Cooperative Agents in Web-Based Distance Learning

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INTRODUCTION

In the last few years, we have observed an explosive growth of multimedia computing, communications, and applications. This revolution is transforming the way people live, work, and interact with each other, and is impacting the way businesses, education, entertainment, and health care are operating. Due to the opportunities provided by the Internet, more and more people are taking advantage of distance learning courses.

During the last few years, enormous research efforts have been dedicated to the development of distance learning systems (Katayama & Kambayashi, 1999; Nakabayashi et al., 1997). Consequently, many large projects such as the CALAT Project (www.calat.com), CALsurf (http://webbase.ntts.co.jp),, WebCAI (http://iclap.ce.nihon-u.ac.jp/~webcai_), The University of The Air (http://www.u-air.ac.jp/, and WIDE University (http://www.sfc.wide.ad.jp/soi/contents.html) have been established (Ogawa, Ijiun, & Murai, 1999).

Recently, several distance learning systems that consider the learner's capability and understanding have been proposed (Matsumoto, Nakayasu, Morita, & Kamejima, 1999; Tamaki et al., 2000). In Matsumoto et al. (1999), an evaluation system of historical data based on learning environment and supported by educational software record is proposed. In this system, reappearance and analysis are carried out only for historical learning data and not for real-time ones. In Tamaki et al. (2000), a multimedia assisted education system with individual student advancement control (MESIA) is proposed. The system is able to keep the teacher operating cost low and to offer fine education through the cooperation of Computer-Assisted Instruction (CAI) and teacher. The system is able to recognize the learners who need assistance, but its main purpose is to support the teacher, not the learners.

In order to offer a suitable and efficient study for learners, in this work, we propose a Web-based distance learning system using cooperative agents. The purpose of our system is to deliver appropriate study materials by judging the learner's degree of understanding. The main elements of the proposed system are the agents, which play the teacher's role and, based on the learning history, analyze the learner's degree of understanding.

To evaluate the proposed system, we developed several experiments and surveys. The evaluation shows that our system can achieve a good delivery of study materials for different learners. Also, by using new features, such as mental action of color and the competition with other learners, the system can further increase learning efficiency.

The article is organized as follows. The system design is introduced in the next section. Then, we deal with data processing and present how our system stimulates the learner's volition. In the following section, we discuss the experimental results. Finally, we give some conclusions and future work.

PROPOSED SYSTEM DESIGN

The proposed system is built on World Wide Web (WWW). In order to have a wide range of applications, we use only standard functions. Therefore, the system can be easily used without depending on the computer environment.

System Structure

The system structure is shown in Figure 1. The agent can get the learner's information by checking the learner's network access. The study materials are prepared on

the same server where the agent is established, but they can be distributed in different servers and can be accessed when they are needed. After the learning session, a confirmation test is performed to check the learner's degree of understanding. This confirmation test is carried out by using choice-type and description-type forms. The collection of learner's information is necessary to provide appropriate study materials to each learner. In order to make the correct judgment about the appropriate amount of delivered materials, we try to collect a large amount of information about the learner and then analyze the collected information.

We use ''network programming'' materials as the study materials. They consist of HTML text, GIF, and JPEG images. The system treats one page of the study materials as an item and manages the access information item by item. In the page of study materials, there are some buttons, such as "NEXT," "DETAIL," "search," and "EXIT." The "NEXT" button sends a request to get the next study material. The "DETAIL" button requires more details about the study materials. The "search" button searches the words and phrases in the study materials. The "EXIT" button stops learning. When learning is stopped, the total learning time is calculated.

Agents

The agents are the main part of the proposed distance learning system. They deal with following procedures: collection of learner's information; management, information analysis; learners' understanding judgment; study materials handling; and communication with learners. The agents are shown in Figure 2.

- **Register Agent (RA):** This agent carries out the learner's authentication and gets the record of the learner's first-time access.
- **Learner Information Agent (LIA):** This agent gets the physical information of the reference time of study materials, the number of references, and test results from the learner. Then, it changes this information into parameters in order to make the analysis.
- **Learner Communication Agent (LCA):** This agent conducts a dialogue with the learner. First, the agent asks the learner a question and, after getting the answer, uses this information as historical data for analysis.
- **Judgment Agent (JA):** Based on the data from LIA and LCA, this agent makes various judgments and gives orders to other agents. The judgment algorithm is shown in Figure 3.
- **Teaching Material Agent (TMA):** This agent carries out the management of study materials. The study materials suitable for the learner are offered by JA order.
- **Test Agent (TA):** This agent manages the test, offers the test to the learner, and corrects the test. Then, it evaluates the learner by grades.

Figure 1. System structure

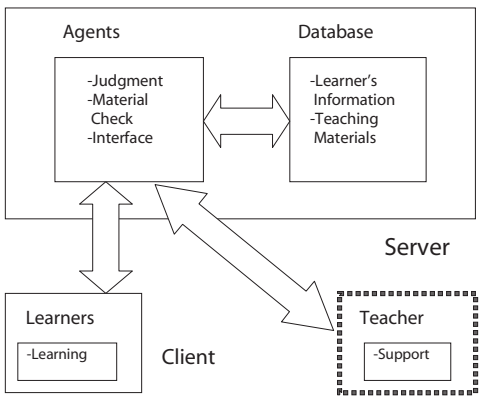

Figure 2. Organization of agents