How Intelligent Are Ambient Intelligence Systems?

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ABSTRACT

Since the appearance of the Ambient Intelligence paradigm, as an evolution of the Ubiquitous Computing, a great deal of the research efforts in this field have been mainly aimed at anticipating user actions and needs, out of a prefixed set. However, Ambient Intelligence is not just constrained to user behaviour pattern matching, but to wisely supervise the whole environment, satisfying those unforeseen requirements or needs, by means of rational decisions. This work points at the lack of commonsense reasoning, as the main reason underlying the existence of these idiots savant systems, capable of accomplishing very specific and complex tasks, but incapable of making decisions out of the prefixed behavioral patterns. This work advocates for the integration of the commonsense reasoning and understanding capabilities as the key elements in bridging the gap between idiot savant systems and real Ambient Intelligence systems.

Keywords: Ambient Intelligence, Ambient Intelligence Systems, Automatic Service Composition, Cyc, Idiots Savant Systems, Ubiquitous Computing

1. INTRODUCTION

The Ubiquitous Computing concept was first defined by Mark Weiser (1995) as a new computing era where electronic devices merge into the background, becoming invisible, in such a way that people could make use of those devices in an unconsciously way, focusing just on their needs and not in the interaction.

One decade later, the IST Advisory Group first stated the concept of Ambient Intelligence (Ducatel et al., 2001), which builds on the Ubiquitous Computing paradigm where people are surrounded by all kind of intelligent intuitive devices, capable of recognizing and responding to their changing needs. In these contexts, people perceive the surrounding as a service provider that satisfies their needs or inquiries in a seamless, unobtrusive, and invisible way. Therefore, these contexts have to be supported on a service-oriented architecture capable of

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dealing with the device heterogeneity and service dynamism, exhibited in these contexts. Nevertheless, the state of the art in Ambient Intelligence, demonstrates that these are well addressed issues, by any of the flavored service-oriented architectures, in the form of an OSGi framework, such in the case of the AMIGO project (2009), web services such as in the Hydra project (2009), middleware technology as in the approach proposed in Villanueva et al. (2009), or a Multi-Agent System such as in the CHIL project (2009). However, there are some other aspects of the Ambient Intelligence that have not been so effectively addressed as the previous ones. Aspects such as the ambiguity, uncertainty, or incompleteness of the context information, prevent Ambient Intelligence systems from being fully context-driven. In the words of Lenat et al. (1990), bottlenecks arise when systems attempt to respond to unexpected situations. This happens to be the most common situations found in Ambient Intelligence contexts. How people react to these unexpected situations provides an idea about the direction where efforts are to be addressed. Generally, when facing novel situations we tend to establish some similarities with past experiences, or resort to the general knowledge about how things work (so-called commonsense), or even look for advice in books, for instance. In any case, Lenat et al. (1990), believe that only Ambient Intelligence systems will be flexible enough to support the scenarios envisioned in Ducatel et al. (2001) when commonsense reasoning starts being considered an structural part of such systems. Automating commonsense reasoning is a task that requires an expressive enough language, a knowledge base where to store such a large amount of knowledge, and a set of mechanisms capable of manipulating this knowledge, so as to infer new information. Regarding the knowledge base, Cyc (Lenat, 1995) and WordNet (Fellbaum, 1998) are by far the most evolved and successful approaches. However, Cyc is the most complete, in terms of the amount of comprising facts, the representation language used—CycL—, and the mechanisms provided to infer and reason upon the stated knowledge, based on planning, deduction, and rules. Essentially, Ambient Intelligence challenges demand a high level of autonomy and self-sufficiency, and this work analyzes how an approach based on Cyc could bridge the gap that prevent Ambient Intelligence systems from being intelligent. Therefore, the remainder of this article is committed to this justification. Section 2 revises the state of the art of Ambient Intelligence systems, so as to identify the main shortcomings, and how these can be overcome by adopting a commonsense approach. Section 3 analyzes the benefits of an approach based on Cyc. Finally, last section outlines the conclusions that can be derived from this work.

2. AN ONTOLOGY FOR AMBIENT INTELLIGENCE

The previous section pointed out commonsense reasoning as a means to support systems capability to react to unexpected situations. However, before getting into the details about how these tasks are performed, we set the basis for the knowledge representation task, prior to tackling the reasoning one. This knowledge engineering task (Brachman et al., 2004) can be summarized so as to identify the relevant entities, their properties and their relationships one to each other, or in other words, providing an ontology for the application domain.

The importance of providing an ontology for Ambient Intelligence is twofold. On the one hand, it unifies the vocabulary used to describe the domain knowledge, by stating the type of objects that play an important role in the domain, their properties and relationships. Moreover, interoperability among the different architectural elements of an Ambient Intelligence system draws on this unified vocabulary. On the other hand, providing an ontology allows that information modelled by means of this ontology can be automatically plugged into large bodies of knowledge, and therefore logically related (Taylor et al., 2007). As will be explained later, this is one of the many strengths of Cyc,
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