Developing Personalized Knowledge Navigation Service for Students Self-Learning based on Interpretive Structural Modeling

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Abstract

This paper designs a personalized navigation service based on the student cognitive levels. The personalized navigation service takes the interpretive structural modeling to generate concept navigation matrix by using the student cognitive background matrix (retrieved from tests and questionnaire) and the concept relation matrix (retrieved from textbooks). According to the knowledge structure and the concept navigation matrix, the service can provide different students their own knowledge navigation maps.

1. Introduction

In this paper, we develop a personalized navigation service to generate personal knowledge navigation map for students self-learning in the virtual universities. The service uses interpretive structural modeling (ISM) [1] and knowledge structure to figure out what cognitive level a student achieved and what concepts a student should either learn next or review again. Therefore, a student could realize how much he/she had already learned and which parts (says concepts or instruction units) he/she needs to study again through the visualized knowledge navigation map.

Section 2 gives an overview of the architecture of generating personal knowledge navigation map. The operation flow is also described based on ISM and knowledge structure step by step in Section 2. Finally, Section 3 makes a simple conclusion and describes some possible future works.

2. Personalized Navigation Service

Figure 1 shows how the personalized knowledge navigation service works.

Figure 1. Personalized Knowledge Navigation Service

In the beginning, the service retrieves the knowledge structure from the textbooks (step I-1). Knowledge structure is used to store attributes of concept. There are several attributes in a concept, including keywords, explanation, description, example, navigation, degree, application, test, evaluation, pass threshold, and a flag. Two important parts are navigation and degree which are described within all prescribed textbooks in China now. Navigation part stores the concept relations include parent
concept (parent node), children concepts (children nodes),
and sibling concepts (sibling nodes). Degrees are the
cognitive levels proposed by Bloom in 1956 [2]. The
student cognitive levels are, from simplest to most
complex: remember, understand, apply, analyze, evaluate,
and create. The degree indicates the cognitive level of
specific concept which students must reach in each
instruction unit of textbooks. The flag indicates a
student's cognitive level in one concept. The flag value is
gotten by testing students. The test scores are divided into
six grades corresponding to each of the degrees. A score
grade is a flag value from one to six. The dividing criteria
are defined by veteran teachers. Evaluation, pass
threshold and a flag are also retrieved from the test results.
Other attributes are constructed by veteran teachers.

Then, a concept adjacency matrix according to the
concept navigation attribute in knowledge structure can
be created (step I-2). Warfield (1982) used concept
adjacency matrix to represent the direct relationship
between two concepts [1]. Finally, the service uses
interpretive structural modeling (ISM) to calculate the
concept relation matrix (step I-3).

To generate a personal knowledge navigation map, the
service gets student cognitive background matrix
according to his/her pre-test and self-evaluation results
(step II-1 to II-2) or midterm test and self-evaluation
results (step II-3 to II-2).

These repeated flows indicate that a student cognitive
background matrix would be changed because he/she
might reach the level of specific concept during the
learning process. According to these test results, we use
zero (0) in the cognitive background matrix to indicate
that a student reaches the level of specific concept.

The final part, the service generates the concept
navigation matrix for specific student according to both
the student cognitive matrix (step II-2) and the concept
relation matrix (step I-3) as the followings:

**Step 1.** According to the knowledge structure, the
concept adjacency matrix \((CAM)\) can be retrieved as I-2 shows.

**Step 2.** Defining identity matrix \((I)\) based on the size
of concept adjacency matrix according to Warfield's ISM theory.

**Step 3.** According to ISM, the service has to find the
concept relation matrix \((CRM = (CAM+I)^n)\)
which satisfies \((CAM+I)^n-1 \neq (CAM+I)^n -I\), as step I-3 shows.

**Step 4.** According to domain experts (teachers), the
service makes matrix multiplication between
cognitive background matrix \((CBM)\) and
concept relation matrix \((CRM)\) to get concept
navigation matrix \((CNM)\). \(CNM = CBM * CRM\), as step III-1 shows.

If a row value in the concept navigation matrix (step III-1)
equals to 0, then it indicates that the student has reach the
learning goal of knowledge point corresponding to this
row.

After the concept navigation matrix is found (step III-
1), the service combines knowledge structure (step I-1)
and the navigation matrix (step III-1) to create a
visualized knowledge navigation map (step III-2). Students
then would be able to see the map by simply
using their web browser. On the left panel (step III-2),
students can easily select a concept node in an instruction
unit (or lesson) to discover their learning performance.
The learning performance then comes out on the right
panel based on the selected concept. Students can clearly
understand their learning states according to different
shapes and cognitive levels:

- the bottom concepts are the premise for the top
  ones;
- the concept with different shapes mean it requires
  students to reach different cognitive levels;
- and, the black level information on the top-right
  near the concept indicates that the student's
  learning performance on the concept. The red
  level information is to remind student to study
  this concept again.

3. Conclusions

A questionnaire has been implemented about this
personlized navigation service for students. The results
showed this service is necessary and important to students
do self-learning. We should have a more accurate method
to reach personalization and adaptively present
personalized knowledge navigation map. Furthermore,
because the student cognitive level changes dynamically
during the self-learning process, we have to improve the
cognitive level evaluation method. Besides, we also need
to establish standards to judge whether students had
reached the concept learning goals or not.

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