Intelligent Computer Teacher in E-Learning Systems

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Abstract:

Intelligent computer teacher and appropriate simulated learning environment were elaborated ensuring high quality individualization of learning process. Individualization of learning process is realized in two ways. Learners can use node points structure for selection of their own learning path ensuring individualization of learning process. Intelligent computer teacher (by the use of artificial intelligence means) can adapt to learners knowledge and abilities ensuring also individualization of learning process. Many experiments concerning investigation and optimization of intelligent computer teacher performance were carried out in simulated learning environment . Such simulated environment ensures possibility of trials repetition from the beginning (impossible in real environment).

1 Introduction

Rich artificial intelligence methods and tools give large possibilities for creation of teaching systems with intelligence. Use of rich artificial intelligence means by intelligent computer teacher (intelligent teaching system) enables individualization of learning process (adaptation, in continuous manner, to learners knowledge and their abilities ensuring optimum learning process for each learner). It is possible by integration of teaching process (teaching actions) and evaluation of learner knowledge (testing actions). Intelligence of such intelligent teaching system is contained in its pedagogical decisions (how and what to teach) and information about learners.

Intelligent computer teacher (ensuring individualization of e-learning process) and appropriate simulated learning environment (comprising different learner models generated randomly that form population of models similar to population of real learners) were elaborated. Such simulated environment, very useful for optimization of learning process, ensures possibility of trials repetition from the beginning (impossible in real environment) and examination of system performance for different models populations (big variety of models enables high quality individualization of learning process). The environment was described in my paper [5] "Simulated Environment for Optimization of E-Learning Process" presented at ICL 2006, Villach, Austria last year.

Different types of e-learning systems according to teachers roles, individualization of learning process from pedagogical point of view, structure of intelligent teaching system,

investigations (carried out in simulated environment) concerning intelligent computer teacher performance and optimization and their results are presented in the paper.

2 Learning Process

2.1 Pedagogical theories

E-learning systems for high quality e-learning process should be designed and built considering pedagogical theories of learning (ensuring good understanding of learning process). Now it is possible to distinguish the following pedagogical theories concerning learning process:

behaviourism - defining learning as a result of reaction for stimuli;

information processing model - according to cognitive psychology a learner processes information similarly to a computer;

constructivism - defining learning as building of knowledge being a result of interpretations assigned to learner experiences.

Learning process.(according to pedagogical theories) does not change, only tools that support such process change. Information and Communication Technologies, being used in education, are new tools added to existing tools, that facilitate learning process. These tools should be used as a set of creative and cognitive tools, not only tools for gathering, storage and transfer of information, ensuring high quality and effective learning. Very quick development of Information and Communication Technologies has enabled the birth of e-learning systems that should ensure creative and cognitive e-learning process for support of intellectual processes in human brain facilitating knowledge creation.

2.2 Individualization of Learning Process

Individualization of learning process (according to pedagogical theories) means use of individual learner features and increase of his individual possibilities for achievement of better learning results.

In accordance with pedagogical analysis and appropriate investigations it is possible to distinguish the following manners of learning process individualization:

- individualized time assignment - learner should receive enough time for learning didactical material according to his abilities, learning styles and other features;
- knowledge completion – use of repetitions and leveling lessons;
- changes of learning content scope and structure – learning content should be interesting and appropriate for learner characteristics;
- individual goals – learner should be informed about their individual learning goals;
- selection of appropriate learning method – frequency of repetitions, way of feedback, individualized control of knowledge, scope of didactic material and learning goals should be consider;
- learner groups – learners are grouped according to their abilities, goals, interests, performed roles;

- use of learning means – learners receive individual didactical packets containing didactical materials in accordance with learner characteristics together with individualized learning program.

3 Types of e-learning systems according to teachers roles

Modern e-learning systems change the role of a teacher from a person who gives lectures in a didactical form (traditional teacher) to the tutor who supports learners in their learning process (asynchronous and synchronous interactions between a tutor and learners). It is possible to distinguish two kinds of a teacher in e-learning systems: human teacher and computer teacher. I have made a classification of e-learning systems, in accordance with new teachers roles, presented below (p.3.1-p.3.5).

Creation of an appropriate e-learning system that supports learners should consider pedagogical theories concerning learning process, creative and cognitive features of a computer (as an extension of a human brain), learners needs and their characteristics.

3.1 Stanford system

Learning process is transparent for a lecturer. Lectures transmitted by television were recorded on video cassettes, digitalized and accessible by the use of Internet (video on demand). Students were allowed to take the lectures asynchronously. Their homeworks and exams were synchronized with those for students on-campus or by broadcast television. To the lecturer, there was no difference between an Internet student and the traditional and television student. Degrees received in an on-line mode are of the same value as degrees received in an on-campus mode.

3.2 E-learning system with human tutor

Human tutor (new profession) supports learners in the learning process by interaction in synchronous and asynchronous modes. Domain knowledge (to learn), learning technology knowledge and knowledge how to use computer and communications tools are indispensable for human tutor to facilitate learning process. Human tutor uses asynchronous and synchronous tools for communication with learners. Synchronous tools are very good for brainstorming and starting of new activities. They enable immediate feedback. Asynchronous tools are very good for self-paced learning, collaboration between learners from different time zones. They enable reflected feedback. In the case of synchronous communication tutors more easily keep the thread of a discussion on track than in the case of asynchronous communication. In the case of asynchronous discussion tutors can answer only once to all (instead of giving answer to each learner) learners and can moderate discussion without the pressure of time (not immediately).

3.3 System using knowbots

Repetitive tasks of human facilitators can be automated by the use of intelligent agents techniques. Knowbots (Knowledge Robots) are intelligent software agents used in online courses that simulate a human relationship, by doing something that another person could otherwise do. Knowbots use intelligent agents techniques. Learners appreciate immediate feedback and the ability to get help rapidly. They want effective immediate feedback (human or machine). Feedback can be provided by intelligent agents in an on demand mode.

Knowbots can perform the duties of online facilitator (tutor) for routine tasks. They are placed between the learner and the teacher/facilitator, enabling the interaction.

3.4 Hybrid system

They are combination of E-learning system with human tutor and System using knowbots. They use knowbots (see p. 3.3) for automation of repetitive tasks, performed by human facilitators, by the use of intelligent agents techniques. Human tutor can communicate with learners by the use of asynchronous and synchronous communication tools (see p. 3.2).

3.5 Intelligent teaching system

An intelligent teaching system (computer teacher), using artificial intelligence means, facilitates the learning process by continuous adaptation to individual learner needs and learner characteristics during learning process. Intelligence of such system is contained in its pedagogical decisions (how and what to teach) and information about learners. Figure 1 shows the concept of such system in accordance with IEEE LTSC standards.

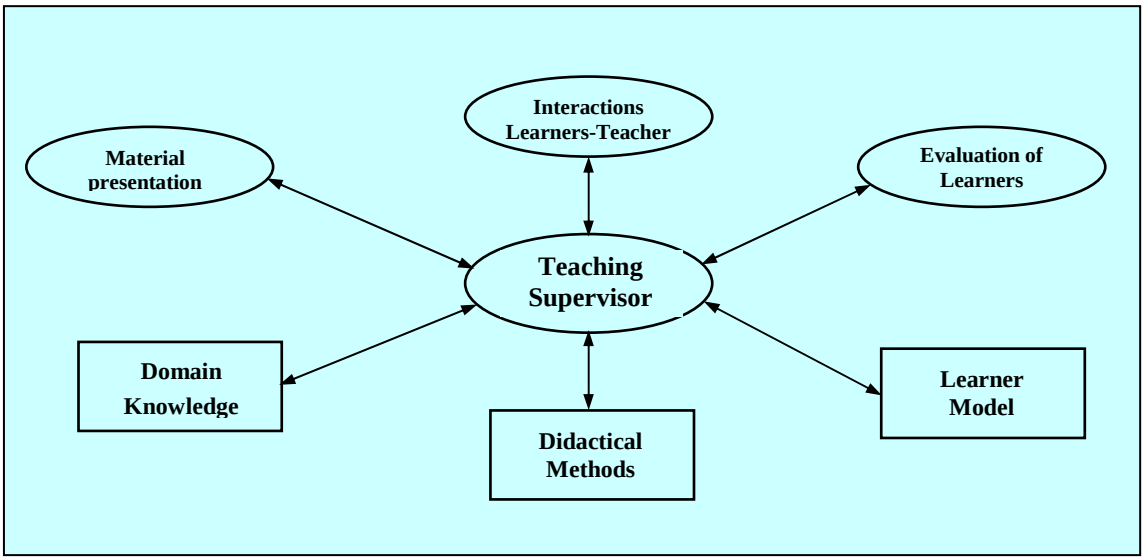

Figure 1. Intelligent Teaching System

The Teaching Supervisor is used for control and co-ordination of other components. The base of Didactical Methods contains different didactical methods supporting course authors and educators. The Learner Model stores information concerning individual learner (especially learner current knowledge state). Learner Model is a set of parameters containing the information about learner's personality, experience, education. It is important for each system adaptive to a user. Domain Knowledge contains learning contents. The Material presentation component enables presentation of learning contents in different ways according to learner characteristic (on the bases of currently updated learner model). The Evaluation of Learners component determines the performance of the learners using tests. The Interactions Learners-Teacher component determines the level of interactivity of a learning environment.

The intelligent teaching system uses information from a learner model in order to determine pedagogical decisions for each learner (especially to control learner's progress and to adapt

the course presentation to individual learner). Teacher strategies comprise didactical methods and the way of material presentation. In practice a teacher uses more than one teaching method during teaching a subject according to the type of domain knowledge. Teachers also switch from one method to another method for the same material according to student different styles. An effective intelligent teaching system must be able to provide multiple teaching method.

4 Intelligent Computer Teacher (ICT)

4.1 Learning individualization

Elaborated Intelligent Teaching System enables individualization of learning process in two ways.

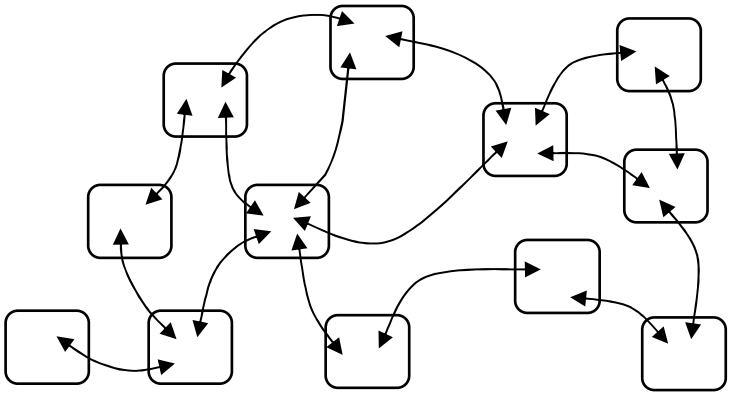

Figure 2. Exemplary node points structure

In first way individualization of learning process is done by learner using node points structure (figure 2). Didactical program (enabling own learning path) is based on the structure of node points. Each node point can contain associated units (parts of didactical material) in different formats. Central link, beginning and start do not occur in the node point structure. It gives possibilities for interdisciplinary knowledge presentation. It also gives possibilities for education in the area of creative thinking. Learner can begin to learn from any node point. Structure of node points enables learners to make decisions during learning process. Such structure enables learners selection of learning path ensuring individualization of learning process.

In second way individualization of learning process is done by an intelligent computer teacher that adapts, in continuous manner, to learners knowledge and abilities ensuring optimum learning process for each learner.

4.2 Structure and performance of Intelligent Computer Teacher

Intelligent Computer Teacher is realized by a computer program ensuring high quality individualization of learning process. It works in accordance with algorithm of optimum teaching. It uses two kinds of pedagogical actions: teaching actions and testing actions. Teaching actions enable realization of teaching process. Testing actions enable evaluation of learner knowledge. Integration of teaching process (teaching actions) with evaluation of

learner knowledge (testing actions) ensures optimization of Intelligent Computer Teacher performance (high level degree of teaching process individualization ensuring learning in optimum selected mode for each learner).

Examination and optimization of Intelligent Computer Teacher performance required creation of an appropriate simulated environment that comprises population of various learner models (big variety of models enables high quality individualization of learning process) generated randomly ensuring population of models with ability distribution similar to typical ability distribution of real learners group. Such simulated environment enables to perform many trials that are difficult or impossible to realize in real environment. It also ensures possibility of trials repetition from the beginning (impossible in real environment). Optimization of Intelligent Computer Teacher performance ensures optimization of E-Learning Process.

Intelligent Computer Teacher (figure 3) consists of two main components: features extractor and neural network. Features extractor is created as a rule system. It stores in its own memory information concerning whole didactical process (pedagogical actions performed by computer teacher and their results). It uses information from learner model in order to control learner's progress and to adapt to individual learner. Information concerning pedagogical actions performed by computer teacher and test results concerning learners knowledge are Input to Features extractor. Features extractor module analyses information stored in its memory and extracts some features that are the output from extractor and simultaneously input to neural network. They are used by neural network to select and perform appropriate pedagogical action for individual learner.

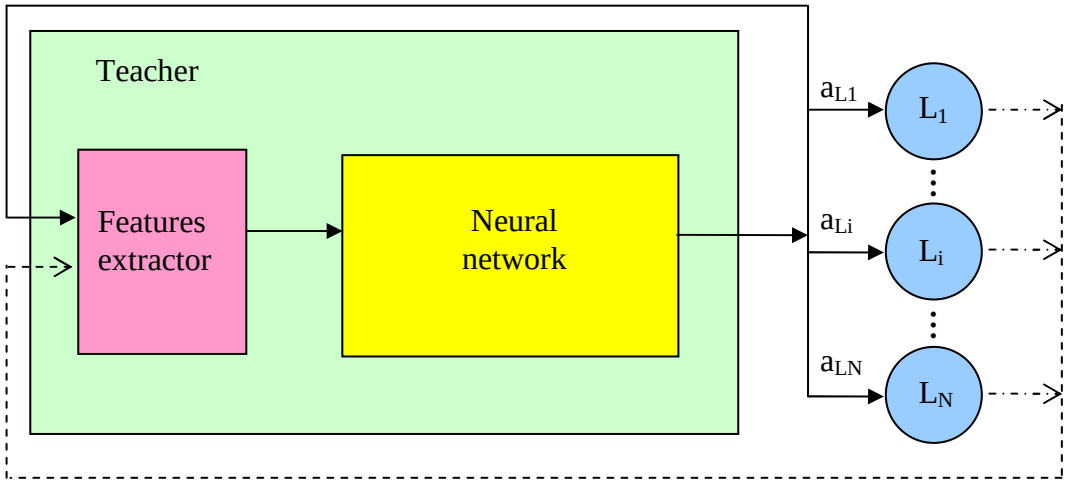

Figure 3. Intelligent Computer Teacher

Some optimization criteria of ICT performance were formulated for examination of ICT performance:

- achievement of maximum possible level of knowledge by representative group of various learners in the scope of didactical material (course containing didactical units) being taught. ICT performance is evaluated by the results achieved by learners population during teaching process;
- achievement of maximum possible level of knowledge by best learner in the representative group of various learners in the scope of didactical material (course containing

didactical units) being taught. ICT performance is evaluated by the results achieved by learners population during teaching process;

– achievement of maximum possible level of knowledge by weak learners in the representative group of various learners in the scope of didactical material (course containing didactical units) being taught. ICT performance is evaluated by the results achieved by learners population during teaching process.

Many experiments concerning ICT performance (according to these criteria) have been made in the simulated environment. Appropriate structure of neural network, as a component of computer teacher, is designed. Training of neural network (according to optimization criterion) is required for better work of Intelligent Computer Teacher. After many trials neural network (component of ICT) acts better. After training neural network selects and performs an appropriate optimum pedagogical action for each learner model (optimization of ICT performance). ITC can also work without individualization but then the results achieved by learners are worse.

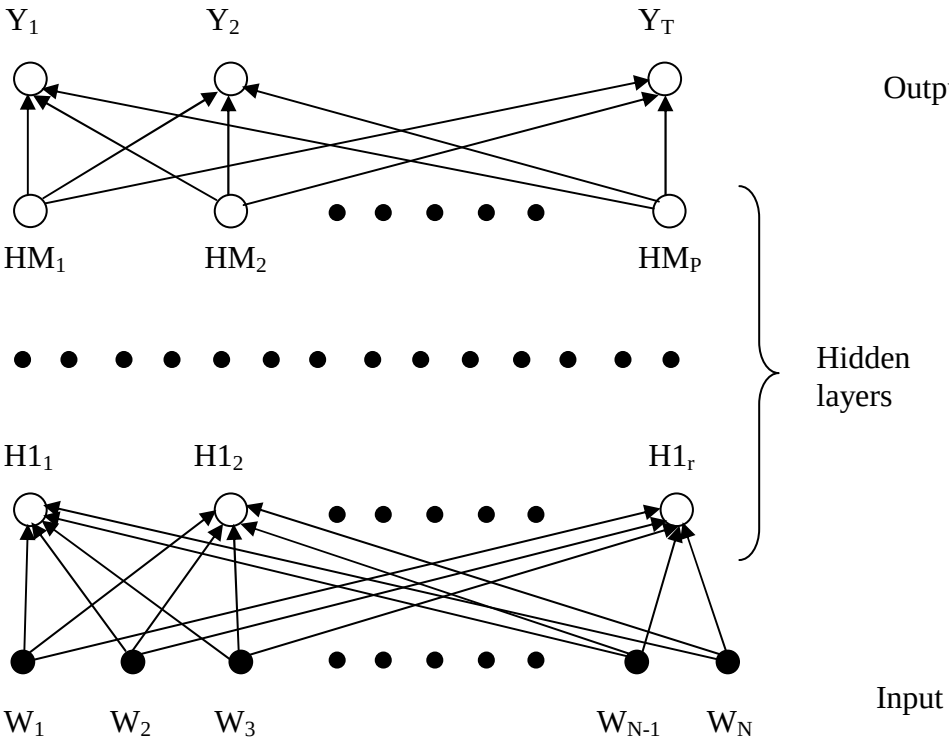

Figure 4. Exemplary neural network

Below is consider neural network after training by the use of first optimization criterion. After training neural network selects and performs an appropriate optimum pedagogical action for each learner model L_i. ITS, by the use of settled number of pedagogical actions (selected by neural network according to algorithm of optimum teaching) enables the achievement of highest level knowledge within the course by representative group of different learners. First time ITS (especially neural network) delivers the same teaching sequence to all learners models. Next pedagogical sequences delivered to learners models (different for particular learners models) depend on previous sequences and their results (test results) ensuring individualization of learning process for each learner model. The following comparison has been made: ITS using the same pedagogical sequences for each learner model from generated models population (ITS teaching without individualization) and ITS using different

pedagogical sequences for each learner model from the same as previous population of generated models (ITS teaching with individualization). The results achieved by models population being taught with individualization were much better than the results achieved by the same models population being taught without individualization.

4.3 Simulated Environment

Simulated learning environment is elaborated enabling investigation and optimization of Intelligent Computer Teacher. More detailed description of such environment is in my paper [5] “Simulated Environment for Optimization of E-Learning Process” presented at ICL 2006, Villach, Austria last year.