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Method of Structuring Intelligent Tutoring System with Self–Improving Function based on Analyzing Learning History

Kim Il Nam[1*], *Kim Ji Song*[2]

[1]Distance Education College, Kim Chaek University of Technology, Pyongyang, DPRK
[2]School of Information Science and Technology, Kim Chaek University of Technology, Pyongyang, DPRK
[*]Corresponding author: Email: kin62316@star–co. net. kp

Summary

In distance education, it is very important to provide students with appropriate learning materials according to their learning order because it is given to students at different ages and capability, which is different from the traditional classroom learning.

The purpose of this study is to structure adaptive learning system based on the analysis of student` learning history. This is to provide learning materials and to decide learning order based on analyzing learning histories of many students whose examination results are the same. In general, students with the same results of the examination are similar in basic knowledge or adjacent knowledge. The proposed adaptive learning system is getting more and more completed during conduct period because of the constant improving and supplement of learning materials and learning order during their studying.

Keywords: distance education; adaptive learning; intelligent tutoring system (ITS)

1. Introduction

Distance education is becoming more and more popular nowadays because of its convenience and effectiveness. In distance education, it is the most important to satisfy the need of individual student. Furthermore, students are different in their basic knowledge state and also different in their understanding, so suitable learning assistance should be given to an individual student.

A lot of studies on intelligent tutoring system (ITS) have been conducted. One of them has proposed a conceptual map model, which provides learning suggestions based on learning materials and test results [4]. This system can provide personalized suggestions for each student based on students' answers and the relationship between learning materials and test items. Another one has presented a method based on Ontologies and Petri nets to allow the development of group learning in the context of ITSs. [3, 8] While Ontologies represent network domain and student models in a shareable format, Petri nets formally specify group interaction protocols. Another one has suggested a method of assessing students' knowledge level through exams by neural networks. [6] The study on the method of intelligent learning system structuring by multi–agent has been widely done. [1, 7, 8, 9] The major advantage of this method is that the function of agents can be automatically improved through increasing their learning abilities. Especially it increases their functions by generating pedagogical agents dynamically and automatically (Abdellah, 2010). [1] The methods that enhance the standard of distance education by constantly renewing database of the systems in operation as well as answering correctly to students' questions by structuring intelligent master answer systems, are introduced. [10]

There is no structure of Intelligent Tutoring System based on the analysis of students` learning history.

In general, students are involved in many learning activities on the internet to understand learning material. Therefore, by analyzing learning histories we can get necessary learning materials to understand the aimed material. However, there are a bunch of materials which could be necessary or unnecessary for students on the internet. These unnecessary materials should not be provided to students. To solve this problem, the method of learning history analysis is applied to all students. This could ensure that necessity of individual material is clear. This is because many students had studied material which is necessary for understanding it and little studied material which is not necessary.

In this way, we can structure intelligent tutoring system based on history.

2. Search for preceding learning materials

In this paper, learning material which a learner is using at a moment are called aimed learning materials and learning materials necessary for understanding aimed materials are called preceding learning materials. The main principles of search for preceding learning materials are as follows;

Principle 1; appropriate preceding learning materials for a student to understand the aimed learning material Cg are among those that other students of the same answer studied with interest.

Principle 2; preceding learning materials necessary for the student to understand the aimed learning material Cg are among those that he has not studied yet or that he studied so long time ago enough to forget.

2.1 Calculation of learning interest degree

In general, it is natural for a student to study several times and for a long time the learning materials that seem necessary for themselves and they only skim over those which are less necessary. How much they were interested in learning is related to how long and how often they touched the learning materials concerned. Learning interest degree is calculated as follows;

$$\gamma_i = \left(1-\exp(-\omega_1 \frac{f_i - f_{\min}}{f_{\max} - f_i})\right)\cdot\left(1-\exp(-\omega_2 \frac{t_i - t_{\min}}{t_{\max} - t_i})\right) \quad (1)$$

where γ_i: Interest degree to learning material; f_i: Student's repeated learning frequency to learning material; $f_{\min}$: Minimum repeated learning frequency with all learning materials he ever

learnt;

f_{max}: Maximum repeated learning frequency with all learning materials he ever learnt; t_i: Student's total learning time to learning material; Student's standard learning time to learning material; t_{min}: Minimum learning time with all learning materials he ever learnt; t_{max}: Maximum learning time with all learning materials he ever learnt; ω_1, ω_2: curve control coefficient on interest degree;

As seen above, to understand how much a student was interested in the preceding learning materials concerned, it is important to bring together all data including standard learning time on learning materials concerned, maximum and minimum learning frequency with learning materials that they learnt before, as well as considering (summing up) the total time and repeated frequency on learning.

2.2 Search for preceding learning materials by Principle 1

First of all, we can get hierarchical tree of learning materials based on analyzing learning histories of other students whose examination results are the same and then we select the necessary learning materials by combining them.

The rules for constructing a hierarchical tree are as follows;

Rule 1: If parent nodes for the focused learning materials are in the same layer, they are linked to the previously−searched parent node with a main solid line and linked to the other one with a dotted one.

Rule 2: If parent nodes for the focused learning materials are in different layers, they are linked to that in the upper layer with a main solid line and linked to that in the lower layer with a dotted line.

Fig. 1 shows a new hierarchical tree of learning materials constructed by combining 3 students' learning histories according to the rules above.

Here the values of interest degree are summed up to be registered. In the hierarchical tree, every node means individual learning material with learning interest degree.

All decided learning materials and individual learning interest degrees are stored in First−Database.

Learning materials the cumulative value of interest degree of which is less than a certain threshold are excluded from the combined hierarchical tree of learning materials.

The excluded materials are stored in Second−Database and removed from First−Database. Reconstructing rules of the hierarchical tree of learning materials are as follows;

Rule 3: If a learning material the cumulative value of which of is less than the threshold is a leaf node, it is excluded from the tree and included in supplementary learning materials.

Rule 4: If a learning material the cumulative value of which of is less than the threshold is a trunk node, a node in the lower layer is linked to that in the upper layer.

Rule 5: A learning material linked with dotted line is linked to only one learning material based upon the learning sequence by analyzing the history.

2.3 Search for preceding learning materials based on Principle 2

Here we analyze the learning history of a student whom learning assistance should be given, and classify preceding learning materials again.

By using history of the student, recently studied materials are stored in Third−Database and removed from First−Database.

According to this point, the second−classified hierarchical tree of learning materials in Fig. 1 is downscaled as shown in Fig. 2.

3. Decision of learning procedure

The order of decided learning materials should be provided.

Because every material takes different effect to understand aimed learning material. So studying materials according to the order leads more easily understanding it for students.

Analyzing learning history of students, we can see that learning materials with more great learning interest degree is more great effect to understand it than less material.

For example, although the cumulative value of interest degree of C_{721} is 0.8, it should not be studied earlier than C_7 the cumulative value of interest degree of which is 0.3.

Learning procedure is decided as follows;

First, learning materials in the upper layer should be studied first.

Second, when learning materials are in the same layer, the material the cumulative value of interest degree is greater should be studied prior to others.

Third, parent node should be studied first and child node next and then other learning materials in the same layer as parent node should be studied.

Fourth, students can take the exam again after studying each learning material.

This is just like a depth−first search. But what is different is that students may sit for an exam after studying each learning material.

Fig. 3 shows the hierarchical tree of preceding learning materials with the orders mentioned above.

For example, the following table shows the learning procedure decided according to the ordered hierarchical tree of preceding learning materials.

Table 1. Learning procedure table

Learning procedure	Learning materials	Cumulative value of interest degree
1	C_4	0.7
2	C_{447}	0.6
3	C_{441}	0.5
4	C_{41}	0.3
5	C_{346}	0.45
6	C_1	0.4
7	C_{124}	0.6
8	C_{126}	0.5
9	C_{13}	0.4
10	C_{17}	0.3
11	C_{171}	0.4
12	C_{176}	0.33
13	C_{175}	0.25
14	C_{33}	0.4
15	C_7	0.3
16	C_{721}	0.4
17	C_{714}	0.35
18	C_{722}	0.3
19	C_{387}	0.29

4. Algorithm

When a student requires assistance, tutoring system finds the learning order for required material. If the order is existed, recently studied materials for the student are stored in Third−Database by analyzing the student` history. And then every material in First, Second, Third−Database is offered one by one according to the order while he passes the exam. Unless the learning order is existed, the learning materials are decided according to above and learning order is made. This time he could take the exam while he is studying. When he has passed the exam, learning materials and learning order are remade by analyzing his learning history.

5. Conclusion

This paper presents a method of system construction that provides different students with learning assistance appropriate to their learning abilities.

The solution lies in presenting and realizing an idea of a method of structuring an intelligent tutoring system more completed based on analyzing learning histories of students.

What is important is that detailed learning assistance can be given according to students' learning abilities because learning procedure table is made to their different exam answers.

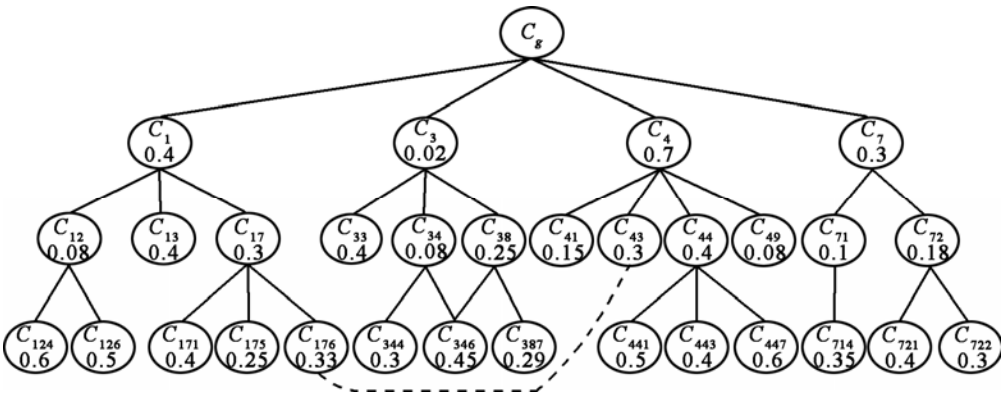

Figure 1. Hierarchical tree of preceding learning materials on **Principle 1**

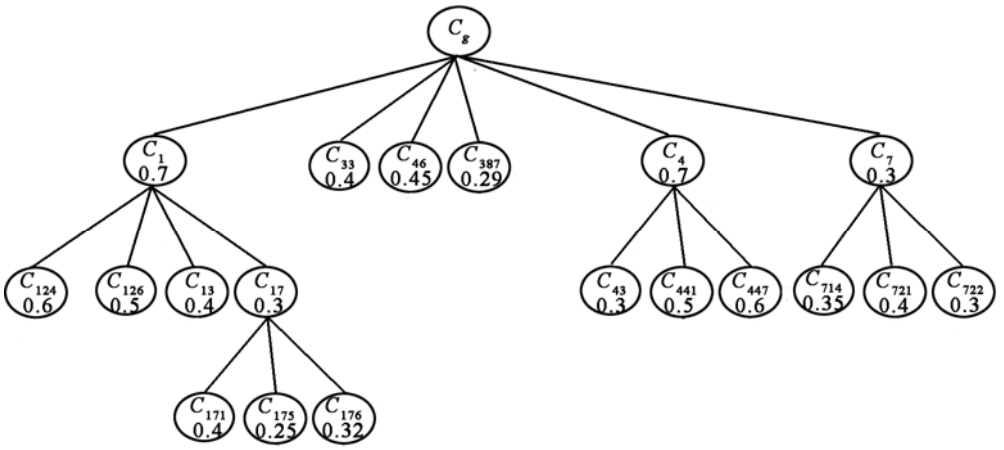

Figure 2. Downscaled hierarchical tree of learning materials on **Principle 2**

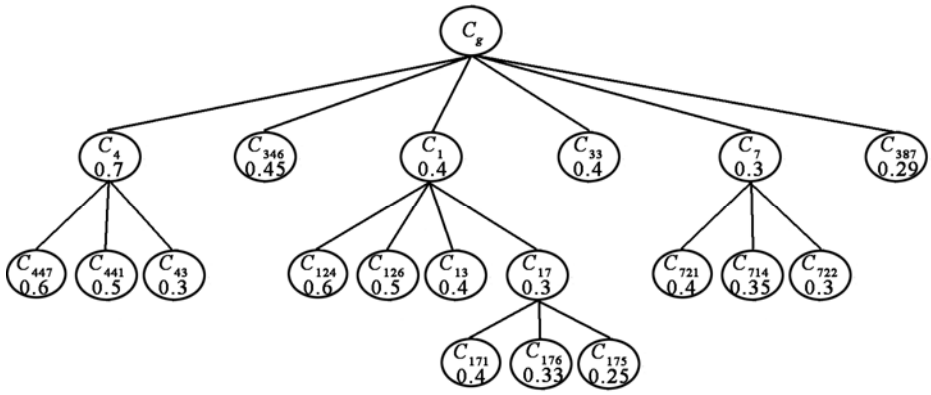

Figure 3. Ordered hierarchical tree of preceding learning materials

And it is of great significance that the more students learn and the more time flies, the more continuously learning procedure table is supplemented and renewed, so that the intelligent tutoring system can be further completed and getting more intelligent. It still suggests an important question to construct more appropriate and intelligent learning control systems in the future. We will study harder to apply a method estimating appropriate exam contents and learning materials in the future.

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