Chapter 12

On the Representation and Recognition of Temporal Patterns of Activities in Smart Environments

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ABSTRACT

This chapter introduces a framework for enabling context-aware behaviors in smart environment applications, with a special emphasis on smart homes and similar scenarios. In particular, an ontology-based architecture is described that allows system designers to specify non-trivial situations the system must be able to detect on the basis of available sensory data. Relevant situations may include activities and events that could be prolonged over long periods of time. Therefore, the ontology encodes temporal operators that, once applied to sensory information, allow the recognition and efficient correlation of different human activities and other events whose temporal relationships are contextually important. Special emphasis is devoted to actual representation and recognition of temporally distributed situations. The proof of the concept is validated through a thoroughly described example of system usage.

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1. INTRODUCTION

Nowadays, the role that context-aware systems are going to play in our society is definitely clear: it is commonly accepted that rich and expressive context models must be designed and realized in order to improve the actual behaviour and to extend the capabilities offered by Ambient Intelligence (AmI in short) systems, such as smart homes, intelligent vehicles or even smart cities.

Although the very notion of “context” is particularly vanishing, the goal of a context-aware system is well defined. Referring to the work described in Dourish (2004), this goal can be resolved in the following question: How computation can be made sensitive and responsive to the setting (both physical and social) in which it is harnessed and used? Common examples are Personal Digital Assistants or Smart Phones that adaptively display information depending on both the surrounding environment and current user activities, such as a to buy list of goods which items are selectable or not depending on their availability in the store the user is currently visiting, or a to do list of activities which elements pop up depending on the current schedule and approaching deadlines.

In order to offer these kinds of services, human behaviour must be carefully detected and understood. The search for expressive and effective context models is heavily related to cognition modelling and understanding, especially in humans. As it has been shown by philosophers, psychologists, and cognitive scientists (refer to the work described in Dourish [2004] and Waldmann [2007] and the references therein), human activity does not necessarily follow long-term plans: on the contrary, it is very “situation dependent” and opportunistic, whereas long-term plans can usually be described as a dynamical sequence of short-term activities, each one set in a specific context. Early work in this field focused on “the big picture,” which allows to consider contexts as well-delimited and stable pieces of information. On the other hand, it seems intuitive that:

1. Contexts are not relevant per se, but especially when related to other “pieces” of information that may originate as a consequence of user activity, specifically distributed over prolonged periods of time.
2. Contexts are not static and monolithic entities: on the contrary, they are based on many constituent parts (depending on activities and roles of the humans involved) and can contribute to other contexts with possibly significant temporal relationships.

To deal with these issues, different context models have been investigated, designed, and effectively used in real-world scenarios, with alternate success. On the basis of these considerations, in the work reported in Krummenacher and Strang (2007), a number of prerequisites are outlined, which are described as follows.

Applicability. The context model must conform to existing environments and different domains of human activity. This requires the definition of common infrastructures and context representation paradigms enforcing scalability and modularity.

Comparability. Proper metrics and classification procedures must be added to the context model in order to compare heterogeneous entities and to analyze sensory information. Furthermore, since context models are aimed at associating a “meaning” to a collection of sensory information, these metrics must span both numerical and symbolic domains.

Traceability. The model must be aware of how incoming data are manipulated before being handled by the model itself. This requires a tight integration between information processing and knowledge representation.

History. Knowledge of past events and activities must be considered in context definitions, along with their relationships with current situations. In particular, it is useful to define very expressive relationships among activities distributed over long periods of time using formalisms allowing to efficiently recognize temporal contexts.