

Overview of Existing Adaptive Hypermedia e-Learning Systems

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Abstrakt (česky): Za posledních 15 let vzniklo relativně velké množství adaptivních hypermediálních výukových systémů a mnoho z nich přineslo velice zajímavé prvky. Bohužel některé zapadly bez větší pozornosti, protože jejich dokumentace byla obtížně dostupná. V tomto příspěvku bych proto chtěl přinést stručný přehled velké většiny systémů, které v dané době vznikly.

Klíčová slova: e-learning, adaptivní systémy, přehled

Abstrakt (English): The past 15 years have seen notable progress in the field of adaptive hypermedia e-learning systems. Many systems were created and some of them brought new, interesting, and unusual ideas. Unfortunately a few were almost forgotten since their documentation was difficult to find. This article presents an overview of almost all existing significant adaptive hypermedia systems from the mentioned period.

Klíčová slova: e-learning, adaptive systems, overview

1 Introduction

Adaptive hypermedia e-learning systems, AHES for short, are an innovative approach to a web learning experience delivery. They try to solve main shortcomings of classical hypermedia e-learning applications: “one-size-fits-all” approach and “lost-in-hyperspace” phenomena by adapting the learning content and its presentation to needs, goals, and learning styles of every individual learner.

The aim of this article is to provide a starting ground for those who would like to explore the topic more in depth. It should overview most of the systems implemented so far; 38 systems are presented in short reviews in section 2 and 33 others are listed in section 3.

2 Reviews

This section contains very short reviews of significant adaptive hypermedia e-learning systems. I have tried to briefly describe the main concept of each system or the most interesting feature it implements; however, space is limited. The list is in alphabetical order.

ACGs – Adaptive Course Generation System is a system for an adaptive course delivery designed and implemented at Faculty of Information Technology, College of Technology, Vietnam National University, Hanoi. It is a basic adaptive e-learning system offering web based courses with adaptive curriculum sequencing. **Resources:** [102].

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- AHA!** – Adaptive Hypermedia for All, sometimes translated also as The Adaptive Hypermedia Architecture, is a complete system for an adaptive course delivery. Employed adaptive techniques are: fragment hiding and link hiding. Knowledge domain is modeled using concepts and actual content is kept directly in pages. Individual pages are stored as XML files with information about concepts, html fragments and pedagogical rules (adaptation rules). AHA! is used in some universities in the Netherlands and Belgium. A few courses are freely available to the general public, including Hypermedia Structures and Systems [121]. **Resources:** [110, 111, 32, 42].
- ALE** – Adaptive Learning Environment is an environment or a toolset and framework for creating adaptive courses. It tracks students' progress through the course and annotates links using this information. Domain structure is represented using classical concept network. **Resources:** [112].
- ALEA** – Adaptive LEArning is an advanced adaptive hypermedia system designed to support the learning of programming languages using examples. It contains examples together with descriptions of their solutions and explanations of general concepts and methods used. It uses layered architecture, is compliant with AHAM, domain structure is modeled using concepts and overlay technique is used for student model. The system supports several advanced techniques of adaptive navigation and fragment based text adoption. **Resources:** [11, 9, 10, 67, 8].
- aLFanet** – Active Learning for Adaptive Internet is a larger project aiming to develop an advanced adaptive learning system. It is a larger collaboration between universities and some private companies supported by European Commission. Different modules were developed by different parties. **Resources:** [113, 115, 52, 33].
- AMBAD** is a tool that should simplify the creation and provide means for running adaptive courses on the base of information ontologies of domains. The project so far focuses mainly on defining the ontologies, resulting data structures and metadata descriptions, and mapping these to the existing standards. **Resources:** [89].
- ANATOM-TUTOR** is one of the first adaptive systems implemented and used practically. It is also one of the few adaptive hypermedia e-learning systems not implemented as a web application. As the name suggests, it was used for anatomy education (specifically for the brain). The didactic module adapts the presentation using user model (to obtain current knowledge) and a set of weighted rules and stereotypes to decide which parts of the explanation text to display. The system has three modes of operation. **Resources:** [7, 79].
- Aurelius** is an adaptive hypermedia learning system created by Anthony O'Donnell as part of his bachelor's thesis. The domain model is directly composed of nodes with document pieces; there is no separate concept network. The innovative part is an administration of a classical learning style test (based on Felder-Silverman model) once the user is registered to collect data for further content adaptation. His thesis also provides brief overview of learning style theories. **Resources:** [91].
- CUMULATE** – Centralized User Modeling Architecture for TEaching is not a complete adaptive hypermedia system, but rather a central user modeling server, enabling other systems to share information about a user. The idea is that learning systems will keep their user models on this server, thus making them accessible to other systems and enabling users to seamlessly use multiple systems as if they were one. The system tracks interaction events and specialized agents can then infer additional information from them. It is the key stone of the KnowledgeTree architecture, a concept promoting

a learning system built from smaller pieces rather than a single monolithic behemoth.
Resources: [16, 116].

DCG – the structure of a course (domain model) of this system is represented as a road-map (graph with custom properties). The curriculum planner searches for sub-graphs connecting the concepts known by the student with the goal-concept (target). It can even change the plan if the student is not able to achieve an acceptable result (knowledge value) for a given concept. In this way DCG supports rather intelligent curriculum sequencing. **Resources:** [101, 13].

ECSAIWeb – A Web-Based Authoring System to Create Adaptive Learning Systems is a web version of ECSAI, the tool for designing intelligent and adaptive tutoring systems. Forms of an adaptive presentation and adaptive navigation are supported. **Resources** [94].

ELENA is a wider e-learning project whose module personal learner assistant is uses some elements of adaptivity. **Resources:** [118, 46, 45].

ELM-PE, ELM-ART, ELM-ART II is a family of three systems. They were designed to support learners of LISP. First version ELM-PE brought adaptive examples, second version added an adaptive textbook, and third version EML-ART II came with numerous improvements of previous concepts. The result was an advanced AHES with wide palette of advanced adaptive techniques. **Resources:** [120, 105, 107, 25, 119].

ELSA (formerly known as Hezinet) is an adaptive hypermedia system used for Basque language learning. It supports adaptive learning and explanation, and provides adaptively generated tests. Its first version called Hezinet was developed as a PhD. thesis. **Resources:** [78, 6, 77].

E-LEN – A Network of e-learning centers is not a system but rather a European project and part of it is a development of design patterns for future adaptive hypermedia systems. **Resources:** [135, 103].

INSPIRE – An INtelligent System for Personalized Instruction in a Remote Environment is a relatively new system which offers adaptive link annotation, adaptive link sorting, and adaptive curriculum sequencing techniques to guide learner through a learning space using a path respecting his learning style (determined by entrance questionnaire). System supports learning goals. **Resources:** [55].

InterBook is a tool for creation and presentation of adaptive electronic textbooks. It offers adaptive link annotation and direct guidance as well as automatically generated glossaries and indexes. Domain structure is modeled using a concept network, where each concept represents an elementary part of knowledge. Each content unit (a page) can have prerequisite concepts and outcome concepts. The system monitors student's progress and keeps track of how much he knows about each concept - this is called an overlay student model. The system uses this information to recommend pages with all prerequisites known. **Resources:** [122, 18, 23, 24].

Interbook@AHA! is an integration of InterBook into AHA! system trying to take the better of both: simple content creation from RTF files and tested interface of InterBook, and better adaptation engine and student modeling from AHA!. **Resources:** [123].

ISIS-TUTOR is a rather old system; the first version appeared around 1992. It is also one of the few non-web based AHES. It uses ISIS print-formatting language to display the output. Only adaptive link annotation on the basis learned, ready to be learned and not ready to be learned is supported. It belongs to the pioneers of AHES. **Resources:** [14, 21].

Knowledge Sea I & II is not a classical AHES as a system presenting its own educational content, but a system which tries to help students with navigation to additional outside content by providing adaptively annotated links based on the topics and recommendations from other students. It integrates adaptivity and social navigation.

Resources: [124, 19, 2, 3].

LeActiveMath – Language-Enhanced, User-Adaptive, Interactive eLearning for Mathematics represents a web-based, intelligent, e-learning system for mathematics, targeted to high school and college or university level classrooms or self-study. The course is adapted according to learner’s goals, learning scenario, learner’s individual competency-level, and user preferences. The system provides both explanations, examples and exercises. **Resources:** [125, 80].

MetaLinks – A HyperBook Authoring Tool is a system for creating web based adaptive electronic text books. The system monitors a student’s path through the content and provides adaptive annotation of links telling the student if all prerequisites for given page have been met or not. **Resources:** [126, 87].

NavEx – Navigation to Examples is a system designed to provide students with an adaptive annotation of programming examples without the need for manual indexing of examples by teachers. The system monitors student’s progress with individual examples and recommends links to examples matching current study goal with all prerequisites met. NavEx does not have its own learning content; it serves as an adaptive value-added service over an existing content provided by other systems. This is possible due to CUMULATE server, which enables NavEx to use student data gathered by example presentation system. **Resources:** [127, 29, 26].

NetCoach tries to simplify the course authoring process by offering the possibility to simply insert content and define a relation between the documents (using concept network). Indexes, glossaries and data for adaptivity are generated automatically. Adaptive annotation of links and curriculum sequencing are supported.

Resources: [128, 106].

OntoEdu – Ontology-based Education Grid System for e-Learning should be composed of a set of services delivering adaptive learning content to viewers using different terminals. No special details have been published so far. **Resources:** [56].

PEBA-II is a text generation system that dynamically and adaptively generates descriptions of animals. User model contains information about animals learner knows. This information is based on user’s progress and introductory questionnaire. System generates animal descriptions based on comparisons with known animals only. System also distinguishes expert and novice users. Technical words are not included for novice users. **Resources:** [109, 114, 81, 84, 83, 85, 82, 40].

PERSO is adaptive e-learning system based on natural language processing and recognition. It uses complex techniques to understand student’s written input, and based on this input it selects the parts of the curriculum to be shown to a student. The system is based on the Latent Semantic Analysis (LSA) [54] and the Case Based Reasoning (CBR) [65]. **Resources:** [36, 35].

Problets is a system for the design and delivery of small programming examples. Each Problets generates problems adaptively, that is only for those concepts that the student has not yet mastered. The system of concepts is used to describe the programming language domain and monitor which parts the student knows on the basis of his performance and answers. They support a step by step animated explanation.

Resources: [129, 50, 72, 74, 49, 41, 66, 70, 71, 73].

QuizGuide helps students to select the most relevant examples by providing adaptive annotation to links to problems. Links are annotated on the basis of known prerequisites using students' knowledge and previous performance and relevance of the topic to current lectures. QuizGuide does not provide the content, problems are presented by QuizPack, and student model is shared through CUMULATE server.

Resources: [130, 26, 28, 27].

QuizVIBE – Accessing Educational Objects with Adaptive Relevance-Based Visualization provides an adaptive visual annotation to quiz links to help students choose an example appropriate to their level of knowledge and points of interest. Links are displayed in 2 dimensional space together with names of relevant concepts. The position of each link is determined by its relevance to a given concept, the closer the more relevant. Additional mark describes difficulty, if it was already solved, and importance to current study goal and student's knowledge. The system does not provide the content, quizzes are presented by QuizPack, and student model is shared through CUMULATE server. **Resources:** [1].

RATH – Relational Adaptive Tutoring Hypertext is an adaptive teaching system based on a prerequisite/outcome concept network domain model structure and overlay student model. The structure of domain and student model is very precisely described by mathematical terms. **Resources:** [131, 134, 59, 58, 5, 4, 60].

SIETTE is a web-based adaptive assessment system where tests can be tailored to student's performance. Various question types are supported, and additional types can be implemented through custom applets. The main idea of adaptivity is to choose questions of proper difficulty. Difficult items are not presented to the subject if the easier ones are not answered correctly. **Resources:** [132, 38].

SKILL – A Scalable Internet-Based Teaching and Learning System uses a classical concept network to model the domain, but only knows the prerequisite relationship. Adaptivity is restricted to showing which pages are advisable to visit (prerequisites met) and which are not. On the other hand it has a unique on-line annotation tool to support collaborative work. **Resources:** [90].

SQL-Tutor is an e-learning system for SQL language. It is built on a Constraint-Based Modeling. The approach concentrates on the violations of the basic principles in the domain of instruction. The system has recognizes several problems and knows their ideal solutions, and uses this to diagnose student's answers. The system provides feedback: correct/incorrect, clause with an error, general description of the error. A student model contains session history in terms of solved problems, and a model student's knowledge in the terms of constraints. **Resources:** [133, 86].

TANGOW – Task-based Adaptive Learner Guidance on the Web is an adaptive hypermedia e-learning system which supports basic adaptivity features. It tracks a student's progress through the course and enables links to other pages as the student learns the previous concepts. It can also adapt the content of the page based on the student's profile. **Resources:** [34].

VARScope is a specific tool which guides students in learning the variable scope concept in C programming language. It suggests best examples to try, visualizes the progress on the topic and offers pre-authored examples with visualization. It is a small system containing only few examples. **Resources:** [68].

WADEIn, cWADEIn, jWADEIn, and WADEIn II is family of systems for adap-

tive visualization and explanation of expression evaluation. It was designed to show students the process step-by-step with helpful visual aids and explanations. The goal is to improve the understanding of the order of execution and semantics. It can work in two modes: exploration (descriptive, teaching) and knowledge evaluation (testing).

Resources: [117, 20, 17, 30].

3 Other Adaptive Systems for e-Learning

This list contains other adaptive hypermedia e-learning systems I found. They are not reviewed either because too little information was published about them or because their functionality or concepts closely resemble already described systems. The ordering is alphabetical.

ACE: [96], ADI: [95], AHM: [39], ART-Web: [104], AST: [97], Cameleon: [76], CHEOPS: [88], CLIBBON: [37], C-book: [63], Epiaim: [44], Hezinet: please look under the key ELSA in the section 2, HYNECOS: [100], Hypadapter: [61], HyperCASE: mentioned in [61], Hyperflex: [62], HyperTutor: [77], Hy-SOM (sometimes called also HysM): [64], I-Help: [31], INTERSIM: [92], ITEM/IP: [15], ITEM/PG: [22], KBS-Hyperbook: [57], Land Use Tutor: [75], Lisp-Critic: [51], MANUEL EXCEL: [43], Medtech: [48], MetaDoc: [12], Multibook: [98], PAKMAS: [99], Shiva: [108], SYPROS: [53], TAILOR: [93], WEST-KBNS: [47].

4 Conclusion

The landscape of adaptive hypermedia e-learning systems is rather rich in ideas and interesting solutions. I was surprised myself when reading about self diagnosing adaptive examples in ELM-ART II or SQL-Tutor, natural language response recognition and evaluation in PERSO, wide testing abilities of the SIETTE, the complex possibilities of AHA! 3.0, the ease of authoring of InterBook, natural language generation of PEBA-II, outstanding results in terms of student activity improvement for NavEx, QuizGuide, and QuizVIBE. Those who would like to know more can find extended version of this article with much longer reviews in my diploma thesis [69].

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