Personalized Adaptation of Learning Environments

Valentin Filatov
Artificial Intelligence Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
e-mail: valentin.filatov@nure.ua

Oleh Zolotukhin
Artificial Intelligence Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
oleg.zolotukhin@nure.ua

Andriy Yerokhin
Software Engineering Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
e-mail: andriy.yerokhin@nure.ua

Maryna Kudryavtseva
Information Control System Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
maryna.kudryavtseva@nure.ua

Abstract. **This work is devoted to the development of personalized training systems. A major problem in learning environmens is applying the same approach to all students: teaching materials, time for their mastering, and a training program that is designed in the same way for everyone. Although, each student is individual has his own skills, ability to assimilate the material, his preferences and other. Recently, recommendation systems, of which the system of personalized learning is a part, have become widespread in the learning environment. On the one hand, this shift is due to mathematical approaches, such as machine learning and data mining, that are used in such systems while, on the other hand, the requirements of technological standards "validated" by the World Wide Web Consortium (W3C). According to this symbiosis of mathematical methods and advanced technologies, it is possible to implement a system that has several advantages: identifying current skill levels, building individual learning trajectories, tracking progress, and recommending relevant learning material. The conducted research demonstrates how to make learning environment more adaptive to the users according to their knowledge base, behavior, preferences, and abilities. In this research, a model of a learning ecosystem based on the knowledge and skills annotations is presented. This model is a general model of the all life learning. Second, this thesis focuses on the creation of tools for personalized assessment, recommendation, and advising.**

Keywords: personalized learning, adaptive learning, learning environment, Semantic Web, recommendation system, academic advising

I. Introduction

It is well known that use of the web-based technology is spreading throughout the world. Web-based learning systems have received increasing attention in recent years. The main advantage of these systems is the ability to learn anytime and anywhere.

The integration of technology in education not only be a new, flexible delivery medium, but also needs to enhance the teaching and learning process by integrating additivity and personalization.

This goal has driven the development of learning environment with individualized learning mechanisms became very popular research topic as well as a body of research. Recent advances in technology have contributed to the use of e-learning in education and made personalization possible.

In such learning environment, it would be an advantage to monitor the learner's knowledge level and automatically adjust the content for each learner to improve the learning process and make it individual for each user or group of users. Since the Web offers a vast amount of information, it would be also reasonable to help the teacher in the creation of materials most suitable for education and also help in finding the most relevant content and converting it to comprehensive information.

It is also necessary to help students with selecting courses and study programs based on their objectives, which will be beneficial in their further career development.

The objective of this research is to study the challenges of the learning environment due to increasing technological progress.

From the point of view of a reasonable user with limited time resources, the time spent learning from a personal device must be as effective as possible.

In general, efficiency in training systems is understood as the minimum time spent on training: i.e., there must be ways of maximally successful assimilation of information. Every learner is individual, and has their own learning speed, knowledge background, and preferences. However, learning systems use average learning program determined to be most suitable for everyone in a specific grade.

The development and use of learning environment with individualized learning mechanisms could assist in online learning and adaptively provide most appropriate learning path for each individual.

Another advantage would be the ability to monitor the learner's knowledge level and automatically adjust the content for each learner to improve the education process and individualize learning individual for each user or group of users.

II. Matherial and Methods

Nowadays exist many types of educational systems: traditional classroom, elearning, learning management systems, adaptive hypermedia education system, educational game environments, virtual environments, ubiquitous computing environment, etc.

Integration of information and communication technology into learning environments has made important contributions for learning process. In existing works [1, 2] authors developed semantic portal as a tool for structural reform of the Ukrainian Educational System. The solution is an ontology-driven portal which is a digital ecosystem for national quality assurance.

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Today exists two educational systems, Learning Management Systems (LMS) and Learning Games (LG). They are a good examples of learning with information technology adoption.

LMS is a server software that provides a set of interfaces to a database that includes user information, courses, and content. These systems allow educational institutions to manage a huge number of online or mixed courses with commonly used interfaces and resource sets. Offline courses that use LMS as obligatory or advanced tool are often expanded online courses [3].

The main advantage of using LMS in the learning process is that is can store an enormous amount of media for information dissemination, communication, and knowledge testing which gathered within a single platform that is publicly available through the Web.

In addition, the use of LMS simplifies the process of accessing information for students' courses, and password-based authentication makes it less likely to worry about course material protection.

The LMS system also has some disadvantages. There are a large number of systems aimed primarily at administrative needs, not students' needs. Often the interface implemented by LMS is extremely difficult, and courses represent repositories of different materials that do not meet the learning objectives.

LG are software that trains and educates a person in the game mode, and can be used for both training and entertainment. The category of the training game includes genres such as quest, arcade, 3D-shooter, simulator, and an interactive course on any subject. The program divides the teaching material into parts, and regulates the sequence of its study. The assimilation of the material is checked by the test offered at the end of each stage of the training [4]. There are two allocated components: teaching and playing.

The training allows to solve educational and training tasks aimed at the assimilation of certain program material and rules that should be followed by the players.

Proposed in this work personalized systems present a specific type of general adaptation systems.

There are two types of adaptation for personalization in learning systems: when the system allows the user to change certain system parameters and personalize its behavior (person-driven personalized system), and when the system adapts to the users automatically according to the users' needs and actions (system-driven personalization).

The main tasks of adaptive systems are as follows:

– Allowing organization of content in various ways, offering learners different contexts and perspectives.

– Identifying the way a learner prefers to learn by organizing assessment of the learning preference.

– Using assessment results to provide intelligent feedback that motivates and helps in maximizing learning performance.

Adaptive learning systems have a range of features and functions:

1. Pre-test: The system assesses the current knowledge and skills of the learner. These assessments gather information about individual learner characteristics, including prior knowledge.

2. Pacing and control: The ability of the learner to control the speed of learning at which the content is delivered and also to choice within the system.

3. Feedback and assessment: system continuously assesses learner's progress, provides feedback about learner's work: feedback can include information about whether the answer was correct or not, also suggest information on resources for opportunities for additional practice.

4. Progress tracking and reports: The system tracks individual progress and allows learners to return to the point where they left off, breaking the work into multiple sessions. The system creates periodic reports for instructors for future guidance of learners based on their performance.

5. Motivation and reward: Adding gamification to the system in a way of rewarding learners with points or badges.

Core elements of the adaptive system:

1. A content model that refers to the way of structuring the topics or content domains with detailed learning outcomes and a defined tasks that must be learned. The sequence of content could be changed according of the learner's performance.

2. A learner model, which refers to estimation of learner's ability level on different topics, tracking their performance and tracking existing knowledge base about mastered topics.

3. An instructional model, which determines how a system selects specific content for a specific student at a specific time. In other words, it puts together the information from the learner model and content model to generate the learning feedback or activity that will be most likely to advance the student's learning.

Technologies used in adaptive learning systems include the following: Semantic Web and rule-based reasoning, Bayesian networks, adaptive hypermedia, service-oriented architecture, agent-based systems, machine learning and data mining, user and group modeling, empirical modeling, context modeling and prediction, quality of service management, and decision support.

In this work, we used mostly Semantic Web Technologies and Data Mining techniques, which are useful in knowledge presentation and knowledge extraction (creation) as well as in the analysis of learners' behavior and in decision support.

Semantic Web technologies aim at adding semantic information to Web contents for creation an environment where software agents can communicate with each other and do tasks more productive.

Semantic Web is a group of technologies and methods that allow machines to understand the meaning of information on the Web and integration of information in an intelligent way [5].

Semantic Web provides environments where software agents can navigate through Web.

These technologies includes Resource Description Framework (RDF), Resource Description Framework Schema (RDFS), Web Ontology Language (OWL), Uniform Resource Identifier (URI), Extensible Markup Language (XML).

Semantic Web allows using more automated functions on the Web such as reasoning, autonomous agents, information and service discovery.

A Recourse Description Framework is an abstract model. According to this model, knowledge is represented by a triplet in the form of a relationship: subject – predicate – object.

Thus, in the RDF model, the nodes of the graph are subjects and objects. The edge always has a direction to the object. A predicate is also often called a property. Each object and subject can be specified both as a Uniform Resource Identifier (URI) and as a symbol and, for some tasks, could be empty.

The predicate must have a unique URI (URL). It has its own description, identified by the URI for a clear understanding. The subject, predicate and object are the names, which could be global, referring to the same entity in all RDF documents where it is used, or local, where the entity referred to by this name cannot be referenced directly from outside the RDF document.

Areas of use:

1. Combining data from various sources without resorting to the creation of specialized programs.

2. Need to give access to your data for others.

3. Need to decentralize data so that they are not "owned" by anyone alone.

4. Need to do something special with large amounts of data, such as to enter, retrieve, view, analyze, or perform a search, etc.

Using an RDF model, it is possible to get:

1. Logical conclusion of new facts.

2. Ensuring Semantic Search.

3. Flexibility of the data model.

4. Extreme ease of data exchange between systems.

The RDF model provides formal descriptions, which means that the search agent can search for the facts and knowledge. In other words, RDF is a universal way of decomposing any knowledge into small pieces.

It sets certain rules regarding semantics, i.e. sense of these pieces. The idea is that, in one simple way, any fact in this structured form could be processed by computer programs. Using RDF it is possible to describe documents, individual fragments of knowledge within a document, or objects in the real world, such as a specific living person.

Ontology is the core element of semantic web. Ontology defines relations between terms. The main uses of ontologies are to enhance the accuracy of searches and reuse of knowledge representation.

By using ontologies, it is possible to enhance the semantic representation of knowledge for association formal descriptions of learning objects, to make reasoning, and to search relevant learning materials, compose new learning path from existing resources.

The benefits of using ontologies are in their re-usability and sharability. Also, ontologies allow access to preferred content. The main advantages of ontologies are a better understanding of information in the document, capturing the contextual relationship among various components within the document, categorization, and contextual search. These options improve the quality of the output in many ways.

Ontological presentation of the learners, courses and specializations are used in personalized learning.

III. RESULT

According to [6] the scheme of automoted process of academic advision is represented in Figure 1.

The given proposition allows manual control of the continuous advising activity for every learner individually, or the more automated process where the role of the advisers is shifted to the higher level of abstraction.

According to [7] the scheme of architecture of smart educational process is represented in Figure 2.

It shows main blocks of the smart educational process. Our approach follows very much the style that in the background section was labelled as “test by loop”.

Periodic testing is the only certain way to ensure that no large knowledge gaps emerge. Relying on just analysis or giving the users only feedback is not enough. We’ve built on the existing models slightly on how wrong answers affect the process. The user is not locked inside a small loop that concentrates on the topic at hand, rather the system will start pinpointing where the knowledge gap is. Thus the system also, in a manner, does a minor scale retention test for the user.

The system has two main databases: learner profile database and curriculum database. Learner profile database stores learner’s data about studies, assessment results, timetables of completed studies, etc.

Curriculum database stores information about compulsory courses, other courses, timetables, etc. The academic advising system’s part consists of several blocks like linking individual students to their peers with similar study path profile together with the recommendation block and planning block. Based on the system architecture, the details of system’s main functionality read as follows:

1. Collection of learner’s personal information.

2. Collection of information about the courses and completed studies.

3. Creation of study progress profiles along the lines of Section3.

4. Linking the individual student to student peers with similar study profile in the institutional environment.

5. Student’s progress check. If student is linked to a profile requiring intrusive advising, inform the adviser and the student by providing the interpreted study profile to support the communication and problem solving.

6. Modification of the study plan on recommended courses and their timetables by taking into account the evidence related to the identified study profile.

Recently, large amounts of data that cannot be processed by databases alone has become common. This type of dataset is processed by data mining; in the educational field, Educational Data Mining (EDM) and the related field learning analytics are significantly involved. These are very fast growing technologies and they are making a big research interest.

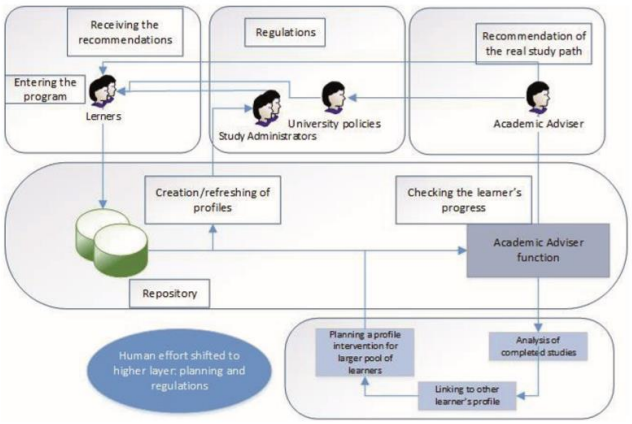

Fig.1. Automoted process of academic advision

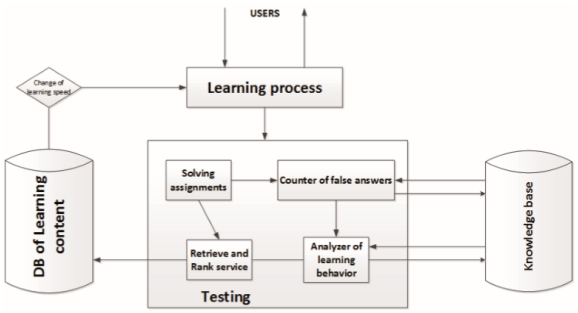

Fig 2. Architecture of smart educational process

Usually, they use machine learning algorithms, data-mining algorithm, statistics and also semantic technologies. These algorithms help solve educational questions, provide tools and technologies, and develop platforms for better learning processes and experiences as well as preparing learners for success and helping teachers during the teaching process. A lifelong learning ecosystem has been proposed that will take into account the knowledge and skills of learners so that a person can be in demand on the labor market, and also to fill their knowledge gaps. This model is based on semantic annotation. This ecosystem could be used for the creation of a lifelong learning process with future career development.

IV. Discussion

This work presents research in the field of personalized and adaptive learning, utilizing technologies of intellectual data analysis.

Research in the field of personalized learning is in great request because of the growing demand for this technology. Adaptive learning is an approach that takes into account the individual abilities and needs of the learner. With the active development of information technologies, learning environment are finding increasing application in the field of education, which allow implementing the ideas of adaptive learning in practice.

The use of adaptive technologies presupposes the integration of information and pedagogical technologies that provide interactivity between the subjects of education and the productivity of the student's learning activity with the use of new information technologies that provide adaptability in the educational process. The studied material is provided to the student at some point in time, taking into account his or her accumulated knowledge, academic performance, and experience. The adaptation process is realized in learning, while an adaptive presentation of course materials takes place.

Conclusion

The studies carried out within the framework of this work have certain limitations. This appears to be due to the fact that the ontological approach of knowledge base creation is not used in many subject areas. For example, the ontology has a description of the students, disciplines and specializations, but specializations are described only by sets of disciplines (courses), and not by a set of competences (knowledge and skills) that student should possess after successfully completing of the program. It should be noted that the ontology have limitations in the subject area. This clearly imposes certain limitations on the use of this knowledge base in the learning process, because it describes only one subject area.

In the future, an extension of subject areas descriptions with an ontological approach is expected, which will greatly expand the possibilities for teaching children. As an example, the knowledge base will contain not only the description of animals, but also other subject areas necessary for enriching the vocabulary of children.

Accordingly, the use of a multidisciplinary ontology will broaden the competencies. Also, the question of keeping ontologies as recent one should be studied properly, so the knowledge which ontologies present will be up to date.

References

[1] Özyurt, Ö., Özyurt, H. *Learning style based individualized adaptive elearning environments:* Computers in Human Behavior 52, 349–358, 2015.

[2] Terziyan,V., Golovianko,M., Shevchenko,O. *Semantic portal as a tool for structural reform of the ukrainian educational system*. InformationTechnology for Development 21 (3), 381–402, 2015.

[3] Kats, Y. *Learning Management System Technologies and Software Solutions forOnline Teaching: Tools and Applications:* Tools and Applications. IGI Global, 2010.

[4] Ghazal, S. , Singh, S. *Game-based language learning: Activities for esl classes with limited access to technology.* ELT Voices- International Journal for Teachers of English 6, 1–8, 2016.

[5] Castellanos-Nieves,D., Fernández-Breis,J.T.,Valencia-García,R., Martínez-Béjar, R.&Iniesta-Moreno,M. *Semantic web technologies for supporting learning assessment.* Information Sciences 181 (9), 1517–1537, 2011.

[6] Zolotukhin, O., Kudryavtseva, M. *Authentication Method in Contactless Payment Systems. International Scientific and Practical Conference «Problems of Infocommunications. Science and Technology»,* 9–12 October, 2018, Kharkiv, Ukraine, pp. 397-400

[7] Yerokhin, A., Zolotukhin, O. *Fuzzy Probabilistic Neural Network in Document Classification Tasks.* Information Extraction and Processing 46 (122), 68–71, 2018.