Goal Oriented Opportunistic Sensing

Gerold Hoelzl
Institute for Pervasive Computing
Johannes Kepler University Linz
Altenbergerstrasse 69
4040 Linz, Austria
gerold.hoelzl@pervasive.jku.at

ABSTRACT

Today's activity and context recognition system have the drawback to use a static sensing infrastructure that has to be defined at the design time of the system. The predefined sensing infrastructure needed to work properly, as well as the fixed recognition purpose limits the flexibility of such a system as it can't react on changes in the sensing infrastructure nor it can address a change in its recognition purpose. In open ended dynamic, environments the sensing infrastructure can change during runtime of the system as new sensors can appear and disappear in a dynamic way. The term opportunistic sensing addresses this in selecting sensors that just happen to be available according to a stated recognition goal instead of using a predefined sensor infrastructure. Methodologies on how to state such a recognition goal to an opportunistic activity and context recognition system and how these goals can be translated into a machine readable and executable form to handle dynamic sensor setups have to be developed within the authors PhD-thesis.

Author Keywords

Goal Oriented Sensing, Goal Processing, Wireless Sensor Networks, Opportunistic Activity and Context Recognition.

ACM Classification Keywords

I.1.0 Computing Methodologies: General

INTRODUCTION AND MOTIVATION

Sensor networks allow us to sense the physical world and detect context and activity which is a key to build and develop intelligent environments [1]. The detection of human activity is an important aspect of context recognition systems [4] and is used in pervasive computing [10], wearable computing [7] and human computer interaction [8] to enable pro actively supporting users just in time.

In nowadays established and well known activity and context recognition systems [9] the sensor configuration and the recognition purpose of the system have to be defined at design time of the system. For a widespread use of activity- and context-aware systems, this application specific sensor deployment is not desirable. Opportunistic activity and context recognition systems ([5], [3]) draw from the characteristics to use sensing devices that just happen to be available rather than pre-defining a fixed sensor infrastructure at design time. Opportunistic sensing offers the possibility to obtain data from sensors that just happen to be available in the area surrounding the user. This enables users or applications to state *recognition goals*, saying what has to be sensed for, at runtime to the system. The available sensing devices that can contribute to the recognition goal are then configured to an ensemble, which is the best set of sensors according to a utility function to recognize the goal.

Due to the increasing availability of resources as sensor systems are getting smaller and smaller, are equipped with (wireless) communication technologies, measure different environmental quantities and are already embedded in different kinds of electronic appliances and gadgets [1] future environments will see an ever larger availability of readily deployed sensors. While some sensors may be known, it is much more likely that in real world deployment of activity-aware systems the nature, the type and the availability of sensors will be highly dynamic and hard to predict. Such environments are open-ended as they change over time as newly developed sensors that were not known at design time of the activity and context-aware system can appear in unpredictable ways.

The use of high level goals to direct the configuration of a context- and activity aware system will lead to systems that automatically configure the available sensing infrastructure in the environment at any point in time to fulfill the recognition goal best possible.

PROBLEM DOMAIN AND RESEARCH CHALLENGES

The main difference between traditional activity and context aware systems compared to the opportunistic approach is the absence of the need to predefine a fixed and static sensing infrastructure at design time and the possibility of users or applications to state recognition goals at runtime. A recognition goal is a high level principle governing how a system should behave [2]. Goals state in an abstract way what the system should do, how it should behave and how this can be achieved. Goals are a way of controlling the behaviour and the configuration of a system. Using high level goals is a novel approach to direct the configuration of a system in the field of sensor networks. As the available sensor infrastructure and their configuration is not known at design time, and due to its highly dynamic nature as sensors can appear and disappear during runtime, the goal has to define what is necessary to achieve its purpose.

So there is the need of defining a goal syntax and a semantic mapping between a high level recognition goal and the available sensors to identify sensor candidates that can contribute to the stated high level goal. This is (i) a *semantic description* of the sensors and their capabilities (referred to as self-description [6]) and (ii) a knowledge base that models for a given application domain the available goals and their relationships to have a common knowledge base.

The following list provides the open research questions in the field of high-level goal formulation, goal processing and goal-oriented sensing that build the base for the authors PhD-thesis:

- *RQ1*: How can a high level recognition goal be formulated and presented to be further processed by an opportunistic activity and context recognition system? How can a high level goal be translated to a machine readable representation and which technologies are applicable for goal representation, composition and translation?
- *RQ2*: How can domain activity knowledge and the relation between the activities be represented and reasoned? Is an ontology an appropriated approach to build this knowledge base? Are there other approaches like *context-free-grammars (CFG)* that could be used for this purpose? In which form is a knowledge-based processing necessary for goal translation and how can this be defined?
- *RQ3*: How can the recognition output of different sensors be combined to fulfill a high level goal and how can this combination be quantified?

ACHIEVED RESULTS

According to the research questions the following results were achieved and integrated into the *Opportunity Framework* [5], a reference implementation of an opportunistic activity and context recognition system: (I) An approach on how to formulate a *high level recognition goal* that allows the selection of the best set of sensors suitable to recognize the goal. (II) An *Activity Relation Ontology* that models activities and their relations extracted from the kitchen-scenario experiment used in [5] was built to allow semantic matchmaking between a high level recognition goal and the sensing infrastructure. (III) Goal processing capabilities that allow to use sensors that were not directly designed to fulfill the stated goal, but can be used instead, according to the defined activity relations, to fulfill the goal.

CONCLUSION

In this paper we presented the main differences between traditional context aware systems and the opportunistic approach. We showed the necessity to state recognition goals at runtime to overcome the static recognition behaviour of nowadays systems. A list of research questions was presented that build the base for the authors PhD thesis. Beside the analysis of existing approaches, the main contribution of this PhD-thesis will be the development of methodologies that sufficient answer the research questions by enabling goal oriented opportunistic sensing. The *Opportunity Framework* is currently being developed and is used for evaluation and testing of the evolved methodologies and techniques.

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Gerold Hölzl is a research member at the Institute for Pervasive Computing at the Johannes Kepler University of Linz, Austria.
During his technical high school years and his master studies of computer science at the Johannes Kepler University of Linz his interests developed in the fields of autonomous sensor networks (integrated into things of everyday life) enabling the vision of technology that disappears and serves people in an unobtrusive manner.
His research interests focus on pervasive and embedded computing, opportunistic activity and context aware systems, goal oriented sensing, pattern classification, mobile and distributed computing and (wireless-) sensor networks.

Presenting his Master Thesis titled: „A personalized body motion sensitive training system based on auditive feedback“ at the MobiCASE 09 conference, he decided to take the opportunity of a scientific carrier and enrolled into the PhD program in August 2010 having Prof. Dr. Alois Ferscha - the Head of the Institute for Pervasive Computing - as supervisor for his research activities in the field of goal-oriented opportunistic sensing.

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