METADYNE

a Dynamic Adaptive Hypermedia System for Teaching

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Summary

Following ITS and ILE, research on Computer Aided Teaching has taken an interest in hypertext systems. However the main advantage of those hypertext systems, i.e. the liberty of navigation, has quickly become a major drawback for a lot of types of system (for instance information systems, help systems, research systems, etc.) and especially teaching systems. From that time, research has turned toward Adaptive Hypermedia and more recently toward Dynamic Adaptive Hypermedia. This paper introduces the architecture of a Dynamic Adaptive Hypermedia tool for Teaching, using the Internet as communication system. This system being developed within our laboratory.

Key words : Adaptive hypermedia, multimedia, object-oriented database, computer aided teaching, Internet.

1 - INTRODUCTION.

Like ITS (Intelligent Tutoring System) [Barron 95] and ILE (Intelligent or Interactive Learning Environment) [Dillenbourg 93], nowadays hypermedia systems constitute an intrinsic component of research on Computer Aided Teaching. Unfortunately, the main advantage of those systems (the non linearity of the student's progression), has quickly turned into a major drawback. Indeed, the student gets lost quickly in the hyperspace. Therefore, ideally, the student could be guided in his/her progress according to his/her own knowledge of the subject, in modifying the content of pages as well as links between the pages, and that is what we call adaptive hypermedia. Once again, this evolution has raised new problems, mainly due to the difficulty of implementing such systems. The used techniques are uncertain enough and moreover some studies have shown that such systems could confuse the learner. Thus for some years, researches have turned toward Dynamic Adaptive Hypermedia. These systems have the particularity to separate the content (domain model) and the form (media being able to introduce the concepts of the model) and to build courses in a dynamic way. In this article, we are aiming to revise classical techniques to transform an hypermedia in an adaptive hypermedia. Next, we will see the characteristics of Dynamic Adaptive System, and more precisely the characteristics of our system.

2 - ADAPTIVE HYPERMEDIA.

First of all, we are going to redefine what hypertexts and hypermedia systems are. A hypertext is a system that allows information to be given in a non linear way. The hypertext systems are made up of nodes (equivalent to book pages) and of links between the different nodes. Thus the user never has to follow the logic of the author. Hypermedia differs from hypertexts by the content of nodes. Nodes are not only a combination of textual data, but can be a combination of various data, such as pictures, animations, videos, etc. Neverless, some authors equally use the terms hypertexts or hypermedia to show that the major interest of these systems is not the content of nodes but the global structure of the system.

The conception of software allowing to create hypertexts (such as HyperCard) and the creation of the World Wide Web have had a real impact on research on Computer Aided Teaching. Beyond non-interactive learning systems like ITS, research has been trying to give more initiative to the learner. However, once again those advantages have raised new problems. The main drawback of a hypertext system is precisely its ever-growing dimension, and therefore the user runs the risk of getting lost in the hyperspace. Moreover, learning hypertexts must be based on judicious data, neither too basic, nor too complicated. The goal of Adaptive Hypermedia for Teaching is to adapt the presentation of the knowledge and to help the learner navigate in the hyperspace. A hypermedia system must enable the user to modify the content of pages and the links between the nodes [Brusilovsky 96a]. But it is on the adaptation of those links that many techniques have been developed [Brusilovsky 96b]. Among these techniques, we can find for instance :

- techniques of direct guidance, whose principle is to propose to the learner a " NEXT " button. With this button, the user can activate the next page, which is chosen by the system. The drawback of this technique is that the learner is no longer using a hypertext system, but a classical one (he/she just follows the choice of the system).
- techniques of links ordering, to show the learner the most important links, i.e. links allowing him/her to access to the most appropriate pages according to the profile of his/her performance. In comparison with direct guidance, this technique is really better, since while it guides the user it allows him/her at the same time to choose the next page. But, some studies (cf. [Brusilovsky 96b]) have shown that this kind of technique could bewildering for the user, as he/she can read the same page a lot of times (with the same content) but with different links.
- techniques of links hiding, whose principle is to hide the links that would allow access to pages the user does not need, or does not have the competence to read.
- techniques of links annotations, that simply describe what the annotated link is aiming at.

Of course, these techniques are only useful if the system has a good user model. In this case, it will take into account the specificities of the profile of the student's performance and will be able to make the best choice of adaptation. We can consider that the user model is composed of two sub-models [Nicaud 94], the *epistemic model* and the *behavioural model* :

- the epistemic model allows us to know the global knowledge of the learner. This model is steadily updated according to the interactions between the user and the system (results of exercises, help requests, etc.).
- the behavioural model allows us to know the usual student behaviour. Thanks to this model, the system can for instance determine the user's most favorite kind of presentation, it can take his/her quick-wittedness into account, etc.

Usually, the epistemic model is a digression from the domain model. As for a lot of Computer Aided Teaching Systems, the domain model is a network of concepts linked by different kinds of relations such as : *" is composed of ", " is a prerequisite of ",* etc. Hypermedia differ from other teaching systems by the relation existing between the domain model and the media used by the system to introduce a concept to the student. The first generation of Adaptive Hypermedia Systems used the *index page method*, where each concept is connected to a page. Through this page, the user can reach all other pages dealing with this concept. The next generation of systems used an index page again, but those index pages allowed the user to reach significant fragments of pages. It was called *fragment indexing method*. This technique is similar to the first one, but leads to a more accurate index. The latest generation of Adaptive Hypermedia Systems has based the hyperspace of the domain model structure [Vassileva 97]. Each concept is linked to one or several pages and the relations are represented by the hypertext links.

3 - DYNAMIC ADAPTIVE HYPERMEDIA.

In order to solve technical difficulties and to improve maintenance, for few years, researchers have been working on Dynamic Adptative Hypermedia System. The main characteristic of this kind of system is to offer the user a virtual hypermedia [Vassileva 95]. Systems are not implemented with physical pages, as they are dynamically built. To prepare courses, Dynamic Adaptive Hypermedia Systems use an architecture similar to the classical ITS architecture, and involving the domain model and the user model. The domain model, like the latest generation of adaptive hypermedia, determines the hypermedia structure. The user model allows the system to be adapted. However, Dynamic Adaptive Hypermedia use a third component too : a multimedia database (or a base of teaching materials [Vassileva 92]). There are a lot of advantages in using this kind of system. For instance the addition of new media can be immediately taken into account. Teachers do not have to think about how they will build the pages of the system (the pages content and the links between the pages). They just have to think the general organisation of the system (domain model) and to create (or to search for) new media to introduce the concept.

4 - METADYNE.

The architecture of our system resembles the architecture of a general Dynamic Adaptive Hypermedia System, i.e. we decided to use the three classical models : the domain model, the user model and the multimedia database. In this section we will explain how we decided to implement those three models, and the choices we made to improve the classical representation.

4.1 - The domain model.

As explained above, the domain model representation is similar to ITS (we often use concept networks). In our system, those concepts are linked by the following relations :

a) *" is sequentially composed by "*, enables to break up the teaching of a concept into the teaching of a succession of concepts. For instance, a course on derivates can begin with a course on simple formulae, then a course on calculation of derivate functions, and finally a course on tangent slopes.

b) *" is derived from "*, enables to see a concept from different points of view. For instance, a course on light can be a course on corpuscular theory or on wave theory.

c) *" is a prerequisite "*, enables to select what must be known to understand the concept. For instance, courses on derivates and limits are prerequisites to a course on asymptotes.

d) *" assistance to the understanding of "*, both encourages the student to go and see a concept, and initializes the user model on the current concept. For instance, prior knowledge of Pascal language can be considered an advantage in learning C language.

We notice that points *a* and *c* are often used in Computer Aided Teaching Systems, unlike the others, and particularly point *d*. However, as we are going to see in the presentation of the user model, the *" assistance to the understanding of"* relation seems to us very important to initialize the user model, and to improve course design.

Moreover in our system, some relations are weighted (*prerequisite* and *assistance to understanding* relationship), so that our system can have a better perception of the student (we will consider that a student must revise a prerequisite concept, if his/her mark is lower than the weight coefficient of the link).

Finally, we have considered that it is important to provide the teachers with a way to pool their knowledge, allowing each to preserve his/her specific vision of the model. Therefore, with this model, we want each teacher to be able to access the different points of view concerning the model (i.e. the point of view for a given teacher, the point of view of a group of teachers and of all the teachers). So each concept, each relation and each weight coefficient are labeled. This kind of annotation has two main advantages. First, each teacher will be able to estimate his/her vision of domain model according to his/her colleagues' vision. The second advantage, for the student, is that the system will be able to choose different pedagogical strategies. For instance, if the student wants to consult a course for an exam, the system will mainly use the point of view of the teacher who will be giving him/her a mark. On the other hand, if the student uses the system freely, then the system will let him/her have a larger vision of the subject.

4.2 - The student model.

In addition to the domain model, a good representation of the student model is essential. We definitely wanted to keep the two sub-models mentioned above. Whereas the epistemic model is always present in Computer Aided Teaching, the behavioural model is often very small or even non-existant. But a hypermedia system, and mainly for education, must be very close to the student, i.e. it must take student's preferences as

well as his/her quick-wittedness into account. We decided to represent the epistemic model by a succession of concept-value couples, representative of the student knowledge for each concept [Gavinet 91]. In the same way, we decided to represent the behavioural model through a succession of entity-value couples to characterize the student.

Although the behavioural model is rather static (even if the behaviour of the student could change according to his/her state of mind), since a lot of parameters are defined during the first session, the epistemic model is completely dynamic, as it is constantly modified by the student. Moreover, we decided to take the time factor into account (an idea from the mnesic networks of [Jorion 89]), because it is easy to forget non-updated knowledge. However, we notice that these two models are linked. For instance the update of the concept weight of the epistemic model is linked to the time factor, which is also related to the behavioural model.

4.3 - The media.

The third Dynamic Adaptive Hypermedia component is the multimedia database (to introduce each concept to the student). To save the media, we use the MATISSE[1] object-oriented database. This database has the particularity of being really object-oriented (with the use of metaclass) and specially designed to solve the multimedia data issues (data size, different formats, etc.). Moreover, this database is the kernel of a multimedia Web server called SEMUSDI[2] (in French, Serveur Multimedia pour les Sciences de l'Ingunieur). This server enables students, teachers, researchers and engineers both to add (after validation by an editorial panel) or to obtain different media (HTML pages, pictures, video, sounds, etc.) by using a simple browser.

We decided not to use a direct link between concept and media, but to use three filters to access a media from a concept. The first one allows the system to sort the media according to their cognitive value (equivalent to Cognitive Media Type of [Recker 95]), for instance a presentation, an example, a definition, an exercise, etc. The second one sorts the media according to the knowledge level required (we do not use the same words to present a concept to an expert as to a novice). Finally, the third filter chooses a medium according to students' preferences.

To conclude, the global working of our system starts by initializing the characteristics of a new student (students' preferences and initialization of the epistemic model). When the student has chosen his/her course, that means that the system has determined the concept, the system extracts the different links that can be activated. Next, the system chooses a framework according to the student's preferences. We notice that using a framework mainly simplifies things for the student, since every course will use the same framework. Next, the system builds an HTML page, putting chosen media and different links in place within the framework. Then, the student can obtain the HTML page. He/she can also visualize the media, activate the linked page and solve exercises. After having validated the current page, the system updates the user's model, and can oblige the student to review certain concepts or, if the results are good, proposes new courses.

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[1] You can obtain information about this database at http://www.adb.fr

[2] You can use this server at http://ServSemusdi.insa-rouen.fr

5 - CONCLUSION.

Dynamic Adaptive Hypermedia has now become a real direction in research among research on Computer Aided Teaching. The dynamic aspect of the system allows to separate the content from the form, since on the one hand we have the domain model representing the knowledge 'in the rough', and on the other hand we have a multimedia database illustrating the courses. Therefore, when we add a new medium to the database, it can immediately be used to create new courses.

Beyond the dynamic aspect, we can distinguish our system from others by :

_ our will to develop an 'intelligent' Web server providing courses, while in general researchers develop independent systems that they then transform into Web servers.

_ the kind of user model that we have chosen. We do not give greater importance to either of the sub-models. For us, the behavioural model is as important as the epistemic model.

_ the use of three filters to choose a media from a concept. With this process, the system will be able to choose the best adapted media for the learner.

_ our intention to use a framework to construct the HTML pages. Therefore, whatever the concept , the learner will read pages with the same structure.

Today, we have mainly focused our work on the SEMUSDI multimedia server. But, soon we are going to implement our domain model and our student model, by using the MATISSE database. Next, we will develop tools to create courses which will be accessible using a simple Web browser. Then any student, whatever his/her geographical location, will be able to learn (or to revise) a course that will be adapted to his/her own personality as well as to his/her own knowledge.

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