Coherence in Modularly Composed Adaptive Learning Documents

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Abstract. In this paper we suggest the Multibook approach how the gap between adaptivity and readability can be diminished. We show how a knowledge base has to be described by metadata (LOM), rhetorical-didactic relations and an underlying ontology to make it possible for the learners to build coherence from the modularly composed document.

1 Introduction

The idea of life long learning makes adaptivity necessary. Adaptivity is best realized using a modular knowledge base where resources can be individually selected according to the special needs of the learner. A disadvantage of modularly composed documents is the missing coherence. The description of the information modules as in the Multibook system (section 2) can help the learner to establish coherence (section 3).

2 Description of the Modules in the Knowledge Base

In order to automatically create dynamic learning documents, Multibook uses the Learning Object Metadata (LOM) approach of the IEEE Working Group P1484.12 [8] as metadata scheme to describe the modules. One of the main prerequisites to accomplish the automatic generation of lessons out of modules, is supporting coherence between the modules. Learners usually tend to distrust working documents which were generated adaptively by computer systems. This will get the worse, the less coherence the system can provide between two subsequent modules in the document.

2.1 Metadata Attributing Single Modules

LOM provides attributes divided in nine categories to describe a learning module. These categories include attributes to represent properties like copyright or utilization aspects of the module and attributes which express the "pedagogical properties" of the module. The problem with these properties is that different authors have different conceptions about the values of these attributes, even if there is a fixed vocabulary for the attribute value. Computer based agents however have to examine exactly these fields if they want to make decisions about the selection of a module from a pedagogical point of view. If the authors of the modules had different meanings about the values for the same property, the generated document will neither be very useful for a learner, nor be a coherent document. To decide whether or not a resource is appropriate for a user in a current situation, more information about the context, where the

resource shall be used, is necessary. Furthermore the system needs more information about the background of the learner and also the criteria of the metadata author, who has tagged the resource. These restricts the effective use of algorithms to calculate values like the level of difficulty of a document to closed systems. Additionally more "pedagogical" metadata about a resource can be collected to generate a coherent document. The main disadvantage of a closed system is obvious. The system is not able to use resources generated and described outside of the system. Furthermore not many authors of learning material are willing to provide enough metadata, because describing a resource with metadata can be a time consuming effort. As soon as material, which was built and tagged outside the system, is considered, the coherence of the generated document decreases. More metadata does not necessarily guarantee a better quality of the generated documents. Even if the document was generated of pedagogically fitting modules, the coherence inside the document can still be low. In contrast to metadata schemes used in closed systems, the big advantage of LOM is, that it is very easy to find and (re-)use modular resources generated outside Multibook. As we want to show in chapter 3, we believe that it is possible to select appropriate modules described with LOM and some extensions we are using in Multibook, to generate a coherent document for an individual learner.

2.2 Relations between Modules

The second important aspect for generating coherent documents of modular resources is the possibility to express explicit relationships between modules. The proposed values are:
{isPartOf, HasPart, IsVersionOf,HasVersion, IsFormatOf,HasFormat, References IsReferencedBy, IsBasedOn, IsBasisFor, Requires IsRequiredBy}
Unfortunately, the relations mix content-based and conceptual connections between the modules. The fact that a module is referencing another one, is an indication that the modules contain information about the same topic. It is not enough information to decide, if these connected modules can be presented in a certain order. The relations "isPartOf/hasPart" and "isVersionOf/hasVersion" can be useful for organizing generated lessons. To generate the lesson itself they are not helpful. The relation "Requires/isRequiredBy" is also inappropriate. If a module completely depends on the existence and accessibility of another module, the approach of independent and reusable learning modules gets completely lost. Modules connected with the relation "isBasedOn/IsBasisFor" have the same problem. If this relation expresses a content based connection between two modules, there is no difference between a "isBasedOn" relation and a "isRequired" one. If someone wants to express the fact that a module is dealing with a concept, which is explained in another module, he or she shouldn't express this fact with connecting two concrete modules or, in other words, representations of the concepts. This kind of connection is independent of the actual modules and should therefore be modeled separately. Multibook uses for this purpose a terminological ontology, where the concepts of the knowledge domain are represented and connected by semantic relations. The modules are connected to the respective concept. Relations between single modules should be restricted to didactic relations. These are for both a computer-based agent and a human learner useful to gain additional, more profound or explaining material. A short characterization of these rhetorical-didactic relations and how they are used to establish coherence is given in the next chapter.

3 Coherence

A criterion of a text is coherence. As Kuhlen remarked in [2] there cannot be (and from our point of view should not be) coherence in a hypertext system as such. It is up to the users to create coherence for their individual path through the system. An educational hypertext system should support the learners at this task.
In the following sections we show how this support can be added to learning systems with a modular knowledge base.

3.1 Local Coherence

Traditionally, the authors assume the job of relating two subsequent sentences or paragraphs. The basic tool is the order of the sections. Phrases like "It follows ..." or "Whereas, ..." etc. state the kind of relation between the sections, the second sentences or paragraph is a conclusion resp. a restriction of the first one. By using a consistent vocabulary and a recognizable style, the authors can support the users at following their train of thoughts and hence at building up coherence by themselves.
With a modular knowledge base – probably originated by several authors – none of these instruments is available. In the following sections we show a possibility to add coherence to such a knowledge base.

Guided Tour. To re-establish clues for coherence, some systems introduce guided tours, especially for beginners. A guided tour is one linear path through the material. By following the path, readers are discharged of the decision making whether two modules are connected at all. They can assume that subsequent modules are related. But adaptivity and guided tour is a contradiction in terms. The "one size fits all" approach does not meet the requirements of life long learning with respect to individuality.
The solution we suggest in the project Multibook are individually generated guided tours [6]. Here, no pre-fixed sections of modules are represented to the learners. The lessons are dynamically composed according to the user profile. The information gained from the user profile is matched to the formal description of the knowledge base. For more details see [4]. The learners are able to visit the neighbor modules which are not included in their guided tour. They can get a natural language list in a natural language with the names of links outgoing from the current module. This way, a deviation of length 1 from the selected path is possible.

Exploiting the Relations. Any link between two modules represents a relation. Untyped links are not really helpful to develop an understanding of the kind of relation. Typed links are fairly widespread and various. Some systems exploit the traffic light metaphor (see for example [1], [7]).
Based on the Rhetorical Structure Theory by Mann and Thompson [3] we have developed a set of relations between modules. We call these relations rhetorical-didactic, examples are "explains" or "deepens" (for a more detailed list see [5]). They can be applied to give clues of coherence. The system adds in the presentation fixed short sentences between two modules according to the relation connecting them. An example of such a sentence is "The following will present deeper aspects." This way, we re-establish the textual clues for coherence. One rhetorical-didactic relation plays an additional role. If a module can be considered as a continuation of another, they can be connected by the relation "continues". It is not necessary that the two modules are deeply semantically related. They may be a continued example: a module being a graphic of an apple might serve as an example for fruit, another module showing a

sliced apple might illustrate the structure of a stone fruit. By connecting these modules, the system can – if appropriate – present both to the learner and constitute a thread, else missed in this surrounding.

3.2 Global Coherence

Overview over the Domain. Clues for global coherence of a linear text can often be found in the way the text is presented. Ideally, the users of an adaptive learning system should not be bothered by classifying the context, since they can assume that the information offered to them is adequate.
Normally, authors categorize their books by adding a blurb. Often here is stated the position of this book with respect to the knowledge domain. Articles or conference papers are specified with keywords.
In Multibook, the learners are supported to classify the module or set of modules to a bigger context by showing them a simplified graphical presentation of the ontology where the modules are connected to. Up to about 30 nodes which can be atomic or subsumptions of several nodes are displayed to the learner. The relations between the nodes are not well-defined semantic, but more associative ones. The user can explore this representation by expanding the subsumed nodes. With this tool, the learners can get an overview of the domain.

Table of Contents. The mightiest tool for document-immanent global coherence is a table of contents. Tables of contents offer the readers an overview of the structure of the document. Authors manifest the order and hierarchy, and this way give clues of the position of the single parts in the document. Readers are always able to locate the present piece of information in the context of the whole document.
In Multibook, the documents are composed dynamically from the modules. There is no generally valid table of contents. Therefore, also the tables of content have to be created on the fly. We utilize the underlain ontology; concepts of the ontology serve as entries for the table of content. The selection, order and hierarchy is determined by rules according to the user profile [6]. Which parts the user has already seen and where she or he is at the moment is indicated by colors. The dynamically generated table of contents has the same functionality as in linear documents. Additionally, the learners can navigate on it.

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