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NAVIGATION SUPPORT IN A WEB-BASED ADAPTIVE EDUCATIONAL HYPERMEDIA SYSTEM

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Abstract

While using the Web-based hypermedia courseware the students need navigational help to find their way through the learning material. Otherwise, they could get "lost in hyperspace". In this paper we describe our approach developing Web-based adaptive educational hypermedia systems (AEHS) with the emphasis on adaptive navigation support. Our goal is to develop an AEHS, which would restrict the student's choice as little as possible, but also guide the student to take the best learning paths.

Introduction

Traditional computer-aided education has been greatly enhanced by utilizing the Web-based hypermedia systems. Despite their advantages, some problems related to the usage of such WWW systems become apparent as well, particularly concerning the disorientation of the users, or the "getting lost in hyperspace" problem (Maurer and Scherbakov 1996). Therefore, Web-based educational hypermedia systems should give the students navigational help to find their way through hyperspace and to adapt to the characteristics of the student (Schwarz 1996).

An adaptive hypermedia system (AHS) adapts the presentation of hypermedia content or links, based on the user model (Brusilovsky 1999). Since 1996 the Web has become the primary platform for developing educational adaptive hypermedia systems (De Bra 1999).

In this paper we describe our approach to developing a Web-based adaptive educational hypermedia system with emphasis on adaptive navigation support and lessons sequencing. The purpose of lessons or curriculum sequencing technology is to provide a student with the most suitable sequence of knowledge units to learn. It helps the student to find an optimal navigational path through the material to be learned (Hübscher 2000).

The model we propose marks all the links and suggests which page the student should visit next, according to the student's knowledge and some specific attributes of each lesson. A main principle for our approach is to maximize the space that the user may explore and to accomplish a trade-off between free exploration and guided exploration.

The Model of an Adaptive Educational Hypermedia System

Our model of an adaptive educational hypermedia system consists of the domain model, which describes the structure of the learning domain as a set of reusable concepts linked together with prerequisite relationships, the student model encompassing the student's knowledge of the learning concepts, and the adaptive model which contains rules for adaptation.

The Domain Model

A domain model is in the form of a graph with nodes corresponding to concepts and with links reflecting relationships between concepts. By *concepts* (lessons) we mean elementary pieces of knowledge for the given domain. Links represent *prerequisite relationships* that denote pedagogical constraints, for example "concept C_1 should be learned before concept C_2".

A definition of concept C_i includes a set of multimedia fragments that represent the content of the lesson, a set of prerequisite concepts and a set of multiple-choice/single-answer questions related to the concept.

Concepts are grouped into *modules.* Each module M_k has a set of prerequisite modules and a test T_k with questions for each concept in the module.

The domain model can be viewed as a directed graph $D=(\mathcal{M}, \mathcal{LM})$, where $\mathcal{M}$ is the set of modules and $\mathcal{LM}$ is the set of arcs, $\mathcal{LM} \subseteq \mathcal{M} \times \mathcal{M}$. The arc connecting modules M_i and M_j exists if M_i is prerequisite module for M_j. Each module is also a directed graph with concepts as nodes. Figure 1 illustrates an example of a courseware fragment.

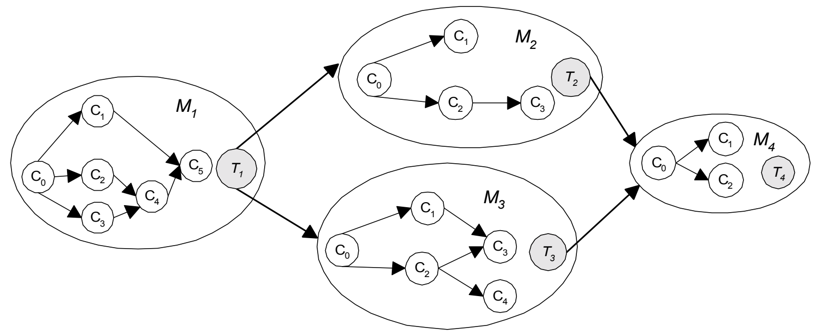

Figure 1. An Example of a Courseware Fragment

The proposed representation for the AEHS domain structure is suitable for storing learning materials from different areas (computer science, mathematics, medicine, art, etc.). The structure of the knowledge is not necessarily hierarchical (chapters, subchapters, pages) but rather concept-oriented.

The Student Model and Testing

The graph described in the previous chapter can be traversed in several ways, if the author has not designed it too strictly. The target of the system is to dynamically calculate a navigation plan as a sequence of concepts, suggesting the appropriate continuation from every concept C_i visited. A variant of the overlay model for representing the student's knowledge is proposed for that (Brusilovsky 1999, De Bra 1999). For every concept C_i the main attributes recorded for each student are r_i and k_i.

r_i is the estimate about the fact if the student has read the concept C_i or not. k_i is the estimate about the student's knowledge of the concept C_i and is calculated using a variant of the MYCIN model, a widely used expert systems' model (Anjaneyulu 1997). The knowledge value of a concept is set by testing and can range from -1 (student does not know the concept) to 1 (student knows the concept). Before the student takes any of the tests, all concepts in the student model have an initial value of $r_i = 0$.

After answering each test question related to the concept C_i, the new knowledge value k_i' for the concept C_i is calculated according to (1). The new value is based on the previous knowledge value k_i and the factor q_i from the domain model, the confidence level of the fact that the student knows or does not know the concept. If the student answers the question correctly, $f = q$, otherwise $f = -q$.

$$k_i' = \begin{cases} k_i + (1 - k_i) \cdot f, & k_i > 0, f > 0 \\ k_i + (1 - k_i) \cdot f, & k_i < 0, f < 0 \\ k_i + (1 - f) \,/\, (1 - \min(|k_i|, |f|)) & \textit{otherwise} \end{cases} \qquad (1)$$

The concept C_i will be considered learned if $k_i > 0$ and if the student has answered to a predefined minimum number of questions for that concept. The lower limit for k_i can be introduced into domain model, if appropriate.

The Adaptation Model and Adaptive Navigation

The adaptation model consists of adaptation rules that define how the domain model and the student model are combined to perform adaptive navigation support.

In our system, we employed adaptive navigation, which is a combination of free (open) and guided (forced) navigation through adaptive annotation and guidance technique. The student can freely follow any hyperlink within a module, but a list of hyperlinks is offered that suit him best, according to the navigation plan generating for him.

According to the student model, the concepts from the module M_k are classified into several subsets: learned concepts, read concepts, completely recommended concepts where all prerequisite concepts have been read, and not recommended concepts. Navigation within the module M_k goes on before the student solves the test T_k. This navigation is actually the traversing of a directed graph (C_k, $\mathcal{L}C_k$), following the hyperlinks suggested by the system on the bottom of the page.

Initially, when the student starts to use the system, there are no *learned* and read concepts. The page containing the concept C_i without prerequisite concepts is opened. The suggested hyperlinks are automatically generated before the page is shown and are listed in the following order: concepts that have C_i as a prerequisite, and all other prerequisites have been read, completely recommended concepts, not recommended concepts, test $T_{k.}$

If the student chooses to follow one of the suggested hyperlinks, r_i is set to 1. Hyperlinks are annotated with various colors corresponding to concept types.

Transition to another module is possible after the successful completion of a test. There are three possible outcomes of the test T_k that belongs to the module M_k: T_k is completely passed and the student could proceed to another module according to the directed graph ($\mathcal{M}_k$, $\mathcal{L}\mathcal{M}_k$); T_k is partially passed according to the previously defined criteria. The concepts C_i with $k_i \le 0$ are offered for repetition but the student could proceed to another module; T_k is not passed, the concepts C_i with $k_i \le$ from M_k are offered for repetition and the student should retake the test T_k in order to proceed to another module.

Conclusion and Future Work

In this paper we have discussed the research work that aims to design a Web-based adaptive educational hypermedia system. The navigation model is based on adaptive lessons sequencing and adaptive navigation support techniques. The work on such a system is currently in progress. To verify the results, sample coursewares will be generated at authors' institutions. The statistical analysis will be performed which will compare the success of the students that were using the courseware to the success of the students from the previous generations. Also, the statistical methods will be introduced, which will attempt to verify if the prerequisite relationships were correctly defined, by correlating the outcome of the test results for all concepts with the results for their prerequisites. Such an analysis is expected to prove if the prerequisites have been correctly defined.

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