Trends of the Usage of Adaptive Learning in Intelligent Tutoring Systems

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Abstract. In this paper general tendencies of adaptive learning are described, which are becoming more and more common in the time when IT technologies and use of internet as well as development of web systems is live topic in researches about technology enchanted learning with the aid of intellectual learning systems. Adaptive learning analysis, intellectual tutoring system description and general ITS structure and general development principles are described based on the bibliography. ITS modules, ITS collaboration with learner, necessity of feedback and existing adaptive learning methods have been described.

Keywords. Intelligent tutoring systems, interactive learning environments, adaptive learning, agent

Introduction

Computer usage in learning is connected with IT development in general; it began at the end of 1950's when machines, which are considered primitive nowadays, were constructed for programmed training. Currently such technologies are used very widely, for example, e-format information literature, virtual training systems and environments, self-appraisal tests, technology enchanted learning as well as animated tutorials.
Improvement of IT technologies, expansion of internet and popularization of web technologies have enabled technology enhanced learning introduction in adoption of general matters and acquaintance of specialized problems. Thus researches on adoption of learning contents into e-environment have become more necessary as a result of such development [21, 9, 1]. Besides technology enhanced learning lets one to pick the place and time where and when to study, which is great advantage compared to traditional full-time education [16].

Identical educational tools and learning methods may not be effective or is less effective for all students. It is possible to make the learning materials more flexible, modify educational approach according to competence and temper of the student and learning tasks, using Intelligent Tutoring Systems (ITS). It is possible to achieve better learning results when fitted educational aids are used for individual needs of every student [13]. Solutions are hunted in diversiform approaches, where ITS already takes important place, as to a certain extent provides flexibility, adaptation, etc. Flexible approach in learning is achieved by usage of several learning strategies, which are

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implemented according to student's progress in learning of the material. Such flexible learning system for industrial purposes has already been described in 1998 [4], where adaptive learning system is described with several learning strategies from several agents.

Further researches [21, 13, 1] are focused on development of adaptive learning system [11]. General adaptive learning tendencies are analysed in this paper and insight onto further researches are given.

1. Analysis of Adaptive Learning

As volume of learning materials is great in e-environment, it is hard for consumers and information seekers choose the right materials, thus it would be necessary to create adaptive learning systems. Adaptive learning may be defined as ''the process of generating a unique learning experience for each learner based on the learner's personality, interests and performance in order to achieve goals such as learner academic improvement, learner satisfaction, effective learning process and so forth" [21].

Learning, methods and student's reaction to learning is not easily definable and describable. Learning methods and successful learning results may not be defined as particular thing, order of matters, sequence of events and thus guarantee successful outcome (student is trained and knows everything that he/she needs). That is the reason why adjustment of learning content to the student's competence is considered to be an open system problem, where adaptation capacity of the student, collaboration with learning environment as well as preferable result of system action plays great importance (it is even hard to define the necessary outcomes, as it is not possible fully evaluate persons' gained knowledge and its system) [19]. In the same way it is hard to define where system's effect on person comes to an end.

When analysing person's behaviour changes as a result of experience, comparing student's behaviour in time period 1 to behaviour in time period 2 (Figure 1) – if behaviour is different in the same circumstances, we may consider that learning has taken place. Such analysis of behaviour would give information on necessity of further training for integrated learning agent.

In the development of learning systems it is necessary to take into account both persons' needs and requirements, as well as resources of information technologies. It is also necessary to evaluate the use of didactic materials – cover learning theory matters, develop training content plan, training methods and organizational forms, all these operations would be arranged and subordinated according to their possible

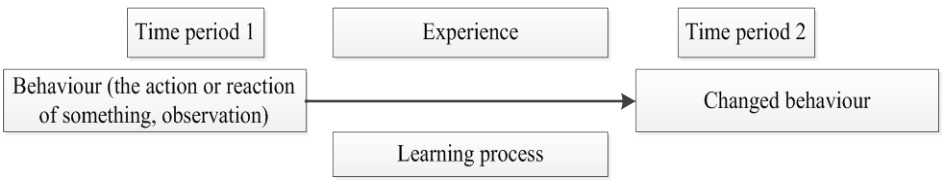

Figure 1. Reproduction of learning [5]

formalization forms for depicting and use in ITS. It is required to include student's reaction to the learning material and analyse the chances of learning outcome stimulation.

In natural environment teacher may pick up each student's individual abilities, character, reaction to learnable material and depending on these parameters, form more or less individualized task set for each individual. It is necessary to integrate analyse mechanisms and reactions to imitate or overcome natural environment achievements. On the other hand if the teacher is located in front of large student group, he/she is not able to catch each student's abilities and necessities, thus e-learning advantage is silhouetted in this case. In e-learning system it is easier to analyse each individual needs [1]. When adjusting training to individual needs, following aspects should be included: individual intellectual abilities, perceptive type, preliminary knowledge, desire for learning, motivation for achievements, self-suggestion [1]. Currently researches are based on development of adaptive systems according to two approaches: 1. adaptivity – system structures didactic material combination according to knowledge about the student; 2. adaptability – system adjusts learning content responding to change in student's knowledge during the use of system [21]. Studies are carried out on development of adaptive learning materials, based on these two approaches.

2. Intelligent Tutoring Systems

Technology enchanted learning is learning where self-motivation, communication, efficiency and technologies are used [16]. ITS is system and technologies where adaptive learning technologies are used, which help individualize and personalize learning process according to individual character and needs [8], analyse knowledge of the theme, student's mood and emotions (human decisions are based not only on analysis of various possibilities and resulting signs, but also on emotions) [18, 2], as well as learning style, typically ITS is constructed as multi-agent systems [3].

There are three main approaches on ITS development [13]:

1. The sequence of curriculum is made so that the student may easily adapt himself/herself, besides material is demonstrated to the student just when he/she needs it.
2. ITS gives detailed feedback to the learner on the imperfect or false solution, helping to learn from ones mistakes.
3. Problem solving methods - little help is provided to the learner, so the right solution is achieved.

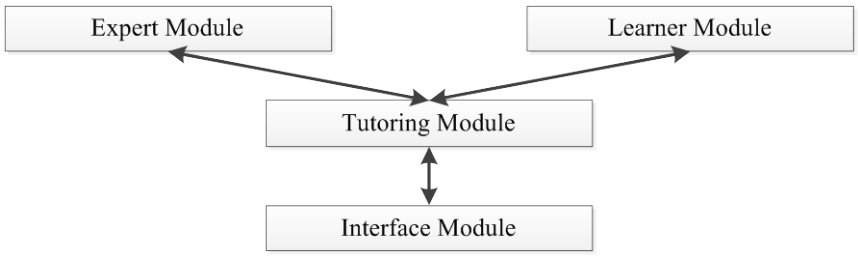

Figure 2. General ITS structure

General ITS structure is given in Figure 2. It is possible to create constructive multi-agent system for adaptive learning, when describing and formalizing information on person's knowledge accumulation and interpretation types. ITS includes both student/learner module and expert module, both of those mutually interacts with tutoring module, which is available for users in user interface. Operation of agents and adaptation to learner takes place in learning/tutoring module, where system receives information about user's activities, acquired knowledge and skills [18, 16, 14].

The necessary information for this system may be supplemented in the expert module, but the information about student is stored in the learner module. Both of these modules interactively serve as information storage for agents, thus operation of modules is defined as follows:

- Learner module is accumulative type – it stores information about student's actions, progress and test results.
- Expert module contains information about learning content. It may be supplemented and in collaboration with student module perform changes in order to bring together learning module action with solving of students' problems in possibly short period of time.
- Tutoring module cooperates with both previous mentioned modules for gaining the material as well as determines the accuracy of student's solutions, based on information contained in the expert module. Module contains algorithms as well, which performs help function for student during learning process.
- Operation in e-learning system is done in the user interface.

Agents integrated in ITS should be able to express attention, adapt themselves to abilities, learning speed, needs and necessities of the leaner [12]. These qualities are attained by integration of fuzzy logic elements into the agent, using their response in planning and expression of emotions in reaction to user's activities.

To achieve high efficiency ITS collaboration with student, it is necessary to integrate natural language processing (NLP) techniques, as a result agents integrated in the system may analyse student's answers qualitatively [15]. If feedback between ITS and learner is provided, better training results are achieved [10, 3, 17], if ITS instantly corrects the mistakes made by learner or shows the right way how to avoid the mistake, knowledge of the student becomes deeper and wider [20, 9]. The knowledge assessment agent using the comparison algorithm based on graph patterns compares a teacher's and a learner's concept maps and assigns score for submitted solution [7]. IKAS (Intelligent Knowledge Assessment System – developed at the Department of Systems Theory and Design of Riga Technical University) basic concept is exercises for knowledge assessment, where natural language processing is not necessary for computerized assessment, as well as teaching staff involvement in evaluation process of competence. Idea map exercises are different and thus are adjustable to different knowledge assessment needs (more simple and complicated exercises). Besides variety of exercises founded in idea maps and arranging possibility after level of difficulty, allows to adjust them to adaptive knowledge assessment [3]. But the system COMPASS (COncept MaP ASSessment and learning environment) is a discipline-independent concept mapping learning environment, developed at the Educational & Language Technology Laboratory of the Department of Informatics & Telecommunications at the University of Athens. The analysis of the map is based on

the assessment of the propositions according to specific criteria, such as completeness, accuracy, superfluity, missing out and non-recognisability, results into the identification of specific error categories (e. g. incomplete relationship, incorrect concept, superfluous relationship, missing proposition), and is discriminated in the qualitative and quantitative analysis. The qualitative analysis is based on the qualitative characterization of the errors and aims to contribute to the qualitative diagnosis of student's knowledge; that is student's incomplete understanding/ beliefs and false beliefs. The quantitative analysis aims to evaluate student's knowledge level and is based on the weights assigned to each error category as well as to each concept and proposition that appear on expert map, reflecting their degree of importance. Pre-defined weights for error categories are supported; the teacher has the possibility to personalize the assessment process and configure the weights [6].

3. Conclusions

In former studies e-learning systems mostly have been formed as systems for information supply, where lectures or distance learning materials are available in e-format. Popularity of internet and web technologies have made e-learning development possible, though available operating systems still are "teacher's" systems where only little attention is paid to learner's needs and abilities [13]. In the latest researches target has been set to individualized e-learning system, directed to the student. Technology enhanced learning have adaptation gaps, where one of the solutions is ITS – where realization of adaptation is made, so that ITS is brought nearer to the person's ability to learn. Currently feedback role is developed the most in ITS, IKAS and COMPASS.

When analysing existing ITS we may conclude that their development is progressing, but still it is not at the level where ITS fully realizes adaptive training – technologies which let course to comply with students' knowledge level and preferences automatically. Adjustment of learning content and didactic materials to student's needs is object of many researches, but trends differs – several researches tries to develop standardized learning content, which could be modified according to progress of the student, others in their turn are directed to personalization of learning content, adaptation directly to student's goals and achievable results. All of these approaches have their drawbacks – first, most of the results and elaboration of these researches are not compatible with existing learning standards, second – ITS that adjusts to the interests of learner may omit important parts of the learning content. Irrespective ITS drawbacks, elaborating and research is very current topic because of e-learning privileges, thereby we may consider development in the direction of ITS to overcome their imperfections and drawing nearer to real setting learning or even gaining advantage over these.

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