SUPPORT PERSONALIZATION OF LEARNING ON THE WEB BY SOFTWARE AGENTS

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Abstract

Personalization of learning on the Web is currently one of the most important issues in the area of e-learning. It involves multiple paradigms, such as context, methodology, and so on. To support personalized learning on the Web requires the coordinated efforts from both teaching and learning. We incorporate the software agents with different expertise into the learning processes to assist individual learners in creation of personally learning experiences by the association of the agents with the Internet-related programs used by the teacher and the learner on the learning. In this paper the learning methods on the Web are explored and a model is then constructed to describe the Web based learning environment. An architectural framework of a multi-agent system to facilitate personalized learning on the Web is presented. After that the supports for personalized learning by the agents in the architecture are analyzed. At the final some conclusions are presented.

Key Words

personalization of learning, Web based learning environment, software agents, Internet-related programs, learning objects

1. Introduction

One of the consequences of the growing need for learning at different stages in the life of the learner has caused a rapid development of electronically based learning, sometimes known as e-learning. It has been widely recognized that e-learning on Internet has many attractive features, for instance it can break down the barrier of geographical location [1] since the teaching and learning are taken place over Internet. Learners can study at any point in time and at any place they like. The most distinguished characteristic of e-learning, however, is it has generated an efficient learning environment where personalization of learning can be supported by a variety of computer programs, tools and advanced technologies concerning teaching and learning.

Personalization of learning involves multiple paradigms. Context is tailored towards the learning desires of individual learners [2]. Methodology is adapted to best suit each learner's interests and skill level. This means, to support personalized learning, the teaching and relevant services should be customized based on the needs of individual learners. Earlier work on learning, especially on e-learning, has revealed that personalization of learning is the most efficient method of learning; it is most beneficial to the construction of knowledge.

Personalization of learning on the Web has attracted considerable research efforts. For instance, Martinz examined how individuals learned on the Web from the learner's emotions and intentions to learn and the social factors and proposed some key design considerations for personalized learning on the Web [3]. Dagger proposed an architecture and methodology for producing personalized course material with terminal awareness [2]. Hawryszkiewycz suggested ways of using generic learning objects to customize learning environments for individual learning [4]. In another research, Hawryszkiewycz classified personalization into two types, i.e. instructor driven and learner driven and customized services to support both by the uses of Web based technologies [5].

This paper is focused on a way to support personalization of learning on the Web by the technology of software agents. It starts with an investigation of the learning methods on the Web. Based on the investigation it then constructs a model to describe the Web based learning environment. The software agents are introduced into the model and integrated with the Internet-related programs at both sides of the learner and the teacher to assist the individuals in study. An architectural framework of a multi-agents system to facilitate personalized learning on the Web is presented. After that the supports for personalized learning by the agents in the architecture are explored. At the final are the conclusions of this paper.

2. The learning methods on the Web

In order to support personalization of learning on the Web by software agents, an important first step is to explore how learners study on the Web. It thus is necessary to make an investigation on the learning methods used by learners while they study on the Web. There are several

ways to do this as many researches have been concerned on the issue before. Unlike others, we explore the learning methods based on the category of the programs used in learning.

2.1 By WWW

Reading web page content. This is similar to reading a textbook in a traditional learning environment but here the textbook is an electronic and organized on a collection of web pages. Learners can freely select interested learning content from a huge number of web page resources on Internet. This learning method is perhaps the most popular one used by the learners on the Web.

Watching lectures. This is similar to attend a lecture in a conventional classroom but there exist two fundamental differences; one is the speaker might be at the other side of the globe, and the other is the speaker might be a well-known expert, specialist or professor. By the method, learners can not only hear from the speaker but also see his face and attitudes. The lecture can be a live presentation but more often a prerecorded one.

Searching for references. This is similar to searching for references in a library but is more convenient and efficient. The resources on Internet are much richer than in any libraries as Internet is being said the largest resource warehouse in the world. The learning method is useful for learners to solve a complex problem and understand an idea in more depth. It is also beneficial to the learners in enlarging their level of knowledge.

Doing exercises or test. This is to perform the exercises and test attached to a web page. Learners can do the exercises or test just after reading the content on the web page and usually can get immediate feedback after submission once the work is done. Such kind of online work can help the learners find problems in their learning, and effectively improve their learning outcomes accordingly.

2.2 By Email

Asking for teacher's help. Learners can ask questions and seek for the individual help by sending email to their teacher when they have a problem concerning a particular learning issue. Here the teacher is not only the instructor in a traditional meaning but also the one in a boarder meaning, *e.g.* the tutor, the coordinator, the field expert, or the person who produces or assembles the learning materials, or even a computer server. Seeking for help via email can avoid the possible embarrassment in a face-to-face situation and hence it provides learners a channel to ask questions in freedom.

Exchanging ideas with peers to help each other. Learners and their peers can make use of email to exchange ideas during learning. They can share their understandings on a learning topic, and even their achievements in learning, with one another. It is a useful learning method as it can

not only improve the learning but also bring about better understandings and friendships among the learners.

Booking electronic references. Learners can send email to join into an email-list to book the electronic learning materials they find interesting on Internet. After that they will receive them at a regular period. This is useful since it can facilitate a deeper exploration of a particular learning topic.

2.3 By BBS or News group

Reading articles to absorb ideas from other people. By reading the articles on a BBS or a news group presented by other people, learners can compare them with their own to check if their own understanding is correct or not. In this way the learners can assimilate a lot of intelligence from other people. This can be an effective supplement to the learning method *reading web page content.*

Releasing questions to ask for solution. Learners can post questions on a BBS or a news group to ask for answers from other people. Usually they are likely to get the correct answers in a very short time. Moreover they can get opportunities to know experts and other learners. This in fact is used frequently by learners when they find difficult to solve a problem on learning.

Presenting a contribution to a learning issue. Learners can release their answer to a question on a BBS or a news group. To do this requires a deeper research, *e.g.* collecting more detailed material related to the question, exploring in a deeper degree, and so on. As a result, this not only helps others solve the problem but also benefits the learners own. It can stimulate learners in their interests of learning and enhance their ability of bringing forth new ideas as well.

2.4 By chat room

Chat room refers to a software program which provides a virtual room for people to chat. With the help of the program a real-time discussion on a learning issue can be carried out among the learners and/or the teachers. Learners who have entered a chat 'room' can freely ask other participants questions and present comments on any learning issues. By such discussions, learners are likely to rapidly solve their problems on learning. This benefits the learners in inspiring their ability of quick thinking and reacting.

2.5 By video conference system

Watching lectures. This is like to *watching lectures* implemented by WWW but here the lecture is a live presentation. Moreover, the learners can exchange messages with the lecturer in a synchronous manner. This, to a certain degree, has a similar effect as they attend a real lecture in a classroom.

Watching the procedure of an experiment. Learners can watch the procedure of an experiment being conducted in

other place because the video conference system can bring everything on the scene to them. This is useful while the learners are not able to personally make an experiment due to various reasons. It can help the learners get the same effect as if they performed the experiment.

Studying in collaboration. Learners can make use of a video conference system to study in collaboration where they accomplish the study task of a topic in groups, exchange ideas, and help one another just as in a classroom. This can activate the learning circumstances and enhance their collaborative ability with other people as well.

3. The model of the learning environment on the Web

According to the constructivist viewpoints, learning is a process of constructing knowledge by learners on the interactions with their environment [6]. The learning environment where learning occurs contains at least the learner, the teacher and a 'sitting' or a 'space' wherein the learner acts, using tools and devices, collecting and interpreting information, interacting perhaps with others [7]. The teacher here is not just in a conventional term, but also refers to the ones in a broader sense, including the providers of the learning content. Learning can achieve success only when both teaching and learning are matched each other and the tools and devices are appropriately used to enrich such a match.

Obviously it is necessary to explore the Web based learning environment in order to look for ways and means to support personalization of learning by agent's techniques. Based on the investigation of the learning methods on the Web, we use a model shown in Figure 1 to describe the Web based learning environment [8].

Our model is distinct from other ones in that its focus of research is on learning. In the previous researches on the Web based learning environment a number of models have been built for various aims. Among them some are teacher-centered and some are learner-centered. In general the teacher-centered emphasizes the role of the teacher, whereas the learner-centered emphasizes the role of the learner. Either the teacher-centered or the learner-centered puts primacy only on sole actor in the learning environment but pays little attention to the role of other actors, especially the comprehensive role of both the teacher and the learner simultaneously [9]. We believe that learning is a systemic phenomenon in a learning environment. Its outcome depends on at least three elements, i.e. teaching, learning and the learning environment where the teaching and learning occur. Learning environment must be studied from both the teacher side and the learner side rather than only from an either side. In this viewpoint, a learning-centered approach is applied into the current research and the model is constructed based on the ideas.
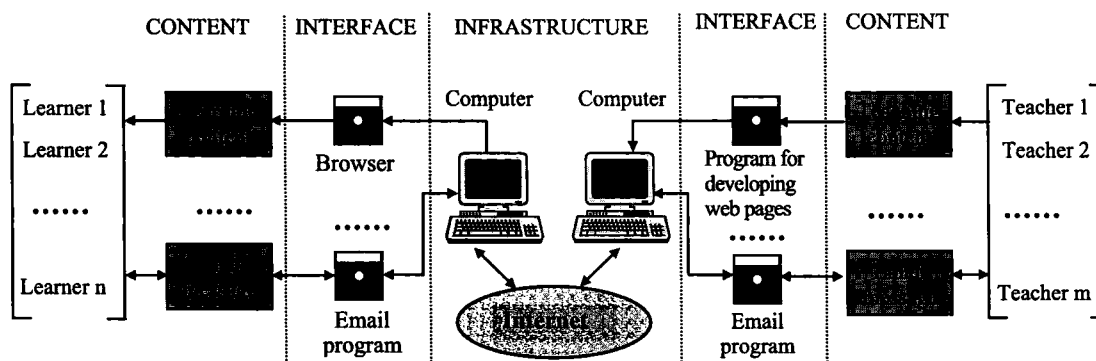

Fig. 1. The learning environment on the Web

In our model, learning is put into a broader context and learning is implied as something that goes on in an environment in which different actors operate, involving themselves in a variety of processes of interaction among themselves and others in the environment [9]. Our model consists of three layers, namely, a content layer, an interface layer, and an infrastructure layer. The three layers work together to provide a complete Web based learning environment.

The content layer is the layer directly faced to the teachers and the learners. This layer contains different forms of learning objects. The learning objects at the teacher side are for teaching, whereas the learning objects at the

learner side are for learning. The typical forms of the learning objects include email, web page, BBS article, and so on. A learning object is any digital resource that can be reused to support learning [10], with a finer granularity, usually smaller than the entire subjects. Learning objects can be assembled to construct larger learning material, e.g. larger pieces of instruction content, lesson plans, exercises, assignments, study notes, book chapters, or complete books. The learning objects at the teacher side are produced or assembled by the teacher according to the pedagogical goals he wants the learners to achieve. The learning objects at the learner side are selected from the repositories of learning objects on Internet by the learner based on his learning desire and

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preference. Clearly, the learning content at the learner side probably differs from the teaching content at the teacher side due to various reasons. It is one of the aims of the current research to mediate the difference between them.

The interface layer is the middle layer between the content layer and the infrastructure layer. It includes all the software programs supporting the teaching and learning on the Web based environment, such as an email program, a web page development program, a browser, a chat program, a BBS, and so on. These Internet-related programs are responsible for processing and delivering learning objects. The programs in the interface layer at the teacher side are different from the ones at the learner side because they are for different uses. As an example, a program for developing web pages is included in the interface layer at the teacher side for the teacher to produce or assemble learning objects upon web pages, whereas a browser is included at the learner side for the learner to browse learning objects on web pages. The interface layer is the layer that allows the teacher and the learner to manipulate the learning objects by selecting a path through them or actively changing them.

The infrastructure layer contains all the essential facilities and tools that support the learning environment. It includes the computer, the operating system, the connection to Internet, the learning object repositories, and all the Internet services available to its users, i.e. the teachers, the learners, and other potential users.

4. The integration of software agents with the Internet-related programs

It can be seen that all the activities concerning the teaching and the learning on the Web are implemented through the comprehensive applications of the Internet-related programs in the interface layer. This reveals clues on how to use the technology of software agents to support personalized learning on the Web. Integration of software agents with those Internet-related programs can be one of the ways to supply individual learners with customized services. For example, an intelligent agent can be employed to assist the learner to pick up the required messages from the large numbers of email messages arriving from many different sources. Moreover, an agent can be employed to supply the learner with the personalized navigation services by searching for the learning objects from the avalanche of web based contents.

A software agent here is referred to a computer program which has a goal and autonomously solves problems through interaction, such as collaboration, competition, negotiation and so on [11]. Pedagogical agents are autonomous agents that support human learning, by interacting with the learner in the interactive learning environment and they extend and improve upon previous

work on intelligent tutoring systems in a number of ways [12]. A number of projects on e-learning have been developed in which more or less the technology of software agents was involved to reach the desired pedagogical goals.

A multi-agent system for the current research has been constructed. It consists of a number of agents with different expertise. In the architecture, the specialized agents are integrated with the Internet-related programs at both the learner side and the teacher side to coordinately assist the individuals in learning. Each learner is assigned a unique personal agent that manages the learner's personal profile, including knowledge background, learning style, interests, courses wanted to learn, etc [13]. Each teacher is assigned a unique personal agent to help the teacher correctly and timely respond to the requests concerning individual learning from the interactions with other agents. Each of the Internet-related programs is assigned a unique agent that assists its users, i.e. the teacher or the learner, to use it in such ways that are beneficial to the individuals in learning. All the agents work together to support the personalization of learning.

At the learner side, all the agents associated respectively to the Internet-related programs talk to the personal agent assigned to the learner and provide it with various assistances, including searching for required learning objects from the repositories of learning objects on Internet on behalf of the learner based on his profile and supplying information for learning decision-making. The personal agent, acting as a personal assistant, assists the learner to arrange learning schedule, select learning method, and supply facilities to his learning based on the messages collected from the interactions with other agents. The personal agent talks to the agents assigned to other learners to facilitate study in collaboration among the learners. The personal agent also talks to the personal agent assigned to the teacher to ask for the personalized learning services on behalf of the learner.

At the teacher side, all the agents associated to the Internet-related programs talk to the personal agent assigned to the teacher and search for information from Internet on behalf of the teacher. The personal agent associated to a teacher acts as a personal assistant of the teacher and its roles are twofold. One is an intelligent tutor [13]; it monitors the learning progress of individual learners and collects the information about their individual learning style from the interactions with other agents, and directly responds to the related learner agent or even the learner as a per-designated condition is detected. The other role is a facilitator of individual learning; based on the messages attained from the interactions with other agents, it correct and timely provides the teacher with suggestions about updating the already-existed learning objects or producing new learning objects so that they suit better to the needs of individual learners.

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5. The support for personalized learning by agents

In this section we will analyze how the agents in our architecture interact with one another to provide assistances for individual learners during their learning. The learning procedure is abstracted from the actual learning procedures and divided into a series of steps so that the analysis can be done step by step.

After a learner has decided to study a particular learning topic, e.g. *database update*, he will usually take the following steps to perform his learning task. Let's see how agents provide him personalized assistances in each step of his learning.

(1) Find a learning resource

The learning resource for a particular learning topic, e.g. *database update*, is most often in the form of accessible web pages at a specific web site. The personal agent assigned to the learner will talk to the Web agent for asking 'where is learning resource for topic *database update*?' after it captures the learning requirements. The Web agent will in turn search for the URL of the site which suits the desired topic from a huge number of web sites and send the result to the personal agent. The search by the Web agent may require use of the rules in the knowledge base, the previous search records, the learner's profile, etc., and sometimes may require comprehensive use of all of them. The personal agent may attain more than one URL and in that case it will consult with the teacher agents or agents for other learners registered in the system. Based on the reply from them and the learner's knowledge background, learning style, the personal agent will select one of them as the learning resource for the learner to access.

There are in fact many other ways in which agents interact with one another to provide assistances in finding out a required learning resource. For example, the learner's personal agent may ask agents for other learners instead of asking the Web agent and can attain the required URL from some of them whose learners have learned the topic before.

In case the learning resource for a particular learning topic is not in the form of web pages but in other forms, e.g. in a BBS, the search procedure is similar to the above and the assistances provided by agents are similar to the above, too.

(2) Access the learning resource

In this step all the agents related to the learner and to his learning are in a monitoring state and they will update relevant records based on the monitored events. For example, the learner's personal agent will update the history record of learning and modify the learning preferences in case of the change has been monitored. The Web agent will make necessary change in the learner's profile. The agent assigned to the teacher who designed or provided the learning resource is also in the monitoring state and it will record the information about the use of the resource.

Meanwhile the learner's personal agent will offer suggestions to the learner in case it finds the access order or routine taken by the learner does not follow the general cognitive rules derived from the models of learner's learning behaviors.

(3) Try to understand the ideas and concepts in the learning material

In this step, the learner's personal agent will give suggestions and supply various facilities to assist the learner in the understanding. For example, it will provide the learner with learning materials dealing with similar topic. In the case that the topic is *database update*, the learning materials can be such topics as *file update*, *database normal forms*, *database integrity*, etc. The difficult level of the provided materials is determined based on the learner's background and learning styles.

Obviously the learner's personal agent needs assistances from other agents to accomplish the above work.

(4) Discuss and ask for assistances if necessary

The learner's personal agent will suggest a method for the learner to seek for help based on his preference and the resources available at that time on Internet. The method can be by several channels, e.g. by email, by chat room, or even by a video conference system. The learner's personal agent will further interact with other agents to search for appropriate people for the learner to discuss with and ask for assistances.

The email agent will promptly pick up the relevant message if email is used as a channel to discuss or get assistances from others. The chat room agent will suggest a suitable room for the learner to enter if he uses chat room to get help.

If the person who is asked for help by the learner is a teacher, the teacher's agent will make necessary notes about the question asked by the learner. The records will be used as an important reference for adjusting teaching.

(5) Try to remember what have learned

One of the important methods to achieve this goal is to do exercises. The learner usually likes to do exercises together with his peers. The learner's personal agent will search learners who are studying the same topic and want to exchange with others. These agents will negotiate with one another to decide the channel to use for the cooperation for the exercise. They may also allocate the roles for each of the learners in the exercise via negotiations. When the collaborative procedure for the exercise begins, the relevant agents will monitor the activities taken by the participants and provide various necessary assistances for the cooperation. For example, the email agent will timely pick up the messages from other participants.

(6) Test to see if the topic has been mastered

The purpose of this step is to check if the ideas and relevant concepts in the learning material has been understood and mastered. In the case that the learning topic is *database update*, it is to check if the ideas about insert, delete, append and change records in database can be correctly understood and the related operations can be successfully carried out. The learner's personal agent will recommend a method to do the test based on the system resource and the learner's preference.

The learner's personal agent will timely give feedback, with sound or/and animations, during the learner performs the test. It gives compliment and encouragement if it believes the operation is fine; otherwise it gives warns. After the test is over, the personal agent will evaluate the test result and gives the learner an evaluate report.

If the result of evaluation is not good, it will suggest the learner go back to do the work again. The above steps will be repeated several times, depending on the outcome of the learning.

It should also be stressed the work taken by the agents in the teacher side during the above steps. The teacher's personal agent monitors and records the learning taken by learners in the procedure. It will provide the teacher with suggestions or directly do it while it finds necessary to adjust or modify the learning material and the used teaching methods based on the records about the learning. To do this requires coordinated efforts from many agents. The most obvious reason is the teacher's personal agent requires exchange of messages with other agents to collect and record the information. In case that a pre-designated condition for responding to the incoming information is detected, the teacher's personal agent may directly respond to other agents, sometimes even individual learners. The aim is to help the teacher timely respond the requests from learners and the agents supporting the learning steps. Clearly all other agents need to work in a collaborative state to support the procedure.

6. Conclusions

The contribution of this paper is two. One is the creation of the model of the Web based learning environment. The model involves not only the learner but also the teacher as well. This enables the support for personalized learning to be studied and implemented from both teaching and learning. The other is the integration of software agents with the Internet-related programs used in the learning at both the teacher side and the learner side. All the teaching and the learning on the Web based learning environment are implemented by the comprehensive applications of the Internet-related programs in the interface layer. Integration of software agents with those programs can support individual learning in a seamless and coherent manner. The support is not only from the agents at the learner side but also from the agents at the teacher side.

Clearly it is more efficient than from the agents at an either side.

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