Adaptive Model for Agent-Based Intelligent Tutoring Systems

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Abstract—**The purpose of this article is to build a model of interaction between the learner and the teacher, where the teacher performs the role of an Intelligent Tutoring System (ITS). If a teacher in the learning process is replaced with a computer system, it should be equipped with a system to adapt to the learner's cognitive state. We studied factors that influence the learner's perception of the information in the learning process. We considered a dialogue model in the process of learning. We used the concept of intelligent agents for modeling and implementing the learner's cognitive state and the tutor's adaptation to the learner for effective learning.**

Keywords-Intelligent Tutoring Systems; Adaptive; Agent; Dialogue Behavior;

I. INTRODUCTION

One of the most prospective and advanced directions in the field of designing of computer-based tutoring is the development and design of Intelligent Tutoring Systems (ITS).

Researchers in the field of ITS usually consider its architecture to consist of a domain model, a student model, a tutor model, and an interface [1-8]. The domain model refers to the topic or curriculum being taught. The student model refers to the student or the user of the ITS. The tutor model refers to the methods of instruction and how the material shall be presented. The interface allows communication between the student and the other models of the ITS.

As one of the participants in the educational process is a human, the system of education must necessarily take into account his or her cognitive characteristics. They are expressed in behavior related to the cause of learning and human capabilities in the process of perception.

The mechanisms of perception, as well as other functions of intelligence, are not fully known, and researchers continue to propose different models [9]. Bruner [10] believes that the process of perception is a process of categorization, in which the body carries out the logical conclusion.

II. COGNITIVE STATE

The basis of learning is the ability of intelligent system to perceive information. Several conditions affect the efficiency of the perception of the learner's knowledge. Key among them:

- The Motivation to learn (m);
- The general level of cognitive abilities (a);
- Uncertainty in the knowledge system of the learner (u);
- The current level of knowledge in a given domain (k);
- Learner fatigue and other physiological factors (f).

Let us consider in more detail each of the listed conditions.

A. Motivation

Motivation is determined by the values and needs of a learner. Apparently, the motivation to learn is based on the general knowledge of an individual's needs. The need for information relates to main or most importantly information, and initiates an individual to reduce the uncertainty of his or her own information state [11].

B. Cognitive abilities

Cognitive abilities determine the cognitive style and affect individual knowledge strategy of the learner (carrying the intelligence). According to [12], intelligence can differ as psychometric, biologic, and social. Psychometric intelligence can be measured using a test system. Its level depends on the cultural influences, family upbringing, educational and social-economic status, but it is largely determined by genetic. Psychometric intelligence relates with Intelligence Quotient (IQ). Until now it was not possible to identify the "common learning" as an ability, similar to general intelligence, while thousands of studies have been conducted on this problem. Therefore, intelligence is considered as the ability, laying the fundamentals of learning, but not the only factor for successful learning.

C. Uncertainty

The target to resolve uncertainty is considered to be a fundamental characteristic of the overall biological function of learners and their intelligence [13]. We propose to extend this property not only to the learner, but also to on the artificial intelligence system, which is the ITS. This is justified as the ITS is required to provide an interface and a general learning model. In the intelligent systems, there is always a motivation, due to the need to reduce the uncertainty of knowledge.

D. Current level of knowledge

The current level of knowledge affects the ability of perception, because the perception process is built on the learner's hypothesis. The larger the knowledge base for the hypothesis, the more efficient the hypothesis will be and the learner will have more knowledge in the domain, and more ability to perceive and learn. The Current level of knowledge of the learner is a generalized term, which implies a knowledge level that should be evaluated before the start of learning, and at any point in time at the process of learning. In education, there are two types of learning tests: short-term and long-term [14]. Short-term tests used before and after the learning session and long-term tests conducted for knowledge assimilation and follow-up testing.

E. Fatigue

It is believed that fatigue (tiredness) is a decrease of efficiency in the perception of the learner's knowledge. The impact of fatigue on the learning process results in increasing the duration of information storage in sensory memory, violating the operations in the primary memory and semantic relationships in the secondary memory [15].

III. The problem of measuring the cognitive state.

Control learning (including the adaptation of ITS) requires the assessment of the state of the learner, his current capacity to learn, and state of knowledge. Such estimates can be obtained as a result of the measurement values, expressed by (1), defining the cognitive style of the learner:

$$C = f(m,a,u,k,f) \quad (1)$$

where C - the integrated assessment of the level of cognitive abilities.

For the measurement of abilities to perceive, psychological-pedagogical methods are applied. The results of these measurements are represented in different scales, which often contain an explicit list of grades. Consider as an example the measurement of the level of motivation.

In the test, "Motivation to Success" [16], the results were generated using the scale: low, average, moderately high level, and very high level of motivation.

Similar methods are used to measure other psycho-physiological parameters of the learner.

The ITS supports the students model in order to assess the students' level of knowledge in a given domain. The implementation of this model is the results of the student test or exam. The ITS builds an integrated assessment of knowledge difference which are the domain and the current knowledge state of the learner. If we assume that the system of knowledge representation is a frame, then the ITS tracks the number of filled slots. Each slot assigns a level of certainty (from 0 to 1) to assess the degree of absorption of each element of knowledge. The ITS monitors students' knowledge system, assesses the uncertainty in his or her knowledge and adjusts the learning process, aiming to eliminate this uncertainty.

IV. Interface model

The communication is the primary means of transferring knowledge from the teacher to the learner. In the case of educational activities with the use of intelligent tutor it provides these types of behavior:

- Define the cognitive abilities of the learner;
- Determine the learner's current level of knowledge;
- Transfer to learner the learning sequences.

The main form of interface at searching and absorbing of new information is the question-answering dialogue. The results obtained in the framework of the logic of question and answer (or question-answering logic) [17], allow us to apply as a means of the interface between intelligent partners of machine dialogue for the modeling and implementation of dialogue behavior in the learning process.

The machine dialogue includes Dialogue Knowledge Base (DiKB) with a full description of partners' stimuli and responses [18]. The behavior of partners simulates group of intelligent agents. Both, agents and DiKB are components of machine dialogue. We understand agent by means proposed in [19], the structure of which is modeled by the simple elements of intelligence functions. The architecture of intelligent agents in ITS consists of the following agents: P-agent implements the functions of measuring the psychological state of the learner, B-agent measures the constant (basic) psychological properties, and C-agent performs the task of measuring the learner's current level of knowledge.

V. Tutor model

The main task of the ITS is to teach the learner. The adaptation of the ITS to the learner can be considered as a feedback control system. We relate the function of receiving the feedback signal and the generation of corrective actions with the function of learning process adaption. These functions are assigned to the P-agent, B-agent, and C-agent.

In this paper we consider the communication behavior of the ITS and the learner as an implementation of the scenarios contained in DiKB machine dialogue. These scripts can be composed by a human–specialist in the domain or can be automatically generated.

The following is the behavior of one of the agents to assess the cognitive state of the learner, including its actions in terms of ITS adaptation.

VI. AGENTS' BEHAVIOR.

The environment of P-agent and B-agent is the psychological scope of the individual learner. The agent is provided with the knowledge (for example, production rules), including when to perform an assessment of the learners' psychological state. The agent counts the time and operates according to the following program:

1. At a certain point in time the P-agent requires the machine dialogue to interrupt the teaching sequence, selects from the scenario control of DiKB another psychological parameters and implements it through a communication channel. This scenario includes a psychometric test sequence.
2. On the basis of obtained perceptions (verbal learner answers and other reactions) and his or her knowledge (including learner knowledge model), the agent takes a decision on continuation or completion of psychometrics.
3. If the measurements are completed, P-agent generates an estimate of the psychological state of the learner which affects the learning.
4. Using its knowledge about the adaptation of the learning process, the agent determines which scenario (of contained DiKB) should be activated for the correction of the psychological state of the learner in order to improve his or her ability to perceive the educational material.
5. In this step the P-agent sends to the machine dialogue the scenario identifier for correction learner status. Then the system returns to machine dialogue.
6. The P-agent puts the data of psychometrics, required for subsequent measurements, in the "psychological" model of the learner.
7. The activities of P-agent are terminated.

B-agent acts similarly, but with the difference that the ITS uses it once before the learning to measure the general (basic) learning abilities.

The main components of adaptive ITS are shown in figure 1. As can be seen, the tutor model allocated between learner model and DiKB. For effective learning, the tutor control program provides psychological comfort brainwork learner and has an impact on the full discovery of his or her intellectual capacities. The ITS provides learner with freedom to choose a line of behavior in the learning process, allows to feel successful learning, thereby creating an atmosphere are mutually supporting communication. Intercept initiative in the process communication is provided by the machine dialogue.

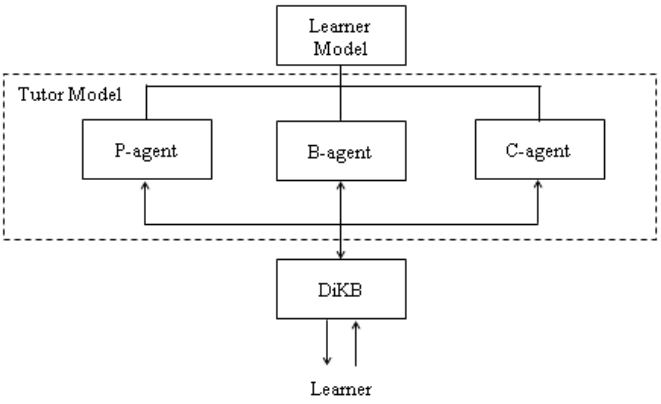

Figure 1. The architecture of adaptive ITS

VII. LEARNER MODEL.

The learner model is an important part of ITS. Generally, this model includes two main components:

The model of knowledge representation, designed to transfer from the knowledge of the ITS to the knowledge of the learner.

The model of behavior, which depends on the ITS and the reactions (including answers) of the learner.

The ITS considers the knowledge base of students' model before start learning as an empty. The filling process begins in the initial measurement of students' knowledge in a given domain. The psychological part of the model reflects the learner's current and constantly inherent characteristics that affect learning. The ITS measures this state through the integration of such indicators, as the general intellectual level, fatigue, motivation, and the start and the current level of knowledge.

VIII. CONCLUSION

In this paper we have presented an adaptive model of interaction between the learner and the teacher, where the teacher performs the role of an ITS, which can adapt to the learner cognitive state. A formal method of dialogue behavior, transformed into a relevant system of interacting agents, allows synthesizing a relatively simple architecture for the implementation of the adaptive learning.

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