Foreword

Automatic course generation is a very important problem with numerous practical applications in e-learning. Therefore, it has been studied since the 1980ies in the areas of intelligent tutoring, AI and education, adaptive hypermedia and Web-based educational systems. Many approaches have been proposed, but hardly any have resulted in generic and practically applied systems. There are many problems that have remained unresolved, for example:

- Extracting from experts and representing pedagogical knowledge in a form suitable to guide instructional planning
- Deciding the level of granularity and appropriate pedagogical annotation of learning materials (objects) to allow for their reuse and retrieval; ensuring interoperability with different repositories of learning objects
- Balancing the pedagogical advantages of planning entire courses versus dynamically planning only the next step to ensure close adaptation to the individual student
- Allowing different degrees of involvement of the instructor and the learner in the planning process, rather than just "take it (the plan) or leave it"
- The limitation of having to focus on presenting single concepts imposed by the separation of content planning from presentation planning
- Ensuring smooth transitions between the individual learning materials in the course.

Carsten Ullrich's work addresses all these problems and brings about a new framework for course generation combining a variety of existing approaches, technologies, and techniques. This framework has been implemented and evaluated with good results in several domains, with users from different countries and universities in the context of an EU project. His work makes several significant contributions to the state of the art in the area of course planning.

First, it defines an extensive list of teaching tasks, methods and scenarios, which is a significant contribution. This knowledge has been extracted from pedagogic experts and literature and is represented in a form that can be processed computationally. Judging from my own experience, extracting, and representing in an explicit and unambiguous form such knowledge is very difficult, which explains the lack of repositories of pedagogical expertise.

Second, it defines a pedagogical ontology of instructional objects. The ontology is simple, general, and it is on a level of granularity that makes it easy for authors to add pedagogical annotation to their learning objects. In this way learning objects can be searched and retrieved by their pedagogical function. This is an important contribution not only for course planning, but for the entire area of e-learning, since the existing standards for learning object annotations (e.g., LOM) provide limited primitives for expressing pedagogical characteristics. An ontology-mapping language is proposed, that enables linking repositories using other ontologies.

Most instructional planners that separate content from presentation planning encounter a problem – the need to focus on the presentation of a single concept at a time. This problem is solved by the use of a hierarchical network planner. From the initial goal setting – selecting a learning goal and scenario – the proposed algorithm plans simultaneously the content and its presentation according to the instructional methods and tasks that are applicable.

The selection of a planning algorithm and the definition of dynamic tasks allow for an elegant solution to the old problem of whether to plan the entire course in advance (thus achieving a general roadmap for the learner which s/he can navigate in) or to plan dynamically only one step ahead (thus taking advantage of the most recent data in the learner model and being able to adapt the course closely to the needs of the learner). The dynamic tasks allow creation of a general course map comprising pedagogically meaningful stages (tasks) and then expanding each dynamic task further, when the time of execution approaches. This also allows for a degree of involvement for the instructor or the learner in the planning process, since the instructor or learner can manually create a plan for any dynamic task, while still enjoying the support of the system in selecting the general plan, creating sub-plan suggestions, selecting relevant learning objects etc. The effect is a pedagogical "neutrality" of the generated plan, allowing for self-directed learning.

A solution is proposed for ensuring smooth transitions between the individual learning materials in the course through generation of narrative text bridges. This is a novel and very useful contribution for the area of instructional planning. While the method of text generation using templates is not novel per se, the use of this technique to create "smooth" presentations in course planning has not been proposed before.

The planner is implemented as a Web service interacting with different learning objects repositories through a mediator that maps their ontologies to the one used by the planner. In this way interoperability with different repositories of learning objects is insured. This feature distinguishes this work from many others that are usable only in the context of one given system and domain.

Finally, the evaluation of the Paigos system both with respect to the technical performance and usability in four different studies (formative and summative evaluation) is a significant contribution by itself. The LeActiveMath project has provided an excellent domain for implementing the tutor and the possibility of evaluating the prototype with components developed by researchers and with students in several different countries and institutions. The fact that Paigos was evaluated on such a large-scale speaks for its viability. Such large scale (not so much in terms of number of users, but in terms of diversity of contexts) evaluation is not typical in the areas of ITS, AI and education, adaptive hypermedia, or even e-learning, and the results (both the problems encountered and the positive results) are very interesting and instructive for anyone building a course-generation tool.

July 2008 Julita Vassileva

Preface

This book presents the topic of course generation based on hierarchical task network planning (HTN planning). This course generation framework enables the formalization and application of complex and realistic pedagogical knowledge. Compared to previous course generation, this approach generates structured courses that are adapted to a variety of different learning goals and to the learners' competencies. The volume describes basic techniques for course generation, which are used to formalize seven different types of courses (for instance, introducing the learner to previously unknown concepts and supporting the learner during rehearsal) and several elementary learning goals (e.g., selecting an appropriate example or exercise).

The course generator presented in this volume is service-oriented, thus allowing the integration of learning supporting services into the generated course in a generic and pedagogically sensible way. Furthermore, learning environments can access the functionality of the course generator using a Web service interface. Repositories are treated as services that can register at the course generator and make their content available for course generation. The registration is based on an ontology of instructional objects. Its classes allow categorizing learning objects according to their pedagogical purpose in a more precise way than existing metadata specifications; hence it can be used for intelligent pedagogical functionalities other than course generation.

Course generation based on HTN planning is implemented in Paigos and was evaluated by technical, formative and summative evaluations. The technical evaluation primarily investigated the performance of Paigos; the formative and summative evaluations targeted the users' acceptance of Paigos and of the generated courses.

Paigos was developed over a period of three years in the ActiveMath group at the German Research Center for Artificial Intelligence (DFKI GmbH), Saarbrücken, Germany within the scope of the FP7 project LeActiveMath (contract number 507826).

I would like to thank my supervisor Erica Melis for her support during my years in the ActiveMath group. Regardless of how much and what she

had to do, Erica was always available for discussion and support, and a never dwindling source of ideas and suggestions. I am also deeply indebted for her careful proofreading of this book.

I also wish to thank Jörg Siekmann for letting me become a member of his research groups. His enthusiasm for artificial intelligence inspired my research from the very beginning.

My special thanks goes to Julita Vassileva for accepting to be the second referee of my thesis and to write the foreword of this book. I hope my research does honor to her pioneering work in course generation.

My gratitude goes to Prof. Ruimin Shen, who enabled me to explore the usage of course generation in a culturally different context in his e-learning lab at Shanghai Jiao Tong University.

Research always takes place within a context. In Saarbrücken, I had the privilege of being the member of two stimulating and encouraging research groups, first the Omega group and then the ActiveMath group. A big thanks for proofreading parts of this book goes to Martin Homik, George Goguadze, Paul Libbrecht and Stefan Winterstein. A similar big thanks goes to Philip Kärger and Tianxiang Lu for implementing several of my ideas.

Large parts of this book were written during the month I was part of the Libbrecht family at "Chez Joséphine" in Saarbrücken. Merci à Paul, Corinne, Pénélope, Mercure, Eliott et Gaspard pour leurs encouragements.

Above all, I want to thank my wife Kerstin. Thank you for your support and patience. Without you, I wouldn't be standing here. Finally, I am deeply grateful to my parents whose support made my studies of computer science possible.

July 2008 Carsten Ullrich

http://www.springer.com/978-3-540-88213-8

Pedagogically Founded Courseware Generation for Web-Based Learning
An HTN-Planning-Based Approach Implemented in Paigos
Ullrich, C.
2008, XVI, 257 p., Softcover
ISBN: 978-3-540-88213-8