Design*. The MIT Press.

Jonathan Kilgour and Jean Carletta. 2006. The nite xml toolkit: demonstration from five corpora. In *NLPXML '06: Proceedings of the 5th Workshop on NLP and XML*, pages 65–68, Morristown, NJ, USA. Association for Computational Linguistics.

Michael Kipp, 2010. *Multimedia Information Extraction*, chapter Multimedia Annotation, Querying and Analysis in ANVIL, page Chapter 19. MIT Press.

Aleksei N. Leontiev. 1978. *Activity, Consciousness, and Personality*. Englewood Cliffs, N.J.: Prentice Hall. (Original work published in Russian in 1975).

Charles Rich. 2009. Building task-based user interfaces with ansi/cea-2018. *Computer*, 42(8):20–27.

Christoph Stahl. 2009. *Spatial Modeling of Activity and User Assistance in Instrumented Environments*. Ph.D. thesis, Universität des Saarlandes, Department of Computer Science.

Gottfried Zimmermann and Gregg Vanderheiden. 2007. The universal control hub: An open platform for remote user interfaces in the digital home. In Julie A. Jacko, editor, *Human-Computer Interaction*, volume 4551 of *LNCS*, pages 1040–1049. Springer.

Ingo Zinnikus, Klaus Fischer, Jan Alexandersson, and Unai Diaz. 2009. Bringing the elderly into the mainstream of e-society: the vital project. In *IADI e-Society Conference*, Barcelona, Spain.