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# E-Learning Systems

Intelligent Techniques for Personalization



Springer

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# Foreword

In past decade a lot of efforts have been put into development of e-learning: many systems and repositories of learning objects have been developed, a notion of learning object has been introduced and spread, learning object metadata standards have been released, interoperability of e-learning system components have been discussed. Thousands of papers, thesis and various research works on e-learning are published every day. It seems that a new journal on e-learning opens every week. Universities already embrace the power of e-learning to deliver content to students all over the world, even for free.

E-learning, as an important segment of educational environments, represents a unique opportunity to learn independently, regardless of time and place, to acquire knowledge without interruption and based on the principles of traditional education. E-learning offers a number of advantages for people and companies looking to develop a new content programme or curricula. That is, whether your trainees are all together in a classroom or scattered all over the country in different time zones, they can still tap into the same course materials, and at a time that's convenient to them.

One of the most important segments in today's development and use of the e-learning system is the personalization of content and building of user profiles based on the learning behaviour of each individual user. The personalization options increase efficiency of e-learning, thus gaining much acceptance as it allows the learners to set their own goals, learn at their own pace, and even decide on their method of learning thus leading to better learning results. In order to personalize the learning process and adapt content to each learner, e-learning systems can use different strategies that have the ability to meet the needs of learners.

This monograph provides a comprehensive research review of intelligent techniques based on the modern perspective of research and innovation for personalization of e-learning systems. Personalized learning approach promotes a tailored support system, helping learner to learn. In order to personalize learning, one needs to personalize learning objects and their modules and courses, learning activities and learning environments.

Special emphasis is given to intelligent tutoring systems as a particular class of e-learning systems, which support and improve the learning and teaching of domain-specific knowledge. Each of the subsequent chapters of this monograph reveals leading-edge research and innovative solution that employ personalization techniques with an application perspective.

It is obvious that different learners have different preferences, needs and approaches to learning. Psychologists distinguish these differences as individual learning styles. Learning styles can be defined as unique manners in which learners begin to concentrate on, process, absorb and retain new and difficult information. Therefore, it is very important to accommodate for the different styles of learners through learning environments that they prefer and find more efficient. Furthermore, in modern Web-based learning environments, the authors avoid creation of static learning material that is presented to the learner in a linear way, due to the large amount of interdependences and conditional links between the various pages. Often, authors create multiple versions of learning resources so the system can propose to the learner the appropriate one. This leads to the learning concept known as content adaptation.

An important part of the personalization possibilities is certainly the prospect of using the recommender system. Recommender system can be defined as a platform for providing recommendations to users based on a specific type of information filtering technique that attempt to recommend information items (movies, music, books, news, Web pages, learning objects and so on). Recommender systems strongly depend on the context or domain they operate in, and it is often not possible to take a recommendation strategy from one context and transfer it to another context or domain. Personalized recommendation can help learners to overcome the information overload problem, by recommending learning resources according to learners' habits and level of knowledge. The first challenge for designing a recommender component for e-learning systems is to define the learners and the purpose of the specific context or domain in a proper way.

To improve recommendation quality, metadata such as content information of items has typically been used as additional knowledge. With the increasing popularity of the collaborative tagging systems, tags could be interesting and useful information to enhance algorithms for recommender systems. Collaborative tagging systems have grown in popularity over the Web in the last years based on their simplicity to categorize and retrieve content using open-ended tags.

A recent trend in the field of e-learning and tutoring systems is to utilize agent technology, develop and use different kinds of agents with various degrees of intelligence, capable of exhibiting both reactive and pro-active behaviour in order to satisfy their design goals in virtual learning environments. The monograph presents a possible trend in use of intelligent agents for personalized learning within tutoring system.

The validity of viewing e-learning initiatives' development from an information systems' perspective is supported by recognizing that both of these efforts are fuelled by a common goal to harness new technologies to better meet the needs of their users.

I believe that the chapters presented in the monograph update on the modern perspective of the education environments and personalization techniques per research and innovation, and are beneficial for designing better e-learning systems. I have recognized the significance of the monograph for researcher, practitioners and students interested in the personalized e-learning technology. I expect it will motivate and encourage new issues and challenges for the future scientific research in this field.

This book is fascinated read for students of all levels and teachers, also for those curious to learn about the e-learning in a systematic way.



Prof. Valentina Dagienė  
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# Preface

The rapid development of the contemporary new Web technologies and methods made online education increasingly accessible, open and adaptable; allowed new techniques, approaches and models to emerge and reasoned the revolution in the digital knowledge age that enabled greater and faster human (social) communication and collaboration and led to fundamentally new forms of economic activity that produced the knowledge economy and required changes in education. The increasing need for quality education requires expertise which is continually being developed. The integration of e-learning (short form of Electronic Learning) into the education system is viewed as one way to meet this growing need for high-quality education.

This monograph brings a result of our attempts to represent the most important aspects of current theory and practice in emergent e-learning approaches, systems and environments. As a specific case study we will present in details Web-based tutoring system we have been developing for last several years. This system incorporates a lot of contemporary techniques and methods from e-learning and technology-enhanced learning areas.

The material covered in the monograph is addressed to students, teachers, researchers and practitioners in the areas of e-learning, recommender systems (RS), semantic Web and machine learning.

This monograph is organized into five major parts. Part I: *Preliminaries*, which includes Chap. 1 of the monograph—*Introduction*, introduces the motivation and objectives studied in the subsequently presented research, and presents major standards and specifications in e-learning.

Part II: *E-learning Systems Personalization*, which consists of Chaps. 2–7, provides an overview of personalization techniques in e-learning systems. Chapter 2—*Personalisation and Adaptation in E-Learning Systems* shows the most popular adaptation forms of educational materials to learners. Chapter 3—*Personalisation Based on Learning Styles* presents the bases of electronic learning techniques for personalization of learning process based on individual learning styles and the possibilities of their integration into e-learning systems. The most popular

adaptation techniques used in e-learning environments are presented in Chap. 4. Following chapter—*Agents in E-Learning Environments*—presents current trends in use of intelligent agents for personalization. Chapter 6—*Recommender Systems in E-Learning Environments*—provides an overview of techniques for recommender systems, folksonomy and tag-based recommender systems to assist the reader in understanding the material which follows. The overview, presented in Chap. 7 includes descriptions of content-based recommender systems, collaborative filtering systems, hybrid approach, memory-based and model-based algorithms, features of collaborative tagging that are generally attributed to their success and popularity, as well as a model for tagging activities and tag-based recommender systems.

Part III: *Semantic Web Technologies in E-Learning* contains a review of the basic elements of semantic Web, as well as the possibilities of applying semantic Web technologies in e-learning. Chapter 9—*Design and Implementation of General Tutoring System Model*—displays the details of a general tutoring system model, supported with semantic Web technologies as well as the principles of creating courses in different domains supported by this model.

Part IV: *Case Study: Design and Implementation of Tutoring System*, which consists of Chaps. 10 and 11, presents the most important requests for implementation of personalization options in e-learning environments, as well as design, architecture and interface of Protus 2.1 system. Chapter 10 presents the details about previous versions of the system, defined user requirements for the new version of the system, architecture details, as well as general principles for application of defined general tutoring model for implementation of programming courses in Protus 2.1. Chapter 11 presents Protus 2.1 functionalities as well as personalization options from the end-user perspective.

Part V: *Evaluation and Discussion*, which contains Chaps. 12 and 13, highlights the results of the evaluation and discussion of analysis of the results regarding the validity of the system. Finally, Chap. 13 concludes this monograph, summarizing the main contributions and discussing the possibilities for future work.

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Involving around 5,000 researchers drawn from universities and companies worldwide, KES facilitates international cooperation and generate synergy in teaching and research. KES regularly provides networking opportunities for professional community through one of the largest conferences of its kind in the area of KES. His interests focus on the artificial intelligence paradigms and their applications in complex systems, security, e-education, e-healthcare, unmanned air vehicles and intelligent agents.

# Abbreviations

|        |                                           |
|--------|-------------------------------------------|
| ABSS   | Agent-Based Search System                 |
| CBR    | Case-Based Reasoning                      |
| CF     | Collaborative Filtering                   |
| CSA    | Cognitive Styles Analysis                 |
| CSL    | Cognitive Styles of Learning              |
| EM     | Expectation–Maximization                  |
| FSLSM  | Felder–Silverman Learning Style Model     |
| GEFT   | Group Embedded Figures Test               |
| HBDI   | Herrmann Brain’s Dominance Instrument     |
| HOSVD  | Higher Order Singular Value Decomposition |
| ICT    | Information and Communication Technology  |
| IDE    | Integrated Development Environment        |
| IF     | Information Filtering                     |
| ILS    | Index of Learning Styles                  |
| IMS CP | IMS Content Packaging                     |
| IMS SS | IMS Simple Sequencing Specification       |
| JDBC   | Java DataBase Connectivity                |
| JECA   | Java Error Correction Algorithm           |
| LA     | Learning Activities                       |
| LAO    | Learning Application Objects              |
| LCMS   | Learning Content Management Systems       |
| LMS    | Learning Management Systems               |
| LO     | Learning Objects                          |
| LOM    | Learning Object Metadata                  |
| LOs    | Learning Objects                          |
| LSA    | Latent Semantic Analysis                  |
| LSI    | Learning Style Inventory                  |
| LSP    | Learning Styles Profiler                  |
| LSQ    | Learning Style Questionnaire              |
| MSD    | Gregorc Mind Styles Delineator            |

|        |                                         |
|--------|-----------------------------------------|
| MSP    | Motivational Style Profile              |
| OWL    | Web Ontology Language                   |
| PLE    | Personal Learning Environment           |
| PLSA   | Probabilistic Latent Semantic Analysis  |
| QTI    | Question & Test Interoperability        |
| RACOFI | Rule-Appling Collaborative Filtering    |
| RDF    | Resource Description Framework          |
| RS     | Recommender Systems                     |
| RTF    | Ranking with Tensor Factorization       |
| SCORM  | Sharable Content Object Reference Model |
| SPARQL | Simple Protocol and RDF Query Language  |
| SVD    | Singular Value Decomposition            |
| SWRL   | Semantic Web Rule Language              |
| W3C    | World Wide Web Consortium               |
| WCR    | Web Content Resources                   |
| XML    | Extensible Markup Language              |

# Abstract

Semantic Web is a next generation of Web that is trying to present information in such a way that they can be used by computers, for display, automation, integration and reuse among different applications. The aim of the monograph is to present the design, implementation and real-life evaluation of a tutoring system for maintenance of courses from various domains using semantic Web technologies. This process includes the creation of the fundamental building blocks of ontologies and rules for carrying out the actions for adaptation of teaching materials and learning processes

The subject of the monograph includes the implementation of a conceptual model of tutoring system for e-learning in different domains using semantic Web technologies and implementation of a prototype system that is applied in designing a personalized tutoring system for learning the Java programming language basics.