Initializing Students Models for the Online Network Educational Systems

Chengling Zhao, Zhimei Sun, Qingtang Liu, Chaowang Shang, Dandan Shen
Department of information and technology, Central China Normal University, Wu-Han, China 430079
ccnuszm@126.com

Abstract - Although the online network educational system provides lots of learning resources, its application is limited for personalized service. How to satisfy the learners with their personalized needs, initializing student model is the research’s primary problem of e-learning. We introduce a framework of initializing student model which aims at the personalized information of learner and evaluation strategies. At last, we develop a prototype of initializing student model system in order to test our framework's feasibility.

Index Terms - Initializing, KNN algorithm, personalized, student model

INTRODUCTION

With the rapid development of Information Technology, the research and design of the online network education systems have become the hot area in education. One of the system’s aims is how to provide better personalized service for students. If each student learns with the same mode, it can’t satisfy the student with his personalized need. But if the student model makes initial estimations of the new student’s knowledge level and his personalized characteristics before his study, the problem of personalized need will be solved. So Initializing Student Model is the research’s primary problem of the online network educational systems.

The initialization of a student model is an evaluation method for knowledge level, learning characteristic, cognitive characteristic etc., before the student begins to learn. At present, there are several approaches to initialize the student model ([2]). 1. Some systems assume that a new student knows nothing (e.g. [4]). Although this method is the easiest way to initialize the student model, it has poor performance for students because of their different knowledge and personalized characteristics. 2. We usually design a pre-test to evaluate students’ knowledge level of the online network educational systems. To some extent, the result of pre-test can provide a reference for us about the students’ knowledge level, but it lacks in concrete knowledge point evaluation and ignores the effect of students’ characteristics on learning. 3. The system may define initial values for the student model by using the stereotype model (e.g. [5,6]). The stereotype model formed either directly by the instructor or after a preliminary test that has been posted to the student, they can evaluate the state of concrete knowledge-point mastered by combining the overlay student model. However, stereotype does not permit the formation of a student model that focus on special individual characteristics. 4. Virvou and her colleague put forward a method initializing student model based on the KNN (k-nearest neighbor) algorithm (e.g. [1,3]). This is a comprehensive, effective initializing student model method, but the choice of student model parameters only includes knowledge level and a self-estimation of how careful the student is while he solves exercises (namely careless, averagely careful, or very careful). The method ignores some personalized characteristics (such as cognitive ability) which will influence the later learning, and the system lacks in definition of learning characteristics.

In this paper, we discuss the initialization of a student model from the perspective of constructing, simulating and evaluating. In section 2, it describes the framework of initializing student model and its work flow. In section 3, it analyses how to select initializing parameters of a student model. In section 4, it shows us a prototype built up by OOPL (object-oriented programming language), and finally, we evaluate the model and point out the problems which need to be explored further.

THE FRAMEWORK OF INITIALIZING STUDENT MODEL

In the online network educational systems, the student model should not only reflect the students’ knowledge structure, but also their personalized characteristics.

Mostly, we consider more about the effect of the student’s pre-knowledge on the present learning, but ignore the effect of personalized characteristics (the students’ learning style, cognitive proneness etc). IEEE LTCS puts forward IEEE 1484.2 PAPI (Public and Private Information) learner model, and this framework supplements learning style based on learner model. So the students’ personalized characteristics not only contain the basic information (such as a student’s name, ID and personal file), but also include the personalized characteristics (such as learning style and cognitive level). This information is shown in the first student model.

We always adopt a pre-test to evaluate learners’ knowledge structure (such as the learner is a beginner, intermediate or advanced?), but in the process of learning, the state of knowledge point mastered influences the latter learning to some extent. So we judge a new student’s state of knowledge point according to the distance weighted KNN algorithm. The KNN algorithm only needs the referenced spots aggregate of samples, while verifying, and the tested sample belonged to the category that the most of K referenced samples belonged to. But the distance weighted KNN
algorithm comes forth the KNN algorithm. Firstly, it calculates the distance of the referenced sample and the tested sample, and acquires the similar degree of them, the nearer the distance is, the more the similar degree is, and the bigger the weigh is, vice versa. And then, it figures out the demanded attribute value of the tested sample by using the distance weighted mean value algorithm. In the initializing student model, it calculates every knowledge point’s mean value of the referenced students in the same knowledge level, and gets the state of knowledge point mastered of the tested student.

So the basic ideal of the Initializing Student Model is: firstly, it obtains students’ information which includes personalized characteristics received by questionnaire and the grade of knowledge level got by pre-test. The first student model is composed of personalized characteristics and knowledge level. It can judge the students’ knowledge level cursorily. Secondly, it evaluates the state of knowledge point mastered of the new student by combining the information of the student model knowledge base and the distance weighted KNN algorithm. And the result is fed back to the student model knowledge base which is one of the student’s attribute values together with the first student model vector. Finally, it reaches the aim of initialization. The Initializing Student Model framework is represented in figure 1.

**THE INITIALIZING STUDENT MODEL FRAMEWORK**

**THE SELECTION OF INITIALIZING STUDENT MODEL PARAMETERS**

The initializing student model mainly includes the first student model and student model knowledge base. They get the parameters of the student model by using different methods.

1. **Parameters of knowledge structure**
   - Knowledge level: Before the new student begins to learn, the system offers a pre-test paper according to the learning contents which can evaluate the student’s present knowledge level. The result of pre-test is the grade of student’s knowledge level.
   - The state of knowledge point: the state of knowledge point mastered of the referenced student is achieved by using overlay student model and the state is reflected through the attribute values. These attribute values are shown with number form 0 to 100. When it is evaluated, 0 means that the student knows nothing, and 100 means that the student masters well. The state of knowledge point of the new student is calculated according to the KNN algorithm.

2. **Parameters of personalized characteristics**
   - Students’ basic information: it mainly includes name, student ID and personal file. The information can be acquired by registering before the student loads.
   - Personalized characteristics: it mainly includes learning style and cognitive level which will affect the later learning. The student’s learning style is primarily acquired from the B.A.Soloman’s learning style table. Based on the four aspects (disposition, perceiving, input and understanding) of information. B.A.Soloman divides learning style into four dimensions and eight types, that is active vs. reflective, sensing vs. intuitive, visual vs. verbal, sequential vs. global. The student must fill B.A.Soloman’s learning style questionnaire after registering, and the system will determine the learning style according to the answers. We evaluate student’s cognitive abilities from six aspects (know, understand, apply, analyze, synthesize and evaluate), in accordance with Bloom’s “Taxonomy of educational objective” theory in this system. Every student’s cognitive ability corresponds to a vector which has six dimensions that is \{know, understand, apply, analyze, synthesize and evaluate\}. According to “the method of successive approach”, student’s cognitive ability is evaluated. This method includes several steps: Firstly, the student evaluates his cognitive ability by filling the value into the evaluation table. The range of the value is a number from 0 to 100, but in order to facilitate evaluating, we divide the numbers (0—100) into11 grades (0, 10, 20⋯⋯, 90, 100). Number 100 means that the cognitive ability is the best, and number 0 means the worst. Secondly, according to the student’s cognitive ability, let him answer the tested questions selected from the corresponding knowledge base. Depending on the answers, the system can modify the student’s first evaluation value. For example, if his answer is right, the value of cognitive ability will be added 1 mark, if not, it will be subtracted 1 mark. Then, we can get the student’s modified values, and the system will go to the knowledge base again to select a question which is corresponding to the student’s cognitive
ability, and examine the student sequentially. Finally, we can get the accurate value of cognitive ability after we repeat those steps several times.

III. Evaluation of knowledge point

Student Model Knowledge Base is composed of the degree of knowledge points mastered and the first student model. But the evaluation of knowledge points depends on the KNN algorithm. First, the system calculates the distance between two values \( x \) and \( y \) of a given attribute \( a \) of student which is defined in (1):

\[
d_a(x, y) = \sqrt{(x - y)^2}
\]

(1)

\((x, y\) are the attribute values)

After calculating the distances of all attributes, the system calculates the distance of two students according to the formulation (2). The similar degree is reflected by the distance. The nearer the distance is, the more the similar degree is, and the bigger the weight is. The weighted is calculated using (3):

\[
\Delta(s_x, s_y) = \sum_{a=1}^{n} d_a(x_a, y_a)
\]

(2)

\((n\) is the number of attributes)

The weight of every student: \( W_i = \frac{1}{\Delta(s_q, s_i)} \)

(3)

\((S_q\) is the new student, \(S_i\) is the referenced student)

Finally, the system uses a distance weighted mean value of the degree of knowledge point of the \( k \) referenced students that belong to the same knowledge level with the new student. The degree of concrete knowledge point mastered of the new student \((S_q)\) is presented in (4):

\[
Know_{\text{Point}}(\text{KnowledgePoint}, s_q) = \frac{\sum_{i=1}^{k} W_i Know_{\text{Point}}(\text{KnowledgePoint}, s_i)}{\sum_{i=1}^{k} W_i}
\]

(4) \((S_q\) is the new student, \(S_i\) is the referenced student)

THE REALIZATION OF INITIALIZING STUDENT MODEL

We simulate the model by using Object-oriented Programming.

Case: A junior named Wang Qiang loads web-based curriculum “Computer-Based Education” for the first time, and he is ready to learn “The Strategy of Courseware Design”, the system will provide the questionnaire to him before his learning, and the result is that he is a “beginner”. Before he registers, he should answer the learning style questionnaire, the answer is shown in table 1, but in the first student model it displays concrete learning style according to the field which the number belonged to. In this system, his learning style is reflective, intuitive, visual and sequential according to his answer. At the same time, the result of cognitive level test is “understand”. the first model is illustrated in the following Figure2.

![Figure 2](image)

**FIGURE 2**

THE FIRST STUDENT MODEL

![Figure 3](image)

**FIGURE 3**

THE RESULT OF KNN ALGORITHM

At the same time, the system builds knowledge base firstly, the model can build different knowledge table according to the subjects, and we can add corresponding concrete knowledge points into the table. When we assess the state of concrete knowledge points of the new student, we choose all referenced students belonged to the same knowledge level with the new student, the information of the state of knowledge points mastered is shown in table2. The result of KNN algorithm is the state of concrete knowledge points mastered of the new student. It is illustrated in figure 3.

In order to assess the effectiveness of the initializing student model, we conducted an evaluation study. Before Wang Qiang loads web-based curriculum, we ask Wang Qiang’s teacher to tell us his learning style and knowledge level according to his experience, the answer is his knowledge...
level should be beginner, and he prefers to think through problems firstly on his own and discover new relationships. He can be innovative in his approach to problem solving and understand new information best by seeing it. At last, the teacher estimates the state of the four knowledge points mastered which the system assesses them based on KNN algorithm, and the value is 50-60. To compare the estimate value with the calculated value of Figure 2, Figure 3, most of them accord with each other. So we think the initializing student model system is feasible.

<table>
<thead>
<tr>
<th>active vs. reflective</th>
<th>sensing vs. intuitive</th>
<th>visual vs. verbal</th>
<th>sequential vs. global</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td>3a</td>
<td>a</td>
</tr>
<tr>
<td>b</td>
<td>1</td>
<td>b</td>
<td>3a</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

TABLE 2
THE STATE OF KNOWLEDGE POINT MASTERED OF THE REFERENCED STUDENTS

<table>
<thead>
<tr>
<th>ID</th>
<th>knowledge point1</th>
<th>knowledge point2</th>
<th>knowledge point3</th>
<th>knowledge point4</th>
</tr>
</thead>
<tbody>
<tr>
<td>19990201</td>
<td>64</td>
<td>35</td>
<td>61</td>
<td>59</td>
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<tr>
<td>19990206</td>
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</tr>
<tr>
<td>19990213</td>
<td>50</td>
<td>55</td>
<td>58</td>
<td>53</td>
</tr>
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</table>

CONCLUSIONS AND FUTURE WORKS

This model has several advantages. For example, it can get the information of student’s characteristics conveniently, and the abstract information can be quantified. It can establish knowledge table dynamically, and add concrete knowledge points depending on the students’ needs. So it can be used in several different web-based education systems. At the same time, it can evaluate the state of knowledge points mastered accurately with KNN algorithm, while many systems can only evaluate the unit of the knowledge. It is very important to attain student personalized characteristics, but how to make personalized characteristic quantify better is a problem which need to be explored further.

REFERENCES