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Design and Development of an Authoring Tool for Pedagogical Relationship Types between Concepts

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Abstract: In this paper the design and development approach of an authoring tool for defining pedagogical relationship types is described. Pedagogical relationship types are used to define adaptation strategies which can be used by an adaptation engine to create an adaptive course based on user model information. Based on domain models consisting of concepts and relationships between concepts, pedagogical relationships can be used to connect concepts of domain models in a pedagogical meaningful way. Each type of these relationships contains adaptation code which formally specifies the meaning of relationships on a technical and a pedagogical level. To support authors in creating these relationship types a tool is being developed which easily allows the authoring process.

Keywords: adaptation strategies, concept relationship, authoring tool, adaptive engine

Introduction

After more than a decade of research activities in the field of educational adaptive systems (for example [2]) an effort in the context of the EC-funded project GRAPPLE is currently undertaken to develop a generic adaptation approach which can be used in popular Learning Management Systems (LMS) [7]. For this reason the GRAPPLE Adaptive Learning Environment (GALE) is being developed and integrated with the major LMSs (including Moodle and Sakai) using a service-oriented architecture approach. While typical LMSs often have functionalities for managing learning material and courses, they often have only little or no features for providing learning content in an adaptive way. At this point GALE comes into play, since it is designed to provide adaptation functionalities, such adaptive guidance through link generation and annotation, or adaptive page content to automatically compensate missing prerequisite knowledge.

In order to fulfil advanced adaptation tasks, GALE is equipped with a domain model and user model infrastructure. For the sake of integration these models are connected with information available in the LMS. While actual resources and general information on users are available in the LMS, the GALE manages conceptual knowledge on subject domains (domain models) and information on learning progress of users regarding domain knowledge (user models). Obviously conceptual domain knowledge and pedagogical strategies used for adaptation behaviour of GALE have to be created by a content author.

After describing related work, this paper presents the GRAPPLE approach how pedagogical strategies can be created upon conceptual knowledge using pedagogical

relationship types (also called concept relationship types (CRT)). Then the formal definition of a CRT and the implementation of the authoring tool is presented. A conclusion and an outlook on further work are given in the last section.

1. Related Work

1.1 Concept relationship types in AHA! and their use in the Graph Author tool

When the AHA! system [5] was initially designed, the actions of the user resulted in user model updates, which in turn resulted in adaptation through a set of event-condition-action rules (ECA rules) that had to be created by the author of the adaptive application (or course). This was a laborious process because it required a lot of repetitive work to author many instances of identical or very similar user model and adaptation behaviour. At the same time, it was also difficult for non-technical authors to create ECA rules in order to define the adaptation for their course material.

AHA! Version 2 (and later 3) introduced concept relationships (CRs) and concept relationship types (CRTs) [4]. A CRT represents a type of relationship between a set of generic concepts (or placeholders or variables for concepts). A CR is an actual relationship between a set of specific concepts (or real concepts from the adaptive application). This is how CRs and CRTs are defined in the AHAM reference model [6]. In AHA! a CR or CRT is limited to being a unary or binary relationship (type).

1.2 The Domain Map Editor for Defining Skills and Skill Structures

The Domain Map Editor is a tool for structuring knowledge domains and for defining curricula. It has been developed in the FP6 research project iClass (http://www.iclass.info/) in conjunction with other skill-based learning tools (for planning, competence assessment, self-evaluation, learner knowledge presentation) which make use of the structured data [1]. The base elements of these tools are the skill and the prerequisite relation between skills. Prerequisite relations between skills are the most important information used for the adaptation process. A prerequisite relation between skills expresses the psychological dependence between skills. If a person has available a specific skill, then - due to psychological reasons - this person also has available all prerequisite skills. Therefore a learner should acquire skills in a sequence which relies on the fact that for each skill all prerequisite skills should be taught before. In this way a meaningful sequence of learning objects can be created automatically. In the light of CRTs there is only one relationship type, which is the prerequisite relationship between skills. This type cannot be altered and it is not possible to add new relationship types.

1.3 My Online Teacher

My Online Teacher (MOT) (http://www.dcs.warwick.ac.uk/~acristea/mot.html) is an adaptive hypermedia authoring system for on-line adaptive course production, which can provide specifications of adaptation for various types of user-model and presentation-model related adaptations. MOT is based on the Layers of Adaptive Granularity (LAG) model [3] which has been introduced as a model for the adaptive behavior within adaptive hypermedia (AH). LAG is destined for authors of AH entering this process at the different levels of difficulty and flexibility: direct adaptation rules, adaptation language and adaptation

strategies. LAG allows modeling reusable adaptation at different levels: beginner authors can reuse entire strategies, by just reading their description. The collection of adaptation strategies is not unlike how CRTs are supposed to be stored, based on their name, their description, and their code. The other similarity is the reusability factor and their generality (can be applied for any domain models). For authors with more experience, direct programming in the adaptation language is possible, thus allowing both altering of extant strategies, as well as the creation of new ones. Again, this is similar to the CRT editing/modifying/deleting.

2. Pedagogical Relationships between Concepts

2.1 Using pedagogical relationships to define an adaptation strategy upon a domain model

The domain model (DM) defines and represents a knowledge domain. Basically, the domain model consists of a set of concepts and relations between the concepts (concept map, see Figure 1). The DM does not represent actual content resources (hyper documents or learning objects), but is rather the underlying representation of the domain to which content resources can be related. This means that the DM represents the domain on a conceptual level, and is defined completely independent from actual content resources. The DM can be created by a teacher/course author familiar with the subject domain, and is visualised in form of a subject matter graph (conceptual graph), where the nodes represent the concepts and the edges represent the relations between concepts.

Basically, three different categories of relationships (or relationship types) can be distinguished and are involved in the context of the authoring tools: hierarchical relations, semantic relations, and pedagogical relations. While hierarchical relations and semantic relations among domain concepts are dealt with in the DM, the pedagogical relations actually refer to the relationship types that are captured by the CRT. These pedagogical relationships are not used to describe the domain on a semantic level, but constitute types of relations that are used for defining adaptation rules and that are subsequently used for realising instructional strategies. By using concepts from the DM and connecting them with pedagogical relationships the Concept Adaptation Model (CAM) is created which is used by the adaptation engine for the adaptive course (see Figure 1).

Special cases are, however, semantic relations or hierarchical relations of the domain model that are used for pedagogical purposes. Such relations need to be associated a certain adaptation behaviour, which is possible also via the CRT tool. An example is, for instance, the usage of the hierarchical is-a relation between concepts to present them in breadth-first or depth-first manner, as required by the holistic and sequential learning styles, respectively.

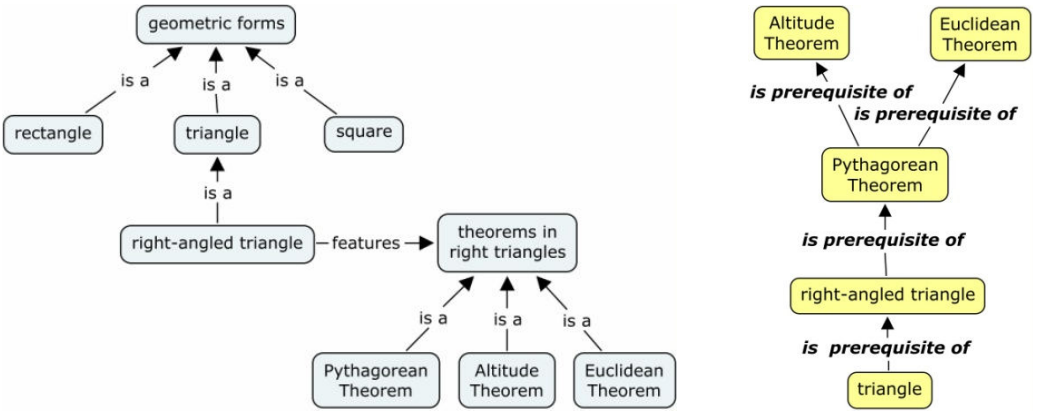

Figure 1: The graph on the left side depicts a domain model and the graph on the right side shows how concepts from the domain model are connected with the pedagogical "prerequisite" relationship type.

2.2 Concept Relationship Types

The pedagogical relationships described above are instances of concept relationship types. In contrast to the pedagogical relationships which are used between concrete concepts, the concept relationship types (CRT) are the formal specifications of pedagogical relationships. They define the structure how (and how many) concepts can be connected and most importantly they also define the meaning of a pedagogical relationship.
In order to define the meaning each CRT has to be assigned with a piece of adaptation code which can be interpreted by the adaptation engine. In this way the adaptation behaviour can be specified for each CRT which defines the behaviour of the adaptation engine. The language for this piece of code is the GRAPPLE adaptation language (GAL) which is currently developed. For example, the GAL code for prerequisite relationship type will be something like "if (user has visited concept A) then (concept B is suitable)". As seen in this example, the user model variables can be accessed using the adaptation language. Information of a user, such as visiting state of a concept or knowledge level of a concept can be used to formally define the adaptation behaviour. In this way the pedagogical meaning can be formally expressed.

3. Implementation of an Authoring Tool for Concept Relationship Types

The CRT authoring tool consists of a Web-based tool which provides the possibility to create and define CRTs and a Web Service where the created CRTs can be stored and retrieved by other tools. Authors can input the information described above in a graphical way and save them to the Web Service. For the reason of interoperability the CRT data is expressed in an XML-based format and the certain CRTs are saved as XML files on the server side into a database behind the Web Service. The graphical tool is implemented in Adobe Flex 3 technology (http://www.adobe.com/de/products/flex/) and the Web Service is realised with Apache Axis2 framework (http://ws.apache.org/axis2/).

The information needed to specify a CRT includes:

- general information of CRTs, such as name and description,
- information how an instance of a CRT should be visually represented in the CAM
- the GAL code which formally defines the adaptation behaviour
- the user variables which the GAL code is accessing
- the properties of the source and target socket which the CRT connects

- constraints, such as the information if sequences of CRT instances may form a loop (which would not make any sense for prerequisite relationships) or if concepts with specific attributes are excluded
- some technical information such as creation time or author

The most challenging part of the tool development is to provide as much as possible support to the author who wants to create and modify adaptation code. Programming adaptation code directly in GRAPPLE adaptation language excludes most content authors who do not have programming skills available from creating their own CRTs. Therefore, this authoring tool shall provide graphical techniques, which allows an inexperienced author to create new CRTs easily.

4. Conclusion and Outlook

In this paper the design and development approach of an authoring tool for pedagogical relationship types has been described. Pedagogical relationship types are used to define adaptation strategies which can be used the adaptation engine to create an adaptive course based on user model information.

Further development will focus on providing visual support for authoring the adaptation behaviour which is expressed in programming code. This should enable beginner authors to create new CRTs or to modify existing ones. Evaluation of this tool will be done in the context of the GRAPPLE project internal evaluation of the authoring tools.

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