Improving the Usability of Hypertext Courseware through Adaptive Linking

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ABSTRACT
Hypertext is being used more and more for on-line course texts. But the navigational freedom offered by a rich link structure is a burdon for students who need guidance throughout the learning process. This paper presents a framework for adaptive link structures. By enabling links when a student is ready to read the pages these links lead to, and by disabling links to pages that are no longer needed, the student can be assured that links always lead to interesting new information she is ready to read. This framework is illustrated by means of courseware for an on-line course on "Hypermedia structures and systems", developed at the Eindhoven University of Technology, and currently offered at six different universities in the Netherlands and Belgium.

KEYWORDS: hypertext courseware, adaptive interaction, dynamic link structure

1 INTRODUCTION

Hypertext is being used more and more often in distance education, as a replacement for paper course texts. A textbook usually suggests only one (linear) reading order. The student can of course elect to read the pages in a different order, but in many cases such alternative order does not make sense. A hypertext offers many intended different reading orders. Every page (or node) contains links to a number of different pages which can be read next. In many hypertext systems the contents of nodes and the link structure are static. This implies that the author must make sure that the reader is never invited to follow links that lead to information she cannot (yet) understand. Later, when the reader has gained more knowledge, additional links could become interesting, and some instructional links may become superfluous, but the static link structure makes it impossible to adapt to the reader's state of mind.

In [3] an overview is given of techniques for adapting a hypermedia document to the user's state or level of expertise. Most techniques offer some variant of conditional text, resulting in variants of text fragments, whole pages, or even clusters of pages. Also, the link structure of a hyperdocument can be adaptive to offer navigation guidance. Guidance can be *positive*, e. g. by means of sorting available links according to user preference or relevance, or *negative*, e. g. by annotating, dimming or even hiding links which the user should not (yet) follow. The InterBook tool [5], which evolved from the ELM-ART tutoring system developed at the University of Trier [4], uses *adaptive link annotation* to show the type and educational state of links. The link structure itself appears to remain static, but visual cues are used to advise the student to follow certain links and to avoid certain other links. In the ELM-ART course, and probably also in Interbook, links may first get a "red light" annotation, which is changed to a "green light" when the student is ready to follow them. Once a node has been given a green light it is never advised against anymore. This (short) paper describes an experiment in which *adaptive linking* is used to actually modify (and not just annotate) the link structure depending on the student's knowledge state. Links are not only added when a student is ready to follow them, but may also be removed when it is no longer appropriate to follow them. (Hence the proverbial green light could turn red again.)

2 LEARNING THROUGH ADAPTIVE HYPERTEXT

According to [1] a primary concern when using hypertext for the creation of a course text is the structure to be given to the knowledge it conveys so that a student can easily and naturally find the most appropriate information depending on her needs. The difficulty in achieving this goal is that the needs of a student evolve with her assimilation of that conveyed knowledge. Hence the structure given to the presented information must change along with the development of the student's knowledge. This is precisely what adaptive hypertext courseware tries to achieve. Ideally, by the time the student finishes a course the hypertext should have modified its structure from a textbook into a reference guide. Navigational suggestions offered by links should have changed from a learning order to a topic index structure.

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The course "2L670: Hypermedia Structures and Systems" is an introductory course on the topic of hypermedia, and is taught entirely through an adaptive hypertext course text. Experience with an initial, static version, in use since early 1994, lead to the development of a second (but still static) version in which the student's progress was continuously monitored [6]. In January 1997 the third version was installed, which added adaptive linking based on the student's progress.

The source "code" for the course text contains all possible links. Based on the knowledge of the student the system, implemented as a set of CGI-scripts, filters each page to show or hide links. Filtering is done based on the user's understanding of "concepts" that are associated with pages and multiple-choice tests. Every page has three attributes:

- The knowledge (concepts) the student acquires when (after) visiting the page;
- The foreknowledge the student needs to access the page;
- The foreknowledge that makes links to the page superfluous.

In the hypertext course text some links may be "hardcoded", meaning that the link "really" belongs there, and is therefore always displayed. All other (normal) links are only shown when the student has gained the required foreknowledge, and has not yet gained knowledge that makes links to the page superfluous.

3 PRELIMINARY EVALUATION

The adaptive courseware has been used in a trial in 1996, before becoming the standard version as of January 1997. So far one interesting difference has emerged in students' reactions between those who used the older static link structure and those who used the adaptive version. In the static version there was no way to quickly glance through the entire course text (something which is easy with a paper textbook). However, the students never complained about that, because they could at least glance at a few pages from each chapter right from the start. In the adaptive version there is of course also no way to glance through the entire course text, but the students complain about it. It is clear that the links that are enabled at each moment serve as a generalization of the notion of the "next page" in a book, and that the illusion that by following only a few links one could get an overview of what's in the course has disappeared.

We believe that part of the problem with adaptive linking stems from the fact that while a link is hidden its link text and the sentence(s) surrounding the link remain unchanged. This text often strongly suggest the presence of the link. Adaptive node contents could solve this problem, and is being worked on for the next version of course 2L670.[2]

4 CURRENT AND FUTURE WORK

We are currently implementing the conditional inclusion of text fragments, by means of the C preprocessor (cpp). Although this technique could also be used to conditionally hide or show links in HTML documents we intend to restrict the cpp use to text alterations. A masters student is analyzing the log files to determine in what way the adaptive link structure has influenced the navigational behavior of students, compared to the previous static structure.

What remains to be done in adaptive hypertext research is to develop a method to evaluate the browsing semantics. In a static hypertext document one can easily determine whether all nodes are reachable, where infinite loops are located, and one can calculate metrics such as compactness, stratum or the percentage of cross-reference links (vs. hierarchical links) [2]. Determining whether there are unreachable nodes or infinite loops in an adaptive link structure is much more difficult, as is calculating metrics of the perceived link structure (i. e. the structure as seen by the user while navigating through the course text).

[2]Interested readers can view the adaptive course text at http://wwwis.win.tue.nl/2L670/.

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