

The Research and Design of Web-based Intelligent Tutoring System

Jing Huang¹ and Zhu Chen²

¹*Yun Nan Police Officer Academy, Kunming, Yunnan, China, 650223*

²*Qu Jing Business and Technology School, Qujing, Yunnan, China, 655000*
Huangjing78820@163.com¹, lsrynu2009@126.com²

Abstract

With the popularity of emerging intelligent tutoring system, combined computer assisted instruction with artificial intelligence, the artificial researches and designs web-based intelligent tutoring system, especially makes an analysis on the structural composition and key technology. Based on the intelligent technology, there are five models in the intelligent tutoring system. They are cognition student model, knowledge representation model, intelligence frame tutoring model and learning guidance reasoning model. By the five models, it can be a more intelligent college tutoring system. It not only can improve the efficiency, but also can build an intelligent management on tutoring and learning. Then it can bring much convenience for tutoring and has much practical significance.

Keywords: *Intelligent Tutoring System, Computer Assisted Tutoring, Intelligent Tutoring Management, Five Models*

1. Computer Assisted Intelligent Tutoring System

Computer Assisted Instruction is that the computer can help or replace the teacher to accomplish partial tutoring task, pass tutoring information, impart knowledge and training skill, and service to student directly. But, it is not only an assisted tutoring tool. With the mature of computer network technology, artificial intelligence has made a success in expert system, which provides new space for the development of CAI [1]. ICAI improves based on CAI, including artificial intelligent technology AI. ICAI not only overcomes some weakness of traditional CAI, but also provides new environment for students [2]. Based on different physical and psychological feature, it takes different tutoring methods and strategy, and finds the mistakes and reasons. Also, it can raise appropriate strategy according to the mistakes. So, it can meet the need according to one's different features [3].

Traditional tutoring is “How to Teach”, instead of “How to learn”. Due to this, the CAI system has some obvious shortcomings.

(1) Lack of Network Support [4]

CAI systems are burned on CD currently, and only can be used under standalone. Also the knowledge can't be updated by network. The CAI once completed, it can't be updated and maintained. So it will be obsoleted as time goes by.

(2) Lack of Intelligence

CAI system, which has no intelligence, can't arrange the most suitable learning content for student, and is unable to achieve the requirement of individualized teaching and heuristic teaching.

(3) Lack of Teachers' Instruction [5]

Current CAI system once has been sold, it all depends on students themselves while how to operate and study. The teachers know nothing about their students. When the

students have some problems, they are unable to ask help to their teacher. There is no communication between teacher and student, which makes the system less suitable.

(4) Lack of Instructor's Supervision

Current CAI is used as an adjective way of teaching, instead of independent. To a large extent, the academic department has no necessary supervision and restriction.

(5) Lack of Parents' Participation

Each parent has responsibility to know and concern the children's learning. Once they take part in the whole management at school, the system will be more reasonable and more perfect [6].

Now, under the guidance of modern educational theory, web-based ICAI applies internet development, artificial intelligence technology, web technology and network database technology to analysis and design [7]. Compared with the traditional tutoring system, web-based ICAI is more innovative, so it can optimize the tutoring by analyzing Teaching and Learning.

(1) For students, when there is misunderstanding or learning gaps, they are lack of strong support and guidance [8]. Based on intelligent network tutoring platform students' learning progress, they can guarantee that the computer without the instructor's case, can analysis of student learning and weakness; It gives targeted teaching suggestions according to result analysis; Choosing practice text based learning content and model; It also can help the student analyze the error correction, or even be able to find the root, which causes the learning difficulties and errors [9].

(2) For teachers, they can check students' learning through the IHTS platform directly at office or at home; According to the actual situation of students, the teacher can change teaching strategy, provide teaching focus, and adjust teaching content in a targeted manner.

(3) For instructor, they can log on to the IHTS platform to supervise teachers' teaching and students' learning at office; Making evaluation to teaching effectiveness; Taking the whole and individual situation of learning; And providing reference comments to teachers.

(4) For parents and students, they can log on to the WBIETS system by computer, which connected to the Internet, and enter the student ID, then they can check the learning and personal position in the class. It's helpful for parents and students to know more about the learning.

2. Intelligence Computer Assisted Instruction System and Structure

Intelligence Computer Assisted Instruction, also called ICAI, is an advanced form of traditional CAI. It is based on constructive learning theory. In this kind of education system, it introduces advanced artificial intelligent technology, and establishes an intelligent diagnosis mechanism in the learning process, so that the course has a certain "ideology" [10]. It has changed the modeled and mechanized traditional CAI teaching. In the past, it was a one-way transmission, but now, it has been a two-way teaching based on appropriate teaching strategies. This ICAI establishes good cognitive model based on each student, to determine student learning, learning progress and mastery of course content [11]. Through the intelligent analysis system, it can search, judge and make decision, and build a suitable learning strategy. Thereby they can make a reasonable arrangement for teaching content and progress; For some learning errors, through the intelligent diagnosis mechanism to analysis, find the reasons of errors and provide a reasonable improvement program, while modify the original learning strategy; For the errors all students have or common problems, ICAI also can analysis and form a teaching mentoring program [12]. It can help teacher adjust curriculum improvement, provide basis of test items, and provide policy recommendations for the relevant courses.

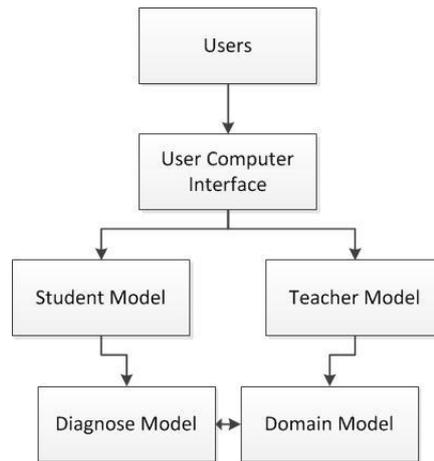


Figure 1. ICAI System Model Structure

(1) Student Model

Student model is the core of individualized teaching of ICAI. After students` learning and testing during the process of system teaching, it is an information characterization of students' knowledge level, cognitive ability, learning motivation, learning styles and other islearning information [13].

(2) Teacher Model

Teacher model is the center of intelligent tutoring system, used in organizing, managing and implementing. The effect is that combined target with actual level, and learning results to analysis the current state of students, give teaching strategies and select the most effective teaching methods, so that it can supervise and evaluate the results of learning, and achieve individualized guidance.

(3) Domain Model

Domain model contains knowledge base both students and teachers. Knowledge base of students includes advanced university, knowledge level, problem-solving situation, learning situation, learn ability, comprehensive level and so on.

(4) Diagnosis Model

Diagnosis model consists of diagnosis and evaluation. The effect of diagnosis is finding errors and defects in student learning, and teaching based on the errors and defects, which allows the system to carry out individualized teaching methods [14].

(5) Rule Inference Base

Rule inference base has implemented with production systems in artificial intelligence, including database, rule base and inference control. Rule base is the core part of produced system, used to store general knowledge. It is composed with many rules, and the rules are expressed in the form of "IF ... THEN"

3. The Analysis and Design of Intelligent College Tutoring System

3.1. System Composition

According to the division of different roles in WBIETS system, the system can be divided into four parts. They are the student subsystem, teacher subsystem, education staff subsystem and administrator subsystem [15].

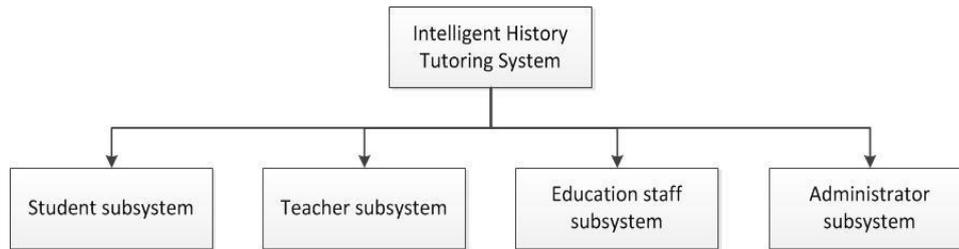


Figure 2. Composition of Intelligent College Tutoring System, Divided by Users

It uses the popular B/S three-layer model design, compared with the traditional C/S, is easy to expand. The development cycle is short, and it is easy to transplant. What is more, there is no need to install. The three-layer model includes the interaction layer, the intermediate layer and the data layer. Interaction Layer is the interface between the client and the user, and the client uses the IE browser. It meets the development direction of Internet, without geographical restrictions; the intermediate layer is a WEB server, it accepts the request of browser and gives returns; The data layer is a database server, with student model, teacher model and domain model. The varieties of data analysis and process mean the access to database ultimately [16].



Figure 3. Three-layer Structure of Intelligent College Tutoring System

3.2. Functional Design and System Framework

Main features: Supporting the teacher, student, education staff and administrator to complete a variety of teaching, assessment and management in the Web.

(1) Student-oriented functions: Analyze learning of student; Analyze weakness of student; Give targeted recommendation based on the result of analysis; Choosing text based on learning content and student model; Analyze and correct students' answers.

(2) Teachers-oriented function: Check students' progress; Check students' learning; Change teaching strategy and targeted manner based on the actual situation of students; Provide teaching focus, adjust teaching content, and update the test bank.

(3) Education staff-oriented functions: Supervise teachers' teaching and students' learning; Evaluate the effectiveness of teacher; Master the overall situation of all students and individual situation of each class and profession; Provide reference according to teaching evaluation [17].

(4) Administrator-oriented functions: Undertake the management and maintenance of teaching platform, to ensure the normal operation of teaching platform; Build, group, extended and revised exam resources; Modify user and set the password and other administrative privileges.

Below is the system framework

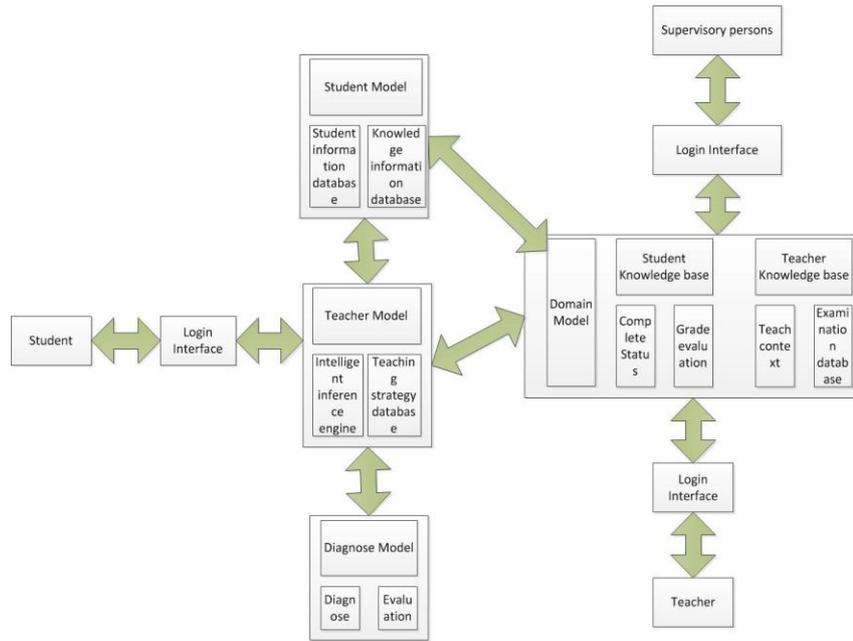


Figure 4. System Framework of Intelligent College Tutoring System

3.3. Key Technology and Structure Construction

3.3.1. Acknowledge Student Model

From the point of pedagogic, the cognitive ability of student can be divided into memorizing, understanding, analysis, application, synthesis and evaluation. While design and evaluate the model, the text bank is needed. We must define the cognitive ability of the test in the entry process. True is 1, false is -1, and empty is 0 [18].

(1) Each question in the text bank reflects one or more cognitive learning skill. If the questions can't react a particular cognitive skill, then the element is 0, and it can't be involved in the skill evaluation. During the text entry process, all the elements in vector table set to 0 at first. Then analyze the answer and problem-solving steps, and compared with the standard answer. Following the matching rate, the subject of difficulty, the cognitive skills and topics related to the type of vector table corresponding to the recording element assignment can be considered. When matching rate corresponding up to 90% at least of the element sets to 1, otherwise sets to -1.

Table 1. Student Cognitive Skill Table

Question Index	Cognitive competence(R _{ij})					
	Memorize	Comprehend	Analyze	Apply	Comprehensive	evaluate
1	1	0	-1	1	1	0
2	0	-1	1	1	1	1
...
n	-1	0	0	1	0	0

(2) After answering a part of the problems, calculating the correct rate of cognitive ability to obtain vector

$$A_i = (a_1, a_2, a_3, a_4, a_5, a_6), a \in [0,1], 1 \leq i \leq 6, a_i \text{ is the correct rate of one cognitive skill.}$$

$$a_i = \frac{R_{ij}(1)}{R_{ij}(1) + R_{ij}(-1)}, 0 \leq j \leq n \quad b \quad (3-1)$$

n is the number of text, $R_{ij}(1)$ is the correct times of i cognitive skill during the text.

$R_{ij}(-1)$ is the false times of j cognitive skill during the text.

(3) There are different types of questions in the text. Usually, it designs different types to text the six practical ability, so as to constitute the evaluation matrix of all kinds of text and cognitive ability.

$$G = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{16} \\ a_{21} & a_{22} & \dots & a_{26} \\ \dots & \dots & \dots & \dots \\ a_{61} & a_{62} & \dots & a_{66} \end{pmatrix} \quad (3-2)$$

Each row represents a cognitive evaluation capacity.

3.3.2. Knowledge Concept Graph Model

The structure of subject knowledge is a key technology in intelligent tutoring system. Using the knowledge based on concept graph model, analyzing the subject material and test questions to determine the relationship between subject concept and test question. It is easy to find misconceptions and make personalized recommendations.

(1) Structure of Subject Knowledge and Concept Graph Model

Subject knowledge material can be viewed as a tree structure contains chapters, sections, subsections and key concepts. This way has global understanding to subject content. But additional information also is needed if you want to diagnose learning state of student. For example, in the learning system of English, students fail to learn "subjunctive", probably because that he fails to learn "all kinds of tense usage". That is, when determining the relationships between concepts, it is possible to determine individual student's learning problem and provide advice

In order to establish the model between concepts, we can use the symbolic concept graph. For example, the two concepts C_i and C_j , if you want to learn more complex C_j , C_i is the prerequisite. So you will find concept influences relationship, such as $C_i \rightarrow C_j$. A concept may have more than one prerequisite, and vice versa.

(2) Construct Concept Influence Graph

Before constructing the graph, the relationship should be expressed in two-dimensional table (called the relation table CET), such as the following graph, C_i is the prerequisite of C_j , NP_j means the prerequisite number of C_j . If $CET(C_i, C_j) = 1$, it means that C_i is one of the prerequisites of C_j . If student fails to learn C_j maybe he could not get C_i well. If $CET(C_i, C_j) = 0$, it means that C_i and C_j have no interaction.

Table 2.

$C_j \backslash C_i$	C1	C2	C3	C4	C5	C6	C7
C1	0	1	1	0	0	0	0
C2	0	0	0	1	1	0	0
C3	0	0	0	0	0	0	0

C4	0	0	0	0	0	0	1
C5	0	0	0	0	0	0	0
C6	0	0	0	1	0	0	0
C7	0	0	0	0	0	0	0
NP_j	0	1	1	2	0	0	1

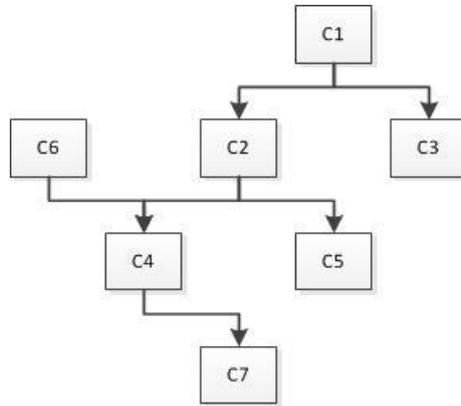


Figure 3.

Obviously, the main problem of learning this unit comes from the concept C2, C4 and C7. What is more, C2 is the core concept in the path, so students will be required to learn concept C2 in-depth. Finding errors in the learning process immediately, and pointing out the root of errors, then correcting, it is the important aspect of expressing ICAI intelligence. Also it is one of the design difficulties in ICAI system. Currently, there are three methods to diagnosis errors in the ICAI system. They are enumeration method, generation method, and reconstruction method. Although the three methods all can find errors, they are difficult to find the cause and process of errors. Using concept graph can better find the root of errors, and easy to diagnose students' misconception.

3.3.3. Intelligence Tutoring Strategy

The learning of student is divided into 5 levels: excellent, good, middle, passed and bad, then you can use the framework structure to determine the students' level of learning. Framework [15] is a kind of representations of knowledge in artificial intelligence. Now it has been widely used. Framework is a set of things that describe all aspects of the property, and reflect the data structure of relationships between related things. It is the basic unit of knowledge representation. A framework constitutes of many "groove". Groove also is divided into many "side" according to the specific circumstances. Groove is used to describe the particular aspect of an object, and the side is used to describe the aspect of respective property. Groove and side have their own property values, and they are called groove value and side value. Simply, the frame is made of characteristic graphs, and constituted in the form of "framework - groove - side - value".

The determined framework of students' level consists of four grooves (four factors). They are the testing scores, reading context, answer accuracy and answer assistant. The side is not included. The score of groove 1 test is that the students enter the system and finish some knowledge test within specified time, to have an overview of the students' situation that grasp the related knowledge: The remaining three grooves is the completed situation that learning the knowledge and solving the problems in the unit. Coding the four factors which determine students' level, the turn is "S", "P" "Q" "H". Learning state coding graph is 3-3. Each groove may have multiple values. Infer groove is used to indicate the logical relationship between two things that frameworks described. It can be

used to indicate the corresponding production rules [16].

Table 3. Coding Graph

Study factors	Code condition	Encode
Testing scores	S	S1(>90), S2(89-90), S3(70-79), S4(60-69), S5(<59)
Reading context	P	P1(100%), P2(>60%), P3(<60%)
Answer accuracy	Q	Q1(>95%), Q2(70%-94%), Q3(50%-69%), S4(<50%)
Answer assistant	H	H1(0), H2(<20%), H3(20%-60%), S4(>60%)

In this framework, to ensure that each of four factors (S, P, Q, H) only has one value in the program. For example, the value of factor P is P1, so it can't take P2 either. The other three factors are similar. We take a poor student as the specific case. His value is $[S5, P2, Q3, H4]$. It means that the student's test scores are below 60 points, and read context is more than 50%, and the answers accuracy is between 50% -69%, also the answer assistance is above 60%. Then the student can be regarded as a poor student. It can be seen; the table above is the child graph of learning state graph in coding rules.

3.3.4. Uncertainty Reasoning Model

The difficulty of researching and developing expert system is that the uncertainty knowledge representation and reasoning method. In the actual process of developing intelligent tutoring expert system, creating a complete student model is quite difficult. From student data to student model, it is the establishment of mapping, which requires the knowledge of tutoring experts. And the knowledge derives from experts' tutoring practice. The experience knowledge has very strong related areas and uncertainties, if it is expressed inconsistent, incomplete or vague, even if the data collected is accurate, it also may lead to failure of the model attributes. Of course, it is not simple to ensure the knowledge quality of student data and attribute mapping. There are many uncertainties in the process of creating student model [17]. Therefore, in order to express the uncertain knowledge in expert system, and use the uncertainties to make judgment, reasoning and decision, we not only need to research the uncertain knowledge's representation, but also to study the reasoning method of uncertainty.

In some reasoning, the uncertainty of knowledge (including rules and facts uncertainty) will lead to the uncertainty of conclusion. Faced with this reasoning, we must use the uncertain reasoning to get conclusion from irregular rules and uncertain facts. Therefore, uncertainty reasoning need to consider the $CF(A)$ and $CF(R)$. We get $CF(D)$ from $CF(A_i)$ and $CF(R_j)$, and other preconditions [18].

When experts use heuristic rules in reasoning, they must make an effective and sufficient estimation to the conclusion. They usually use "probable", "not very likely" or "possible" to measure the reliability of conclusions. However, these words are clearly lack of accurate calculation to probability. Instead, the experts get heuristic information from their reasoning experience. That means it needs certain measure to reflect the belief of data quality. For example, a student finish learning the unit (0.1) means that he really has finished the content in this unit. But the effectiveness of learning is quite poor, almost not learn at all. Belief and incomplete data can make a restriction to the conclusion regular propagation. Faced with the uncertainty reasoning, we need to add a credible factor for each rule to measure the credibility of the conclusions. Such as $P \rightarrow Q(0.9)$, means that "If you think P is true, then the possibility is 90 percent that Q is true." Thus, the heuristic rules can clearly indicate the credibility of faith. To create a rule base, at first you must make sure a CF for per rule. CF reflects the credibility of rules. The measure of credibility can be used to adjust the system. Although the small measure hardly has influence on the

whole operation, the effect is huge. So it is necessary to build a complete knowledge, and it will provide the best support for correct diagnosis.

3.4. Model Verification

In order to better reflect the advantages of intelligent model and the improvements of tutoring system, the author makes respectively verification based on traditional tutoring model and intelligent tutoring model, by simulating some teacher and student data.

In the traditional tutoring model, the system data can only extract teacher's related data, including tutoring time and learning hours. Recording the learning results by texts is lack of certain process analysis. In fact, learning is a cognitive process, and is a mutative process continuously. It is not enough to analyze tutoring process only by some data, and that will not be clear.

In contrast, intelligent tutoring model in this paper can be established into four parts. They are student cognitive model, knowledge conceptual graph model, intelligent tutoring strategy model and uncertain reasoning model. By the four models, we can effectively analyze the cognitive processes of students, and strategy process of teachers. Meanwhile, we can gain the advantages of tutoring by transformation process of knowledge. In addition, by uncertain reasoning model, we are able to derive the process of acquisition and acceptance effectively, and it is helpful to make a further analysis: both disadvantages in tutoring and knowledge acquisition state. Compared with traditional model, it obtains data and analysis by algorithm. So it is efficient and stable. It also has great influence on intelligence analysis and subsequent tutoring.

4. Conclusion

With the continuous development of computer technology and intelligence technology, the Intelligent Computer Assisted Instruction is made of traditional Computer Assisted Instruction and Artificial Intelligence. It has changed the stereotype and mechanization in traditional tutoring. Through the statistical analysis, it can form a mentoring program of tutoring, and provide basis for adjusting tutoring content. It also provides a new tutoring ideas and methods. Under the new intelligence tutoring system, it has studied and designed the Web-based Intelligent Tutoring System. To the key technologies, including system structure, system composition each module, it has made analysis and design. On the application of intelligent technology, there are five models in the intelligent tutoring models. They are cognition student model, knowledge representation model, intelligence frame tutoring model and learning guidance reasoning model. Through the five models above, it can build a more intelligent tutoring system. It not only can improve the teaching efficiency, but also can form an intelligent management in teaching and learning. Also, it brings great convenience to tutoring, and has a strong practical significance.

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Authors



Jing Huang, She was born in 1978 in Hebei Province. She has got the Master Degree, and now she is a lecturer of Yunnan Police Officer Academy, her main research direction is researching and teaching of college Ideological and Political Theory.



Zhu Chen, She was born in 1979 in Binchuan City of Yunnan Province. She has got the Master Degree of computer software and theory, and now she is a lecturer of Qu Jing Business and Technology School, her main research direction is computer software and theory.