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On Agent-Based Intelligent Touring System Model Construction

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ABSTRACT: With rapid development of information technology, advantages of web-based education like low cost, varied forms, wide popularity and flexibility are showing up. Being able to realize teaching methods which are hard to be realized in traditional means of teaching, web-based education is an ideal means of education in terms of distance education and school teaching. However, it also has such problems as incapability in teaching students according to their aptitude, low level of intelligence, unsatisfactory functions of test and evaluation, lack of effective guidance, lack of advance idea in system design. Application of Agent-based Intelligent Touring System (ITS) in web-based education carves out new space for web-based education research. This article, based on constructivism theory, introduces Agent and constructs an Agent-based web-education system model, along with relevant Agents in this model. Knowledge model is constructed for intelligent and individualized teaching. This article is an initial research on application of Agent in web-based education and provides fundamental base for further research in this field.

KEYWORDS: Agent; ITS; Network teaching; Individualization.

INTRODUCTION

ITS can date back to the 1950s, with research developing from linear program, branching program, integrated model, standardization to application of learning situation and virtual reality. ITS is generally known as a learning support system in which computer takes the role of teacher in providing individualized teaching and instruction to different learners by using artificial intelligence technology. Featuring interactivity, sharability, openness, autonomy and cooperation, it represents a new phase in the development from modern distance education to intelligent education [1]. This system, however, is found incapable in meeting requirements of different learners due to lack of feedback and evaluation models. In this article, based on fuzzy theory, information gathered in the process of learning is evaluated in real time and the result is delivered to the system, teacher and students along with suggestions of learning to realize automatic learning.

CONCEPT OF INTELLIGENT AGENT

The concept of Agent can be traced back to 1977 in Carl Hewitt's article named Viewing Control Structures as Patterns of Passing Messages, in which he introduced the word "Actor" and defied it the object with compatibility, interactivity and concurrent processing mechanism. This object has got a closed inner state and is able to realize information transformation and feedback with other objects of the same kind. The word Agent was first seen in M.Minsky's Society of Mind published in 1986, in which M.Minsky suggests that Agents feature both sociality and intelligence and they are units with special functions. Here's the definition of Agent given by Foundation for Intelligent Physical Agent (FIPA): Agent is an entity in a specific environment. It is able to analyze data obtained from a specific environment. Such data reflects events taken place in this environment and is able to operate in a manner that impacts the environment [2,3]. In this definition, Agent is defined as an entity in a specific environment. It can either be an intelligent software or a hardware (like intelligent chip or robot).

A rational Agent should be one that does the right job. We can evaluate effectiveness of Agent by use of parameter "performance measure". An Agent in activity acts on itself and the environment and reflects the later, flexibly and autonomously acts in the later. In the architecture of Agent designed for application, environment design program in which Agent can be trained should be incorporated. At same time, performance measure should be incorporated to evaluate effectiveness of the Agent. The operating environment function is as follows:

Function RUN-EVAL-ENVIRONMENT*(state,update-fn,agents, termination,performance-fn) returns scores*
Local variables:scores,a vector the same size as agents,all 0 repeat
For each agent in agents do
Percept[agent]get-percept(agent,state)
End

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For each agent in agents do
Action[agent]program[agent](percept[agent])

THE STRUCTURE OF INTELLIGENT TUTORING SYSTEM

Architecture of ITS is shown in Figure (1) consists of three components: storage component, system component and individualized learning environment.

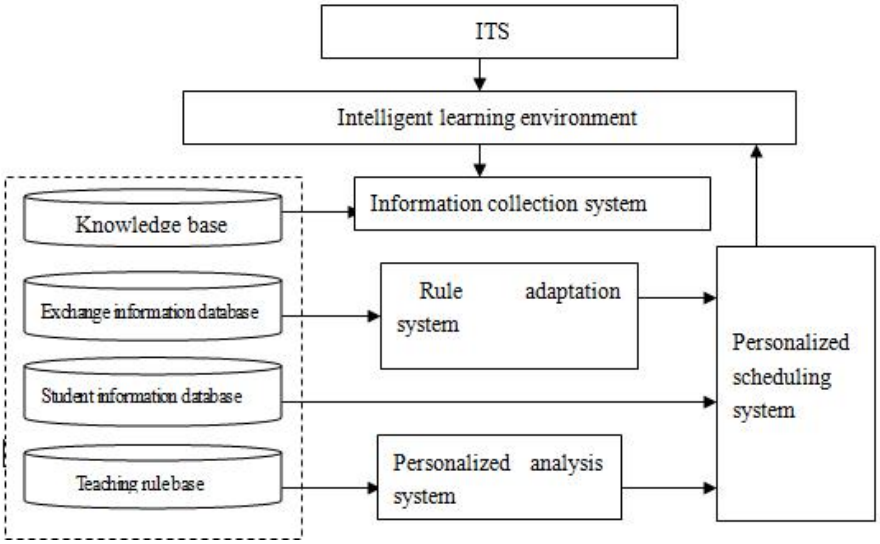

Figure (1). The structure of intelligent tutoring system.

The storage component consists of: knowledge base, information base, student date base and teaching rule base. System management component consists of: information collection system, rule adaptation system, individuality analysis system and individuality dispatching system. The individualized learning environment is produced in individuality dispatching system based on analysis of information in storage component.

The system has three layers in architecture. Adding or deleting data on storage layer will not affect individualized learning environment, likewise, modification to individualized learning environment will not affect storage layer, either. The connection between storage layer and application layer is complete by individualized dispatching system.

Data is collected at the same time when student uses the system.

The most important feature of ITS is being intelligent, knowing each student's learning ability, foundation of learning level of knowledge, and is able to design learning platform according to specific characteristic of the student, offering varied means of teaching and tailored instruction. Student logs in the system and start learning. At the end of learning, student can choose to do test, after which the system would give suggestions as to whether the student should go on to the next chapter or stay on this chapter according to test result.

System Composition

This system consists of three groups of users: administrator, student and teacher. The model is shown in Figure (2).

1. System management function

The management function includes； learning resource management, student management, BBS management, news notification management, intelligent problem solving management.

2. Teacher function

Teaches can put out and manage teaching content as well as relevant teaching information, give assignments, organize discussion, communicate with students and find problems in students' learning through the system. The function includes lesson preparation, resource maintenance, test, problem solving, assignment management, discussion and communication.

3. Student learning function

Being verified, student becomes legal user of the system and is allowed to have e-learning in the system. After logging in, student will be able to see chapter titles and browse a large amount of multimedia teaching notes, teacher's lectures and videos which do not need to be downloaded for use. There's on-line assignment, too. After a period of learning, student can finish some assignments arranged by teachers responsible for this part of teaching.

When encounter questions in the process of e-learning, student can ask questions at any time to get the answer through the system. The questions might be answered by other students learning in the system or teachers on line, or problem solving base of the system.

Test system consists of on-line test and test management.

Student test: Student can enter test subsystem after logging in and clicking on-line test link. The system chooses questions and make out a test paper according to question amount, form, score, proportion of subjective and objective questions set by teaching management module. After student finishing the test and submitting the paper, score is recorded and given to the student. Right answer is given for question that is done wrong and explanation is given for difficult ones.

Test setting and management: test questions are entered, modified and deleted here. Test setting is the main function of this component, including test paper composition, question management, form and score of question, total score, etc.

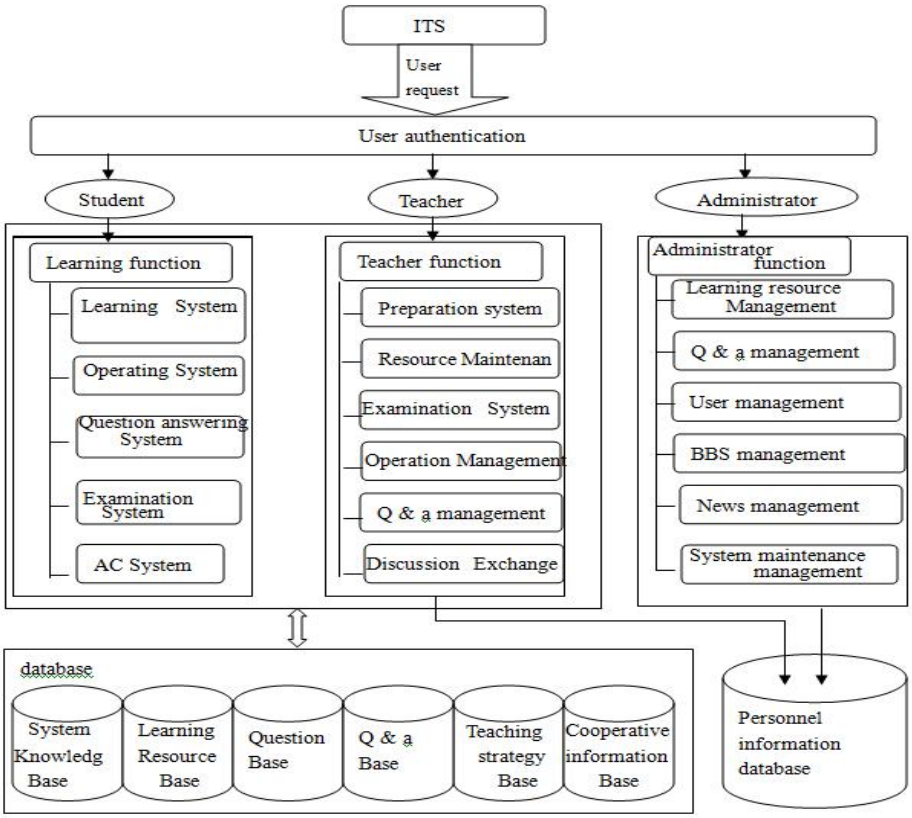

Figure (2). Functional model.

Agent-based ITS Model Construction

A large amount of information can be produced when user uses the above mentioned function modules of ITS. Such information which includes user's habit and hobby, learning process and progress, constitutes fine reference for system ratiocination. Proper and comprehensive use of such information improves the system's level of intelligence. Therefore, we need to find an effective way to unite all functions into a whole to realize share of information. ITS is a complicatedly constructed system with various sorts of information. The system works through various modules that can deal with various scenes occur in teaching process. We can make use of these modules to construct Agents with problem solving ability to assist users in certain functions [4]. Interdependence between function modules can be

solved through interactive cooperation. Based on such analysis, we construct a multi-Agent-based model for modern distance education system to solve these problems.

The system adopts B/A/S mode, i.e. Browser/Agent/Server structure [5]. The Browser is for webpage browsing, server for logic processing of system and application as well as data exchange in database. This is a "thin client" mode that accelerates visiting speed. Client uses browser to get on to the Internet, so it's unnecessary to install client program for specific client and it provides a uniform environment for complicated distributive applications. Client can also operate JavaApplet to enhance its function and reduce pressure on the server. JavaApplet can operate within client's authorization, which enhances security. The intermediate agent layer consists of various Agents which help realize teaching function. Server needs HTTP and FTP operation to assist communication. The various agents on intermediate agent layer are coordinated by FIPA-AcL language.

The first layer is browser layer mainly for user interface display and data exchange with user, thus requires display logic. Besides, multi-media data input and output, obtaining of user data and behavior, acceptance of task as well as processing result feedback are all realized on this layer.

The second layer is intermediate agent layer. This part constitutes the core of web education and realizes main functions of web education system. This layer mainly includes three types of Agents, namely Client Agent, Management Agent and Function Agent. Client Agent further includes Student Agent and Teacher Agent. Management Agent includes logging in Agent and Management Agent. Function Agent is used to realize part of the teaching functions and includes Teaching Agent, Problem Solving Agent, Test Agent, Assignment Agent, etc.

The third layer is data layer for storage of various data, including knowledge base, information base, resource base, etc. The knowledge base is made up of knowledge needs to be known for the course being taught. This layer serves for teaching material preparation, storage and management of knowledge. The test base is made up of test papers. Answer and standard for judgment is included in addition to questions. Each question in the test base has set property in terms of knowledge point, level of difficulty, question type, etc. The Test Agent chooses proper test paper that fits student's level based on these properties, which changes from time to time [6,7].

Architecture And Function Of Key Agents In The System

Complicated system can be simplified through modularization. Agent is a tool that can realize system modularization. To achieve modularization design of web education system and improve system interactivity and intelligence, we designed independent Agents including Teaching Agent, Student Agent, etc. to realize a majority of functions. Major Agents and corresponding functions are as follows [8,9].

Logging in Agent

User can register, log in, log out or cancel. Once a user logs in, the system verifies user identification and automatically creates Student Agent or Teacher Agent. Once a user logs in for the first time, his or her registration data will be stored in users' basic information form. Newly registered student users have to fill cognitive ability evaluation forms which will be stored in student cognitive ability forms. Student Agent will be notified to store a student's learning record if he or she logs out.

Logging in Agent includes monitor module, judgment module and communication module. Monitor module monitors logging in and logging out. Judgment module compares logging in data collected by monitor module with that stored in database to decide whether it is the right user. When user logs out, communication module communicates with Management Agent so student's learning can be continued.

Student Agent

Student Agent has the following functions:

a. Based on user ID, package student information and request and send them to Management Agent. Management Agent will choose proper teaching policy based on this;

b. One of the most important functions of Student Agent is to guide students in learning. Student Agent records students'learning condition and dynamically chooses what to teach and gives advices as how to learn.

c. Interactions will go on among Student Agent, Assignment Agent, Test Agent and Teacher Agent. Students get their assignment and test papers, ask questions and get answers; assignment answer and test answer will be sent to Assignment Agent and Test Agent.

d. Collect students' learning information (like duration of learning) and send it to Management Agent to give suggestions on learning;

e. Store students' learning record when students log out.

Teacher Agent

Teacher Agent is created by Logging in Agent. It simulates human intelligence, boasts rich knowledge and experience in teacher. Teacher Agent controls specific teaching segments of the whole system with following functions;

a. Help teachers modify, add, delete and renew teaching content, policy and rule;

b. Check students' learning condition and send suggestions to Management Agent according to such condition and students' request. Provide guidance and management in teaching and create foundation for individualized learning.

c. Analyze students' learning progress, performance, learning attitude, psychology and comprehensive ability based on students' database and make proper evaluation concerning students' learning so as to reorganize teaching content, make adjustment to teaching procedure and approach, make the optimum teaching scheme.

d. Prepare assignment and test paper, put them on the web and mark them. Timely renew teaching content and test question base.

e. Answer students' questions on line. Seek answers in answer base to solve problems that can't be solved in Problem Solving Agent; timely renew answer base;

f. Collect feedback from students in the process of teaching to enrich student base and teaching policy base and renew knowledge base;

g. Finish communication with other Agents.

Management Agent

The main function of Management Agent is to control coordination among various Agents. This Agent has both communication and management functions. When there're no teachers on line, Teaching Management Agent has to do part of the work that should be done by teachers.

Main functions of Management Agent are as follows:

a. Obtain students' learning history according to students' ID and basic information supplied by Student Agent as well as communication with Learning Record Agent.

b. Provide the student with proper teaching content based on student's request and communication with Teaching Agent;

c. Give assignment with appropriate degree of difficulty based on student's request, learning progress and communication with Assignment Agent;

d. Give exercises or test questions with appropriate degree of difficulty based on student's request, learning condition and communication with Test Agent;

e. Give answers based on students' request and communication with Problem Solving Agent;

f. Give suggestions to students based on evaluation sent back by Assignment Agent and Test Agent;

g. Give suggestions to students based on learning condition information (like time for learning) obtained from Student Agent.

OBJECT MODELS OF ITS

Learner Model

Definition: Learner model describes properties of learners, including personal data, security data, schoolwork data, hobbies, relationship, learning behavior [12,13]:

Learner model={personal data, security data, schoolwork data, hobbies data, relationship data, learning behavior }

(1) Personal data is mainly for management purpose, but not learner's performance and record.

Personal data:: =<learner identification, name, gender, date of birth, telephone number, E-mail, expandable template>

(2) Security data is learner's security certificate data.

Security data: :=<learner identification, log in password, expandable template>.

(3) Schoolwork data is simple data in connection with learner's study.

Schoolwork data::=<learner identification, courses, accomplishment, expandable template>.

(4) Hobbies data provides human-computer interaction parameter choice.

Hobbies data::=<learner identification, emotion, hobbies, inclination to media, type of learning, expandable template>.

(5) Relationship data describes the relationship between learner and other users of the system(like teachers and other learners).

Relationship data::=<learner identification, relationship, degree, expandable template>.

(6) Learning behavior describes learner's operation on knowledge points (like assignment, exercises, test, question and media learning).

Learning behavior data={assignment data, exercises data, test data, question data, media learning data, expandable template}.

Evaluation of Learning Objectives

Teaching objective evaluation constitutes an important part of teaching evaluation. Achievement of teaching objective is a standard used to judge whether a class is successful. For students, that means whether the students have achieved their learning objectives. Based on famous US education psychologist Bloom's "taxonomy of educational objectives" fuzzy data model, student's performance is used in assessing whether objectives are realized and make teaching plans according to student's learning condition [14,15] .

To set indices of evaluation process and degree of membership function for each index, questionnaires were made for students and teachers in connection with courseware data, test score, problem solving score, assignment score, discussion performance, etc.

To decide relationship between the six objectives (cognition, comprehension, application, analysis, evaluation, creation) and study performance, we hereby set the domain F=[0,100]. See fuzzy sets and its implication in Table 1.

For purpose of research, here we set five score ranges: T_1=[0,60], T_2=[61,70], T_3=[71,80] , T_4=[81,90] , T_5=[91,100] correspondingly for learning objectives. This was decided on basis of 48 questionnaires collected from excellent teachers with rich teaching experience. See survey result in Table 2. For scores corresponding to cognition, inclusive and partially inclusive T1 counts for 4, $u(T_1) = 4/48 = 0.083$; inclusive and partially inclusive T_2 counts for 12, $u(T_2) = 12/48 = 0.25$

Table 1. Fuzzy sets and its implication.

fuzzy sets	implication
M_1	To achieve the learning objectives of cognition
M_2	To achieve the learning objectives of comprehension
M_3	To achieve the learning objectives of application

M_4	To achieve the learning objectives of analysis
M_5	To achieve the learning objectives of evaluation
M_6	To achieve the learning objectives of creation

Table 2. Study target survey Statistical table.

	T_1	T_2	T_3	T_4	T_5
cognition	4	12	36	2	0
comprehension	3	14	38	3	0
application	0	4	42	10	2
analysis	0	2	26	40	4
evaluation	0	0	14	42	10
creation	0	0	8	38	16

$$u(T) = [\mu(T_1), \mu(T_2), \mu(T_3), \mu(T_4), \mu(T_5)]^T = \begin{bmatrix} 0.083 & 0.0625 & 0 & 0 & 0 & 0 \\ 0.25 & 0.29 & 0.083 & 0.042 & 0 & 0 \\ 0.75 & 0.79 & 0.875 & 0.54 & 0.29 & 0.17 \\ 0.042 & 0.0625 & 0.21 & 0.83 & 0.875 & 0.79 \\ 0 & 0 & 0.042 & 0.083 & 0.21 & 0.33 \end{bmatrix}$$

Student conducts self testing after learning. The testing questions are randomly chosen from expert model. Each question is associated with one or more knowledge points. Student's self testing score can be seen as the score for each knowledge point. We can see in which score range it lies (i=1,2,3,4,5) and obtain (i=1,2,3,4,5). For each knowledge point, the teacher model has set an objective that the student is expected to reach. After comparison, we can see whether a student has reached the objective. For example, a student gets 76 point for a knowledge point which belongs to the objective of application, as we know, 76 lies in T3 and T_3=[0.75,0.79,0.875,0.54,0.29,0.17], which means the possibility of the student's score to reach application objective is 0.875, then we can say this student has reached learning objective.

CONCLUSION

Agent-based ITS model is constructed after analyzing disadvantages of current web education system. Architecture and function of major Agents in the system is analyzed. Knowledge model, student model, teacher model are constructed. Research is done on assessment of students' score in student model. Result shows that this system is feasible in relevant technique and method which has theoretical research value and reference value. Agent coordination technique will be a main trend in future's web education system application and development. It creates new web education system solution and shows advantage when addressing defects of current solution.

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