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Intelligent Tutoring Systems for World-Wide Web

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Abstract:

A number of powerful technologies which prove to be very effective for 'on-site' education are still not implemented within the WWW framework. One of these technologies is Intelligent Tutoring Systems (ITS) technology. This paper discusses some ways of bringing ITS technology to WWW. We review briefly two techniques from the domain of ITS which could be creatively used with WWW and introduce the MSU project on creating ITS authoring tools for WWW.

Keywords:

Intelligent Tutoring Systems, adaptive sequencing, adaptive hypermedia, authoring tools

Introduction

From the very early days of World-Wide Web (WWW) there were multiple efforts to use WWW facilities for distance learning. At the same time most existing educational WWW applications use the simplest solutions and are generally weaker and more restricted than existing 'on-site' educational systems and tools. A number of powerful technologies which prove to be very effective for 'on-site' education are still not implemented within the WWW framework. One of these technologies is Intelligent Tutoring Systems (ITS) technology (Frasson, Gauthier & McCalla,1992). ITS use the knowledge about the domain, the student, and teaching strategies to support flexible individualised learning and tutoring. Our group in the Moscow State University (MSU) is working on integration of ITS and WWW technologies. This paper review briefly two techniques from the domain of ITS which could be creatively used with WWW and introduce the MSU project on creating ITS authoring tools for WWW.

Porting ITS technologies to hypermedia and WWW

The most obvious way to bring ITS to WWW is to port some existing ITS technologies to WWW. The most relevant technique for that is **intelligent knowledge sequencing and problem sequencing** (see Brusilovsky, 1992 for a review). Intelligent knowledge sequencing implies adaptive selection of the next topic to be learned using the student model and the knowledge about the learning material. Intelligent problem sequencing in the narrow sense implies choosing or generating the next problem for the student to solve, which should be most relevant to his level of knowledge and skills. In a broader sense it implies adaptive sequencing of all kinds of teaching operations - examples, tests, problems, questions, etc.

In a hypermedia systems intelligent knowledge sequencing is usually considered as intelligent sequencing of hypermedia pages or hypernodes. In addition to regular (prescribed) hypermedia buttons or active fields the student is provided with dynamic "intelligent button" called "next" or "teach-me" which activates knowledge sequencing mechanism. This button brings the student to the hypernode, which is most relevant to him from system's point of view. This approach (but different sequencing techniques) is used in the following hypermedia-based systems: SHIVA (Zeiliger, 1993), JSICAI (Tomiya, Kubota & Okamoto, 1994), and ISIS-Tutor (Brusilovsky & Pesin, 1994). Intelligent problem sequencing is usually implemented by the same way - the student is provided with a dynamic button which activates sequencing mechanism. As a result the student is presented with the most relevant problem to solve for the currently studied topic (Kushniruk & Wang, 1994) or for the course in general (Brusilovsky & Zyryanov, 1993; Brusilovsky & Pesin, 1994)

Implementation of intelligent sequencing within hypermedia framework brings new quality by combining student-directed and guided learning. It provides some solution for "getting lost" problem of hypermedia: the learner who can hardly find his own way in hyperspace can now use system guided navigation. At the same time it provides some benefits over traditional "directed" ITS style of teaching: the students who are not satisfied with system-directed sequencing can use hypermedia style of browsing the learning material.

Merging ITS and WWW Hypermedia technologies

Integration of ITS and WWW hypermedia technologies provides a new quality in one more sense: it opens the way to some new intelligent techniques, which are based on both ITS and hypermedia paradigms and which are new in the ITS domain. **Adaptive hypermedia** is a good example of such a technique. As in general hypermedia system, the educational process here is driven by the student. The difference is that adaptive hypermedia systems can use the student model and some other knowledge typical to ITS to adapt its work to the given student. In particular, it can be used to guide the student implicitly. Adaptive hypermedia systems bridge the gap between computer-driven tutoring systems and student-driven educational environments. They combines free browsing with personalization and can support not just two ends (as classic ITS and hypermedia), but all the continuum of learning modes between pure system-controlled and student-controlled. Some WWW information on adaptive hypermedia can be found in (Adaptive hypertext and hypermedia, 1994).

What can be adapted in adaptive hypermedia are the content of a hypermedia page and the links from a page (including index page) to related pages. We distinguish these two techniques of adaptation and call the first technique adaptive presentation (or content-level adaptation) and the second technique adaptive navigation support (or link-level adaptation).

Adaptive presentation is the most popular and the most studied way of hypermedia adaptation. With adaptive presentation the content of a hypermedia page is generated or assembled from pieces according to the user's class and knowledge state. Generally, qualified users receive more detailed and deep information, while novices receive more additional explanation (Beaumont 1994; Boyle & Encarnacion, 1994; Fischer et al. 1990). Two popular application areas for adaptive presentation are adaptive hypermedia-based help in knowledge-based systems (Fischer et al,1990; De Rosis, De Carolis & Pizzutilo, 1993) and on-line documentation systems (Boecker, Hohl & Schwab, 1990; Boyle & Encarnacion, 1994). The experiments, reported in (Boyle & Encarnacion, 1994) shows that adaptive presentation increases user performance. In an educational context adaptive presentation was

implemented in Anatom-Tutor (Beaumont, 1994) and ITEM/IP (Brusilovsky 1992b).

By **adaptive navigation support** we mean all the ways to play with visible links which can support hyperspace navigation. In current systems, three kinds of adaptive navigation support have been suggested and implemented: hiding a part of links, adaptive ordering of visible links, and adaptive annotation of visible links. Hiding of a part of visible links was used in (Brusilovsky, 1992b). Ordering of visible links according to some user-valuable criteria (the more close to the top, the more relevant the link is) can give user a hint when selecting the next link to follow. This technique was suggested in (Boecker, Hohl & Schwab, 1990; Kaplan, Fenwick & Chen, 1993), and the latter paper reports positive experimental results. A promising and flexible technology for adaptive navigation support is adaptive annotation of visible links (augmenting links with personal dynamic comments in any form) (de La Passardiere & Dufresne,1992; Brusilovsky, Pesin & Zyryanov, 1993). Adaptive annotation can use icon (de La Passardiere & Dufresne, 1992), colours (Brusilovsky & Pesin, 1994) or other visual cues to reflect the state of the related nodes according to user knowledge and goals. The most simple adaptive annotation technique is just outlining the links to previously visited nodes, giving two states for visible links (links to visited/not visited nodes). This can be found in many hypermedia systems including NCSA Mosaic. Adaptive hypermedia systems (de La Passardiere & Dufresne,1992; Brusilovsky & Pesin, 1994) can distinguish four and more states on the base of the student model.

The MSU project

The goal of our new project running within Research and Education Laboratory (RED LAB) at the Applied Mathematics and Cybernetics Department of MSU is to apply adaptive sequencing and adaptive hypermedia technology for WWW-based education. We are designing an authoring tools (a shell) which can be used by a human tutor to design an adaptive courseware for distance education. Special editors will help the teacher to represent the knowledge about the domain and to design the set of teaching operations. All knowledge will be represented in the form of frames. The authoring system will then generate courseware for distance learning which will be a combination of HTML files, knowledge frames and program scripts. From that point this courseware can be used by anyone who has access to WWW and Mosaic-like viewers.

Working with the adaptive courseware the students will have navigation support for all the choices they have on a particular page. According to the knowledge state and educational goal of a particular student all the links will be individually 'commented'. Some links can be hidden from the student, but some additional links can be generated. In particular, any page will have a dynamic 'next' link which leads the student to the next 'best' or teaching operation. The content of the hypermedia pages will also be adapted to the student's current knowledge. Students who see the educational material first time will get more explanations, but some second-level details will be hidden to protect them from cognitive overload. Those who are browsing already known material will get less introductory explanations, but more high-level details.

To achieve this high level of adaptivity most of the hypermedia pages which the system presents to the student will not be stored in the HTML or text format, but will be adaptively generated from the knowledge base by the attached scripts. Existing mechanism of Common Gateway Interface and Fill-Out Forms provides a good background for that. Limited space protects us from providing more details for people who are not familiar with CGI and FOF. We refer, however, to the excellent work (Kay & Kummerfeld, 1994) for the comprehensive discussion of how the above features can be

implemented with WWW. This paper is the only one we have found which discuss the problems of implementation of ITS technologies with WWW. This paper also describes a running project, which will implement both adaptive sequencing and adaptive hypermedia features.

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