ABSTRACT

Realization of human-computer symbiosis is an important idea in the context of ubiquitous computing. Symbiotic Computing is a concept that bridges the gap between situations in Real Space (RS) and data in Digital Space (DS). The main purpose is to develop an intelligent software application as well as establish the next generation information platform to develop the symbiotic system. In this paper, the authors argue that it is necessary to build ‘Mutual Cognition’ between human and system. Mutual cognition consists of two functions: ‘RS Cognition’ and ‘DS Cognition’. This paper examines RS Cognition, which consists of many software functions for perceiving various situations like events or humans’ activities in RS. The authors develop two perceptual functions, sitting posture recognition and human’s location estimation for a person, as RS perception tasks. In the resulting experiments, developed functions are quite competent to recognize a human’s activities.

INTRODUCTION

Recently there are a lot of efforts to develop an innovative and intelligent space, room or environment relating data stored in Digital Space (DS) to situations in Real Space (RS) in the context of ubiquitous computing (Weiser, 1991). For example, Robotic Room (Sato, Nishida, & Mizoguchi, 1996), Intelligent Room (Coen, 1998), Easy Living (Shafer et al., 1998; Brummitt et al., 2000), Intelligent Space (Lee, Appenzeller, & Hashimoto, 1998; Lee & Hashimoto, 2002), Aware Home (Kidd et al., 1999), SELF (Nishida et
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al., 2000), Smart Room (Pentland, 2000), Project Oxygen (Rudolph, 2001) and Robot Town Project (Hasegawa & Murakami, 2006; Murakami et al., 2008) have been proposed. Final goal of them will be to realize a secure society and community based on supporting daily life through recognizing situations in RS from various physical data that are obtained by ubiquitous and embedded sensors. Moreover, their projects will aspire to build new man-machine (human-computer) relationships.

In the above context, we have also proposed a concept of Symbiotic Computing since 1994 (Symbiotic Computing, 2010). The notion of human-computer symbiosis is the first used in 1960 (Licklider, 1960). About half a century has passed, however, people cannot receive satisfactory and suitable services without their proactive actions because systems cannot perceive dynamic situation in Real Space (RS). In other words, a lot of current computer service has been realized based on static information only in Digital Space (DS).

The purpose of Symbiotic Computing is mainly to develop flexible information service or application as well as to establish the next generation information platform based on multi-agent framework (Suganuma et al., 2009; Sugawara et al., 2008). In addition, a specific characteristic of Symbiotic Computing is to aim at establishment of ‘Mutual Cognition’ between RS and DS. Mutual cognition is a cognitive process defined by the relation between a personal feeling that “I know what you know about me” and a machine’s activity as if “I know what you know about me.”

Figure 1 shows a model of mutual cognition process which consists of four steps. The first step is to recognize actions of a person or a community. The next step is to infer a request from the recognized actions and send it to DS. The third step is to give valid information or services provided by DS to RS according to situation. The last step is to check feeling of contentment of the human to evaluate the process of the mutual cognition. The realization of mutual cognition can provide suitable and secure services based on a situation in RS to people. We aspire to build new man-machine (human-computer) relationships.

In other words, mutual cognition model is one of the specific models of context-awareness computing (Poslad, 2009). According to Poslad (2009), the term context-aware was first used by Schilit and Theimer (1994) in the context of mobile computing. Until now there were a lot of similar definitions of context or context-awareness (Dey & Abowd, 2000). In order to clear our purpose, we follow the definition of context and context-aware in reference (Dey & Abowd, 2000). Definition 2 is almost equivalent to the idea that symbiotic computing is trying to realize.

**Definition 1:** Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

![Figure 1. Mutual cognition process](image-url)
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