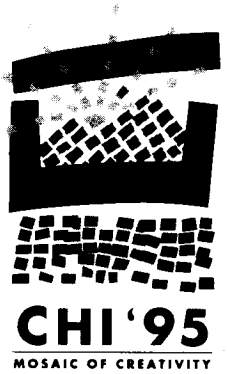
# HUMAN FACTORS IN COMPUTING SYSTEMS

## CHI '95 CONFERENCE COMPANION




CONFERENCE ON
HUMAN FACTORS IN
COMPUTING SYSTEMS
MAY 7-11 1995
DENVER COLORADO USA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# Visual annotation of links in adaptive hypermedia

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## ABSTRACT
Visual annotation of links is a new technique for adaptive navigation support in adaptive educational hypermedia. This paper explains briefly this technique and reports preliminary experimental results of its evaluation. The results show that adaptive visual annotation is helpful and can reduce user floundering in hyperspace.

**KEYWORDS:** User models, adaptive hypermedia, adaptive navigation support

## INTRODUCTION
Adaptive hypermedia (AH) is one of the promising application areas for user modeling and user-adapted interaction techniques [1]. AH systems can be useful in any situation when the 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 about a particular user, represented in the user model, to adapt the information and links being presented to the given user. That is essentially important for educational hypermedia systems, where the same user can have different knowledge on the same topic (and thus need different information on this topic) on different stages of learning. Adaptation can also protect the user from being lost in 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.

We are using AH in educational context as a component of intelligent tutoring system (ITS). The student model of ITS (which is used traditionally for individualizing instruction) is applied in our systems as a user model for AH component. We have implemented several different adaptation techniques for adaptive educational hypermedia [2]. Of particular interest for us is the technique of adaptive visual annotation of hypermedia links. Here we explain briefly this technique and report preliminary experimental results of its evaluation. The results shows that adaptive visual annotation is helpful and can reduce user floundering in hyperspace.



## ADAPTATION IN HYPERMEDIA
What can be adapted in AH are the content of a hypermedia page and the links from a page (including index pages and maps) 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 [3-5]. 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. By adaptive navigation support we mean all the ways to play with visible links which can support hyperspace navigation..

Previous works [3,6] suggest *adaptive ordering* technique for adaptive navigation support. This technique apply user model and some user-valuable criteria to adapt the order of presentation for all possible links. It gives the user a hint which link to follow (the more close to the top, the more relevant the link is). We think that adaptive ordering technique provides a good way to support user navigation in the pages with dozens of possible links, but has less sense in educational context when the number of links is smaller. Some research also shows that the stable order of options in menus is important for novices. We apply another technique for adaptive navigation support in educational hypermedia: visual adaptive annotation of links (augmenting links with dynamic comments in any form) according user's goal and knowledge state [2,7]. We expect that adaptive annotation can give the users some additional information about accessible nodes and thus reduce their floundering in the hyperspace. In particular, we hope that it reduce the number of "orientation" visits when the user visits related nodes just for several seconds to see what is around him.

At present there are very few studies which investigate the effectiveness of AH. The experiments, reported in [5] shows that adaptive presentation increase user performance. The work [6] reports positive experimental results of adaptive ordering technique. By now there was no experiments with adaptive annotation technique, though some related research shows that even non-

adaptive annotation, which tells the user more about the nodes designated by annotated links, can increase students performance [8]. It was the goal of our recent experiment to check the effectiveness of adaptive annotation in educational context.

## THE EXPERIMENT

We use for the experiment an ITS ISIS-Tutor [7]. Hypermedia component of ISIS-Tutor is an interface with a network of concept descriptions, examples and problems. ISIS-Tutor uses colours and special marks to annotate the set of links leading from the current node to related nodes (and from index page to all nodes) according to the current user knowledge and educational goals. The latter means, that the links to concepts which are the goal of the current lesson are marked with a sign "-". The system use the student model to distinguish four knowledge states for each concept which is represented by a hypermedia page: *not-ready-to-be-learned* (i.e. has unlearned prerequisites), *ready-to-be-learned*, *in-work* (learning started), and *learned* (user demonstrate that he knows the concept by solving the required number of problems). Thus, at any moment the hyperspace is divided implicitly into four zones with different educational status. The idea is that marking these zones visually would help the student in hyperspace navigation. In the current version of ISIS-Tutor links to not-ready-to-be-learned concepts were not specially coloured, ready-to-be-learned were coloured red, both in-work and learned were coloured green, and learned concepts was additionally marked with sign "+". Links to problems was adaptively annotated by the same way.

| Group | Overall number of steps | Repetitions of studied concepts | Transitions concept -> concept | Transitions index -> concept |
|---|---|---|---|---|
| A | 78 | 17 | 8.3 | 22.14 |
| B | 53 | 6.75 | 1.4 | 15.5 |
| C | 61.3 | 11 | 2.7 | 16.3 |

Twenty six subjects (first year computer science students of the Moscow State University) took part in the experiment. They were briefly introduced to ISIS-Tutor and then had up to 45 minutes to work with the system. The same educational goal (ten concepts and ten test problems) was set to all the students. To finish the course, each user had to solve all ten problems. The subjects were divided randomly into three groups. Group A worked with hypermedia without any adaptation, the students however were given the numbers of goal concepts (in index and all menus the name of the concept is always preceded by its number). Group B worked with adaptive hypermedia as described above. Group C worked with restrictive version of the same adaptive hypermedia: the links to all not-ready-to-be-learned concepts and problems and to all concepts and problems outside the learning goals were excluded from index and all other menus. The idea of this restriction is to reduce the cognitive load of the student by excluding "not useful" information. All actions of the students working with the system are recorded and then analyzed to compare various aspects of user performance.

The results of the experiment are shown in the table above (all data are average numbers for each group). As we can see, the overall number of navigation steps, the number of repetitions of previously studied concepts, the number of transitions from concept to concept and from index to concept are seriously less for AH. Moreover, this difference is usually bigger for non-restrictive hypermedia.

## DISCUSSION

The results of our experiment show that adaptive visual annotation of hypermedia links in educational context can really reduce user's floundering in the hyperspace and make the learning with hypermedia more goal-oriented. With adaptive annotation the user can achieve the same result with less navigation steps and by less visits to hypernodes. It is interesting to compare our results with the results presented in [5]. This work reports that adaptive presentation in hypermedia can reduce the time for learning the material and improve the comprehension of it, but can not reduce the number of nodes visited in the process of learning. In the same time, adaptive annotation of links can hardly improve the quality of learning, but can reduce the number of visited nodes thus further reducing the learning time. These techniques looks complimentary and can be used together for further improvement of the effectiveness of learning with hypermedia.

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