Task Ontology-Based Human-Computer Interaction

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INTRODUCTION

In ontological engineering research field, the concept of "task ontology" is well-known as a useful technology to systemize and accumulate the knowledge to perform problem-solving tasks (e.g., diagnosis, design, scheduling, and so on). A task ontology refers to a system of a vocabulary/concepts used as building blocks to perform a problem-solving task in a machine readable manner, so that the system and humans can collaboratively solve a problem based on it.

The concept of task ontology was proposed by Mizoguchi (Mizoguchi, Tijerino, & Ikeda, 1992, 1995) and its validity is substantiated by development of many practical knowledge-based systems (Hori & Yoshida, 1998; Ikeda, Seta, & Mizoguchi, 1997; Izumi &Yamaguchi, 2002; Schreiber et al., 2000; Seta, Ikeda, Kakusho, & Mizoguchi, 1997). He stated:

> *…task ontology characterizes the computational architecture of a knowledge-based system which performs a task. The idea of task ontology which serves as a system of the vocabulary/concepts used as building blocks for knowledge-based systems might provide an effective methodology and vocabulary for both analyzing and synthesizing knowledge-based systems. It is useful for describing inherent problem-solving structure of the existing tasks domain-independently. It is obtained by analyzing task structures of real world problem. … The ultimate goal of task ontology research is to provide a theory of all the vocabulary/concepts necessary for building a model of human problem solving processes.* (Mizoguchi, 2003)

We can also recognize task ontology as a static user model (Seta et al., 1997), which captures the meaning of problem-solving processes, that is, the input/output relation of each activity in a problem-solving task and its effects on the real world as well as on the humans' mind.

BACKGROUND

Necessity of Building Task Ontologies as a Basis of HCI

It is extremely difficult to develop an automatic problem-solving system that can cope with a variety of problems. The main reason is that the knowledge for solving a problem varies considerably depending on the nature of the problems. This engenders a fact that is sometimes ignored: Users have more knowledge than computers. From this point of view, the importance of a user-centric system (DeBells, 1995) is now widely recognized by many researchers. Such framework follows a collaborative, problem-solving-based approach between human and computer by establishing harmonious interaction between human and computer.

Many researchers implement such a framework with a human-friendly interface using multimedia network technologies. Needless to say, it is important not only to apply the design principles of the human interface but also principle knowledge for exchanging meaningful information between humans and computers.

Systems have been developed to employ research results of the cognitive science field in order to design usable interfaces that are acceptable to humans. However, regarding the content-oriented view, it is required that the system can understand the meaning of human's cognitive activities in order to capture a human's mind.

We, therefore, need to define a cognitive model, that is, to define the cognitive activities humans perform in a problem-solving/decision-making process and the information they infer, and then systemize them as task ontologies in a machine understandable manner in order to develop an effective human-computer interaction.

Problem-Solving Oriented Learning

A task with complicated decision making is referred to as "Problem-Solving Oriented Learning (PSOL) task" (Seta, Tachibana, Umano, & Ikeda, 2003; Seta & Umano, 2002). Specifically, this refers to a task that does not only require learning to build up sufficient understanding for planning and performing problem-solving processes but also to gain the ability/skill of making efficient problem-solving decisions based on sophisticated strategies.

Consider for example, a learner who is not very familiar with Java and XML programming and tries to develop an XML-based document retrieval system. A novice learner in a problem-solving domain tries to gather information from Web resources, investigates and builds up his/her own understanding of the target area, and makes plans to solve the problem at hand and then perform problem-solving and learning processes. Needless to say, a complete plan cannot be made at once, but is detailed gradually by iterating, spirally, those processes while applying a "trial and error" approach. Thus, it is important for a learner to control his/her own cognitive activities.

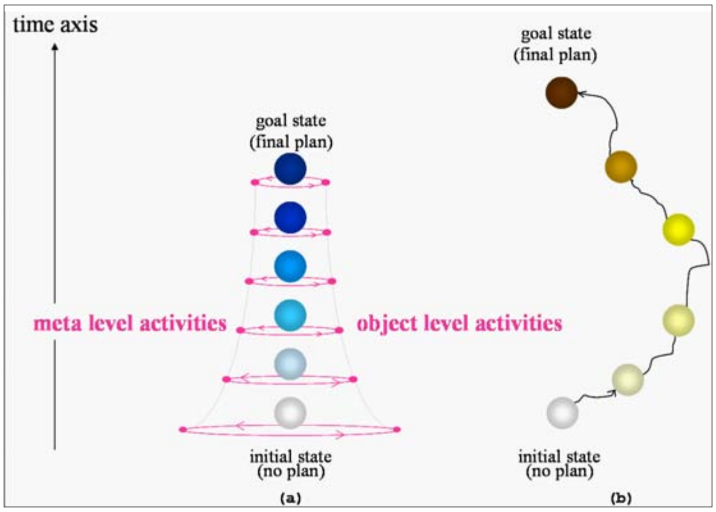
Facilitating Learners' Meta Cognition through HCI

In general, most learners in PSOL tend to work in an *ad hoc* manner without explicit awareness of meaning, goals and roles of their activities. Therefore, it is important to prompt construction of a rational spiral towards making and performing efficient problem-solving processes by giving significant direction using HCI.

Many researchers in the cognitive science field proposed a concept whereby metacognition plays an important role to acquire and transfer expertise (Brown, Bransford, Ferrara, & Campione, 1983; Flavell, 1976; Okamoto, 1999). Furthermore, repeated interaction loops between metacognition activities and cognition activities play an important role in forming an efficient plan for problem-solving and learning processes.

Figure 1 shows the plan being gradually detailed and refined along the time axis. Figure 1(a) is a planning process when a learner has explicit awareness of interactions and iterate metacognition activities and cognition activities spirally, while Figure 1(b) is a planning process with implicit awareness of them. In PSOL, monitor and control of problem-solving/learning processes are typical activities of metacognition while their performances are ones of cognition. It is natural that the former case allows efficient plans for problem-solving workflow more

Figure 1. The interaction helps the effective planning process



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