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An HCI-Based Cognitive Architecture for Learning Process Observation

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ABSTRACT

In this article, a cognitive framework for observing learning activities based on human-computer coupling is proposed. The observation is based on the vectorization of a learning situation along with human-computer interaction factors. An evolutionary high-dimensional topology of learning cognitive flow is introduced for human-computer interaction. In addition, the authors have selected a tree topology as the topological structure of a low-dimensional learning space to process the observations for online learning. Furthermore, the mechanism for the BSM (brain cognitive body-situation of coupling-manifold of information) the coupling morphism is presented. The principle for the coupled observation of objects in a cognitive or learning manifold is proposed. Finally, a special system for teaching and learning is programmed to observe and evaluate learning and mental arithmetic training processes. This system not only provides students with a new ergonomic learning model but also records the students' learning processes. Thus, the teachers can summarize the knowledge points automatically rather than manually.

KEYWORDS

Category and Morphism, Cognitive Architecture, Human-Computer Interaction, Learning Action Recommendation, Learning and Teaching Process, Manifold Topology, Observations, Visualization

INTRODUCTION

With the popularity of computers and mobile intelligent terminals, human-computer interaction has become an important environment for learning. Van Gelder and Port (1995) proposed the dynamic research idea about cognitive science (a declaration of the third competitive paradigm of cognitive science). Thus, psychology has ushered in the era of cognitive science. In addition,

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geometry and topology have emerged developed to provide the mathematical descriptions of cognition (Musso et al., 2019).

In the field of cognitive science, computers are often used as computing and statistical tools for observations. However, they are rarely used to collect data on cognitive activities by researchers (Newell et al., 1958). Formerly, data is collected manually in many psychological experiments. Therefore, using computers to observe cognitive activities and collect cognitive data automatically is a trend in cognitive science studies. Undoubtedly, given the close interaction between computer and brain, the human-computer interactive environment should be an important environment for cognitive observation and data collection.

Cognitive philosophy contains situated cognition, embodied cognition, and distributed cognition. We will briefly discuss about these terms as below:

1. **Situated cognition:** Cognition is an event existing in the overall context of the agent-environment interaction and correlation. Cognition is existence-oriented, activity-directed, and an activity pointing to the environment that can exist outside the brain;
2. **Embodied cognition:** The organism and the environment enfold and unfold to each other in basic cycling that represents the life itself. Cognition and knowledge are generated in the life system, which is coupled with the environment. This is known as a development of the former perspective, thinking cognition, which is equivalent to computing;
3. **Distributed cognition:** Distributed cognition focuses on where human cognition occurs and whether it can cross the cerebral cranium, the psychological boundary of the brain. Therefore, the cerebral cranium is the psychological boundary of cognitive activity. Distributed cognition reflects the situated nature of cognition.

However, current studies in this respect have encountered two technological issues (Mouri et al., 2019, p. 1) differential equations have high demands for continuity and precision of cognition, thus making them difficult for use in analyzing cognitive processes (Cruz-Benito et al., 2019); 2) the data collection methods and technologies for cognitive studies are difficult to be automated, while it is hard for manual data to meet quantity and precision needs (Chung et al., 2019).

Cognitive coupling states are very special advanced human-computer interactive states that are the foundation for observing and studying learning and cognition (Shimin et al., 2012). According to distributed cognition, a digital environment is built between students and intelligent devices, and the problem space in the brain is extended to the information space outside the brain. Researchers modulate the human-computer interactive state to the cognitive coupling state to build a new cognitive and learning environment. The computer becomes the teacher and learning partner. It not only replaces the teacher to do much of the teaching work, but also can continuously collect a huge amount of data on the learning process automatically.

Based on the cutting-edge cognitive philosophies previously discussed, the objects connected with humans and computers are the situation of the human-computer interface and computer peripherals. These objects may include monitors, multimedia, and keyboards. Thus, in the learning situation where the cognition of the human and the computer are coupled, these human-computer interactive situations and interfaces not only interact with the cognitive agent in the brain, but also contact the digital cognitive agent in the information space of the information system. Cognition inside the brain is distributed and extended to the human-computer coupled environment. Comprising of the brain cognitive agent, the human-computer situation and the information system are in the way of agent.

Inspired by this agent, the learning process in a human-computer interactive environment is selected as the first step to try a new paradigm for cognitive studies, and the tree structure is selected as the topological structure of the low-dimensional manifold of cognition to form the framework for the analysis of cognitive manifolds. Afterwards, a system platform for the human-computer interactive learning software is designed to collect learning process of students

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