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Adaptive Educational Hypermedia

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Abstract. Adaptive hypermedia is a relatively new direction of research on the crossroads of hypermedia and user modeling. Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user. Educational hypermedia was one of the first application areas for adaptive hypermedia and is currently one of the most popular and well-investigated. The goal of this presentation is to provide a subjective historical overview of research in adaptive educational hypermedia and summarize the current state of the art.

Adaptive hypermedia is an alternative to the traditional "one-size-fits-all" approach in the development of hypermedia systems. Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user (Brusilovsky, 1996). For example, a student in an adaptive educational hypermedia system will be given a presentation that is adapted specifically to his or her knowledge of the subject (De Bra, & Calvi, 1998), and a suggested set of most relevant links to proceed further (Brusilovsky, Eklund, & Schwarz, 1998). An adaptive electronic encyclopedia will personalize the content of an article to augment the user's existing knowledge and interests (Milosavljevic, 1997). A virtual museum will adapt the presentation of every visited object to the user's individual path through the museum (Oberlander, O'Donnell, Mellish, & Knott, 1998).

AH systems can be useful in any application area where a hypermedia system is expected to be used by people with different goals and knowledge and where the hyperspace is reasonably big. Users with different goals and knowledge may be interested in different pieces of information presented on a hypermedia page and may use different links for navigation. AH tries to overcome this problem by using knowledge represented in the user model to adapt the information and links being presented to the given user. Adaptation can also assist the user in a navigational sense, which is particularly relevant for a large hyperspace. Knowing user goals and knowledge, AH systems can support users in their navigation by limiting browsing space, suggesting most relevant links to follow, or providing adaptive comments to visible links.

In is quite naturally that educational hypermedia was one of the first application areas for AH. In educational context users with learning goals and knowledge on the subjects require essentially different treatment. It is also in educational hypermedia where the problem of "being lost in hyperspace" is especially critical. A number of pioneer adaptive educational hypermedia systems were developed between 1990 and 1996. These systems can be roughly divided into two research streams. The systems of one of these streams were created by researchers in the area of intelligent tutoring systems (ITS) who were trying to extend traditional student modeling and adaptation approaches developed in this field to ITS with hypermedia components (Beaumont, 1994; Brusilovsky, Pesin, & Zyryanov, 1993; Gonschorek, & Herzog, 1995; Pérez, Lopistéguy, Gutiérrez, & Usandizaga, 1995). The systems of another stream were developed by researchers working on educational hypermedia in an attempt to make their systems adapt to individual students (De Bra, 1996; de La Passardiere, & Dufresne, 1992; Hohl, Böcker, & Gunzenhäuser, 1996; Kay, & Kummerfeld, 1994).

Our group at the Moscow State University has started research on adaptive educational hypermedia in 1991 as an extension of our earlier work on curriculum sequencing in ITS. Main focus of our interest was *adaptive navigation support*, currently one of the major AH technologies. We have developed two educational AH systems ITEM/PG (Brusilovsky, et al., 1993) and ISIS-Tutor (Brusilovsky, & Pesin, 1994) and explored several ways of adaptive navigation support. We have used direct guidance in

the form of "teach me" button to provide a one-click access to the next best task. We have used adaptive annotation to color-code the links to "ready", "not-ready", and "already learned" tasks. In one of the versions of ISIS-Tutor we have also used adaptive link removal to remove all links to not-ready tasks. Our vision was that adaptive navigation support in educational hypermedia is "best of both worlds". Choosing next task in an ITS with sequencing is based on machine intelligence. Choosing next task in a traditional hypermedia is based on human intelligence. Adaptive navigation support is an interface that can integrate the power of machine and human intelligence: a user is free to make a choice while still seeing an opinion of an intelligent system.

Despite a number of creative ideas explored and evaluated in the early educational AH systems, it was not until 1996 that this research area has attracted attention of a larger community of researchers. There are two main factors that might account for this growth of research activity. The first factor is the accumulation and consolidation of research experience in the field. It is clearly visible that research in adaptive hypermedia performed and reported up to 1996 has provided a good foundation for the new generation of research. As we noted above, early researchers were generally not aware about each other's work. The early papers provided no (or almost no) references to similar work in adaptive hypermedia, and described original methods and techniques. Almost all the systems developed by 1996 were laboratory systems developed to demonstrate and explore innovative ideas. In contrast, many papers published since 1996 are clearly based on earlier research. These papers cite earlier work, and usually suggest an elaboration or an extension of techniques suggested earlier. In addition, a large number of systems developed since 1996 are either real world systems, or research systems developed for real world settings. This is indicative of the relative maturity of adaptive hypermedia as a research direction.

The second and arguably most important factor is the rapid increase in the use of the World Wide Web. The Web, with its clear demand for adaptivity due to its widely diverse audience served to boost adaptive hypermedia research, providing both a challenge and an attractive platform. Almost all the papers published before 1996 describe classic pre-Web hypertext and hypermedia. In contrast, the majority of papers published since 1996 are devoted to Web-based adaptive hypermedia systems. The major driving factor behind the current stream of work on adaptive educational hypermedia is Web-based education. The need to address heterogeneous audience of Web-based courses individually was clear for many researchers and practitioners. A few early adaptive hypermedia systems developed for Web-based education context by 1996 such as ELM-ART (Brusilovsky, Schwarz, & Weber, 1996), InterBook (Brusilovsky, et al., 1998), PT (Kay, & Kummerfeld, 1997), and 2L670 (De Bra, 1996) provided a "proof of existence" and influenced a number of more recent systems. The majority of adaptive educational hypermedia systems developed since 1996 are Web-based systems and were developed for Web-based education context. Examples are: Medtech (Eliot, Neiman, & Lamar, 1997), AST (Specht, Weber, Heitmeyer, & Schöch, 1997), ADI (Schöch, Specht, & Weber, 1998), HysM: (Kayama, & Okamoto, 1998), AHM (Pilar da Silva, Durm, Duval, & Olivié, 1998), MetaLinks (Murray, Condit, & Haugsjaa, 1998), CHEOPS (Negro, Scarano, & Simari, 1998), RATH (Hockemeyer, Held, & Albert, 1998), TANGOW (Carro, Pulido, & Rodrigues, 1999), Arthur (Gilbert, & Han, 1999), CAMELEON (Laroussi, & Benahmed, 1998), KBS-Hyperbook (Henze, Naceur, Nejd, & Wolpers, 1999), AHA! (De Bra, et al., 1998), SKILL (Neumann, & Zirvas, 1998), Multibook (Steinacker, Seeberg, Rechenberger, Fischer, & Steinmetz, 1998), ACE (Specht, & Oppermann, 1998), ART-Web (Weber, 1999).

The most recent trend in the area of adaptive educational hypermedia is developing comprehensive frameworks for adaptive Web-based education (De Bra, et al., 1998; Henze, & Nejd, 2000; Papanikolaou, Magoulas, & Grigoriadou, 2000; Specht, et al., 1998; Steinacker, et al., 1998; Stern, & Woolf, 2000; Süß, Kammerl, & Freitag, 2000; Weber, 1999). These frameworks are getting close to commercial tools for developing Web-based courses such as WebCT (WebCT, 1999), CourseInfo (Blackboard, 1999) or TopClass (WBT Systems, 1999). Developers of adaptive hypermedia frameworks are clearly interested in making their systems suitable for handling real Web courses. From another side, developers of commercial course management systems are becoming interested in adaptive and personalised systems. The most recent work on learning objects metadata (IEEE LTCS WG12, 2000) builds a good foundation for developing "more intelligent" educational material that could be naturally used by adaptive educational hypermedia systems. In this situation we could hope that adaptive hypermedia technology will soon be used in commercial-strength Web-based systems to deliver thousands of real world courses to students all over the world.

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