Architectural Analysis of Multi-Agents Educational Model in Web-Learning Environments

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ABSTRACT

The article presents a structure for using intelligent multi-agents architecture for an educational system and internet teaching. In this architecture, a model of multi-agents learning environments consists of: the domain model, the communication model and the user model. They contain all the domain knowledge of the target application and the user's profiles. Reconceptualizing the computer as a constructionist medium increases the computer's educational value by allowing the development and support of communities of users. The communication model facilitates communication via more conventional media, but also enables the communication of ideas through the creation and sharing of computational objects (e.g. agents and analysis tools). An agent appears to be appropriate for the implementation of the major functions of intelligent training, support and teaching environments by providing an environment for the definition and sharing of computational components, through the World Wide Web.

Keywords: Artificially intelligent; Multi-Agent–Based e-learning Systems; conventional media; learning environments; the world wide web.

1. INTRODUCTION

Effective communication is a basis for teaching and learning. The dialogue between student and teacher, and between student and student, conveys experience, knowledge, understanding, ideas, and so much more. Application of artificially intelligent (AI) technologies to teaching and learning, therefore, may not necessarily be a solution to the problem of providing the kind of educational experiences desired in today's society. Capturing both the teacher's and student’s/pupil's experiences and knowledge presents an ongoing challenge for AI researchers [1]. The types of knowledge that can be represented, and how best to represent that knowledge, continue to be the foci of AI research. The ability to measure any success or failure of AI applications depends on how one defines intelligence, and artificial intelligence. It becomes even more difficult as the definitions themselves continue to evolve. The tutoring test contended that acting intelligent is intelligent. A formal, working definition of AI was coined by some researchers [2] as "Learning to do and learning to understand: a lesson and a challenge for cognitive modeling". A more recent definition defines AI as "the study of the computations that make it possible to perceive, reason, and act". Research into human learning and cognitive science is a force that continues to reshape our definition of human intelligence, and our definition of artificial intelligence.

Distance education is the practical subset of education that deals with instruction in which distance and time are the criteria attributes; that is, student and teacher (and other students) are separated by distance and/or time, opening up more opportunities to learn through computers, with computers, and from computers [3]. Generally, the focus of distance education has been on using the computer primarily as a communication tool (learning through computers). The "computer-as-mind tool" approach suggests that working with a computer, in an authentic task, acts as a stimulus for learning (learning with computer) [4]. Despite criticism of the “teacher-in-the-box”, efforts to improve the humanness and adaptivity of our interactions with computers will likely improve our ability to learn from them. We have only begun to achieve the critical mass of interface technologies needed to make the computer an intelligent partner in instruction. Work on the development of intelligent agents attempts to produce software that acts as an intelligent assistant. Some intelligent agents feature a conversational component that has a human visage and displays facial gestures in essence displaying personality or character. The work of [5] shows that humans use social rules as they interact with computers. As we combine these capabilities with natural language understanding and the ability to process "spoken speech," the computer approaches the role of partner in a conversation rather than a questioner or simple conditional decision maker.

These streams converge in the need for a definition of interactivity, both in distance learning through computers as communication tools and in intelligent instructional systems where we learn from the computer tutor/teacher.

The intent of this article is to provide an architectural analysis of interactivity, with the goal of constructing intelligent multi-agents learning environments
for an educational system, through the World Wide Web. The Internet technology provides the advantages of interoperability, reusability and accessibility in the field of e-learning. This structure suggests additional variables that could potentially be valuable in understanding interaction in instruction. This article is organized as follows. The next section describes the Web-based intelligent tutoring system (ITS). To describe the computer as a communication medium, Section III presents the computer as a tool whose role is to help the learner, or more generally, the users. Section IV is devoted to the proposed model of multi-agents learning environments: the domain model, the communication model and the user model. Using the proposed model allows the study of the intelligent interface agent's architecture. In section V, we present a range of learning activities in the learning environments that validate our model. Section VI presents the conclusions of this article.

2. WEB-BASED INTELLIGENT TUTORING SYSTEM

Artificial intelligence plays an important role in intelligent tutoring systems (ITS). The architecture of the World Wide Web (WWW) is a good environment for ITS. Web-based education (WEB) is currently a very popular research and development area. The benefits of WEB are obvious: classroom independence and platform independence. WEB courseware installed and supported in one place can be used by thousands of learners all over the world as long as they are equipped with some kind of Internet-connected computer. Thousands of Web-based courses and other educational applications have been made available on the Web within the last five years [6]. The problem is that most of them are nothing more than a network of static hypertext pages. A challenging research goal is the development of advanced Web-based educational applications that have a degree of adaptivity and intelligence. These features are important for WEB applications since distance students usually work on their own (often from home). Intelligent and personalized support that a teacher or a peer student can provide in a normal classroom situation is therefore not easy to obtain. In addition, being adaptive is important for Web-based courseware because it has to be used by a much wider variety of students than any "standalone" educational application. A Web courseware that is designed with a particular class of users in mind may not suit other users. Since the early days of the Web, a number of research teams have implemented different kinds of adaptive and intelligent systems for on-site and distance WEB. One of the aims of this article is to provide a brief review of the work performed so far in this area, focusing in particular on different adaptive and intelligent technologies. In this we are being consistent on the level of technologies so as to have compatibility with earlier papers on adaptive hypermedia and Web-based ITS. By adaptive and intelligent technologies we mean essentially different ways of adding adaptive or intelligent functionality to an educational system [7]. A technology can usually be further dissected into more detailed/sophisticated techniques and methods, which correspond to different variations of this functionality and different ways of implementation. In the next sections we analyze what kinds of technologies are currently available, and how easily they can be implemented on the Web.

With the WWW as an educational platform, it will be feasible for students to access the multimedia courseware with general-purpose browsers. No special tools are required to start learning. For the courseware provider, it is not necessary to worry about the distribution and maintenance of copies of the courseware as they only have to be concerned with the original on their server [6].

3. THE COMPUTER AS A COMMUNICATION MEDIUM

Computers have been used in education for over 25 years. Computer-based training (CBT) and computer-aided instruction (CAI) were the first such systems deployed in an attempt to teach using computers [1]. In these kinds of systems, the instruction was not individualized to the learner's specific needs. While both CBT and CAI may be somewhat effective in helping learners, they do not provide the same kind of individualized attention that a student would receive from a human tutor. Common to these systems is the metaphor of the computer as tool: a tool to write a report, a tool to compute the solution to an equation, a tool to draw a diagram, etc. Simply as a tool, the role of the computer is to help the learner, or more generally, the user, to create something, including the solution to a problem. Even seemingly mundane assistance, such as a spelling checker in a word processor, makes the computer a better tool for doing a job more effectively and efficiently [8].

The notion of the computer as tool, while useful, is too narrow because it limits the scope of observation to a solitary interaction between learners and machines, leaving out important social issues. Instead, this article suggests that the use of computers as a construction medium contributes to the way people think about things and communicate with each other. As an educational medium, the computer allows learners to communicate with each other all over the world via textual email or, increasingly, via multimedia home pages on the WWW. Enhancing computer tools with the ability to easily share and exchange computational artifacts within a potentially large and distributed community not only teaches individuals to communicate their ideas in unique ways to people from varied backgrounds and experience (for instance, a third-grader can build a computer agent that behaves like the juggler he saw performing on the street) but also allows the individual to tap into a large and distributed collection of expertise that was not readily available before [9]. Viewed as a medium, the computer can
enhance the very nature of how and what we communicate. It facilities inter subjectivity (Figure 1).

Fig 1: The medium enables communication between different learners.

Communication between learners, and inter subjectivity (Figure 2), is interaction between the learner and him/herself. Communication, in turn, is an essential part of learning. Teachers must communicate ideas and facts to students. Students communicate with other students in social learning situations to develop answers to questions, to reflect on their understanding, and to concretize their ideas.

Fig 2: The medium enables communication between the learners and themselves

The ability to combine formal information (the products generated by the tool) with informal information (what people use to communicate directly with each other) enables the computer to become a much more active component of the communication process. The trick to having the computer fulfill its potential as a communication medium is to not only simplify and enhance the tools that are a part of that medium, but to ensure that the products of those tools, simulations for example, can then be used to communicate and share ideas. Learning and teaching require the processing and communication of information using media such as papers, videos or, more recently, web pages. While the web has the potential to feature all kinds of content, it is currently typically used to capture static content such as text and pictures. Interactivity in the context of the web is often reduced to navigation of hyper spaces [7].

The goal of adaptive navigation support is to help users to find their paths in hyperspace by adapting link presentation and functionality to the goals, knowledge, and other characteristics of an individual user. It is typically done by one of the following ways:

- Direct guidance: the system outlines visually one of the links on the page showing that this is the best link to follow or generates an additional dynamic link (usually called "next") which is connected to the "next best" page.

- Link sorting: the system sorts all the links of a particular page according to the user model and to some user-valuable criteria: the closer to the top, the more relevant the link.

- Link annotation: the system augments the link with some form of comments, which can tell the user more about the nodes behind the annotated links. These annotations are usually provided in the form of visual cues. Typical visual cues include icons, font colors, sizes, and types [9].

- Link hiding, disabling, and removal: the system tries to prevent the user from following links that are not relevant for him or her at the moment. There are several ways to achieve it. A link can be hidden by turning a usually underlined hot word into a normal word. It can be disabled so that clicking on the hot word will produce no effect for a non-contextual link and the very anchor (hot word or hot spot) can be removed [8].

4. MODEL-BASED INTELLIGENT INTERFACE AGENTS

The proposed model consists of two agents representing a server-client relationship. Models can be used for problem solving or communication. This article is mainly concerned with computer mediated communication of artifact models. We shall adopt a point of view that is our approach is inspired from strongly influenced by the framework for information systems. This point of view can be summarized as follows. In communication, a subject (the emitter) generates a message (e.g. a model) that represents some knowledge about an artifact expressed in a language. The message is transmitted via a channel (a medium such as a computer system) to another subject (the receiver) who interprets the message and constructs a personal conception of its content. Information is the personal knowledge increment of the receiver in interpreting the message. For systems in [10, 11], information and communication are not absolute but relative concepts. They are seen as linking the individual person ("information" as an increase of personal knowledge) and the larger community of which that person is a member (shared knowledge resulting from communication).

It is assumed that two main processes are involved in communication, namely, interpretation and modeling.
During interpretation the receiver perceives the message with their senses and forms a specific pattern of visual, auditory, or other sensations in their mind. Various cognitive processes such as categorization, interface, imagination, etc., then elaborate these perceptions in order to form a mental conception. During modeling the emitter selects the content of a model that is, the aspects of a mental conception that are deemed relevant to answer the question or solve the problem of interest (articulation), and represents the content in a language and a system of signs (externalization). Interpretation and modeling are driven by the subject's conceptual system. The term “conceptual system” is intended here to refer to the collection of relatively stable conceptions (e.g. conceptual categories, cognitive models) formed in a person's mind during his/her experience and interaction with the physical and socio-cultural environment in which he/she lives. In order for the process of communication to be effective, it is necessary for there to be two partners in the communication process [12].

We propose a model-based intelligent interface agents architecture, (see Figure (3)), to support interaction between the domain model, the communication model and interface agents. In this architecture, the facilitator maintains a knowledge base of the capabilities of a collection of agents, including the intelligent interface agent and other agents communicating with each other through this facilitator. Figure (3) provides a view of the interactions between the modules

**Domain model:** This model contains an explicit representation of the target application. The intelligent interface agents get information from the domain model; it infers operations and sends instructions to the target application. The domain model consists of lessons, rules and problems, a task model, a procedural model. Generally, it requires significant knowledge engineering to represent a domain so that other parts of the tutor can access it. One related research issue is how to represent knowledge so that it easily scales up to larger domains. Another open question is how to represent domains other than facts and procedures, such as concepts and mental models.

**Communication model:** Interaction with the learner, including the dialogue and the screen layouts, are controlled by this component which should present the material to the student in the most effective way. This component has not been researched as much as the others, but there has been some promising work in this area.

**User's model:** In order to provide explanations for the users, the intelligent interface agents also need to get the user's personal profiles. The user model contains the user's information, which consists of an interaction history, an interaction and a user profile. The user management agents record the interaction history of the user's interaction with the target application. The interaction model represents a user's interaction habits with the target application, which is inferred from the interaction history. The user profile contains the static information about a user, such as name, gender, knowledge level, etc. The intelligent interface agent keeps track of the user's interaction with the target application; combines the knowledge from the domain model and the user model; decides upon assistance.

![Figure 3](http://www.cisjournal.org)

**Fig 3:** The medium enables communication between the learners and themselves.
5. THE LEARNING ENVIRONMENT

There are several models within the learning environment that provide support to the learners in their exploration of architecture environments. For the purpose of the study three of them are considered part of the basic learning environment and the others are referred to as cognitive support agents. The additional cognitive agents enabled learners to request advice (help), get an overview, or use a hypothesis scratchpad. Participants were given complete freedom in how they interacted with the environment. There were a number of assignments that could be undertaken. There was also access to explanations of concepts, and other models that could be run so that they could observe and adjust the behavior of the system. All participants, in these parts, were given the same time limit to interact with the learning environment and the cognitive agents (for the second group only) [13, 14].

The learning environment provides a range of learning activities, from free exploration to hypothesis generation and testing of concepts, from the concept explanations to assignments that compare the behaviors of more than one model, to assignments that ask the learner to control the behaviors of the system. There is a variety of tasks that should suit a variety of learners' individual learning styles. In hindsight it might have been better if learners were initially taught how to use the hypothesis scratchpad through some easy assignments. This may have increased the use of the hypothesis scratchpad that was considered the most difficult tool to use, but not the one least worth using, which was the overview tool. This article intends to analyze the difference between the conventional teaching method and teaching by using a multi-agents educational model in Web-learning environments. Our experiment was conducted in class room environment where a sample of 230 students was chosen of a secondary school in concepts of Visual Basic Programming (Figure 4). The learning environment enables the learner to study the theory (multi-agents), experience, reflect and plan. They communicate with each other as client-server through the World Wide Web.

5. CONCLUSIONS

In this article, we have presented, described and analyzed a multi-agents architecture and its use in Web-based education systems. The model has been presented for learning and teaching. The domain model, the communication model and the user model have provided considerable functional and helpful enabling of the intelligent interface agents. The learning environment enables the learner to study the theory (multi-agents), experience, reflect and plan. They communicate with each other as client-server through the World Wide Web.

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