Mining learner profile utilizing association rule for web-based learning diagnosis

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Abstract

With the rapid growth of computer and Internet technologies, e-learning has become a major trend in the computer assisted teaching and learning fields. Most past researches for web-based learning focused on the issues of adaptive presentation, adaptive navigation support, curriculum sequencing, and intelligent analysis of student's solutions. These systems commonly neglect to consider whether learner can understand the learning courseware and generate misconception or not. To neglect learner's learning misconception will lead to obviously reducing learning performance, thus generating learning difficult. In order to discover common learning misconceptions of learners, this study employs the association rule to mine the learner profile for diagnosing learners' common learning misconceptions during learning processes. In this paper, the association rules that occurring misconception A implies occurring misconception B can be discovered utilizing the proposed association rule learning diagnosis approach. Meanwhile, this study applies the discovered association rules of the common learning misconceptions to tune courseware structure through modifying the difficulty parameters of courseware in the courseware database so that learning pathway is appropriately tuned. Besides, this paper also presents a remedy learning approach based on the discovered common learning misconceptions to promote learning performance. Experiment results indicate that applying the proposed learning diagnosis approach can correctly discover learners' common learning misconceptions according to learner profile and help learners to learn more effectively.
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1. Instruction

As numerous web-based tutoring systems were successfully developed, a great quantity of hypermedia in courseware has created cognitive overload and disorientation problems (Berghel, 1997; Borchers, Herlockerm, Konstanand, & Riedl, 1998), such that learners are unable to learn very efficiently. To aid more efficient learning, many powerful personalized/adaptive guidance mechanisms, such as adaptive presentation, adaptive navigation support, curriculum sequencing, and intelligent analysis of student's solutions, have been proposed in the past researches (Brusilovsky, 1999; Papanikolaou & Grigoriadou, 2002; Tang &

Mccalla, 2003; Weber & Specht, 1997). However, although many web-based learning techniques have been proposed to assist web-based learning, few researches have attempted to diagnose students' learning problems for the developed web-based tutoring systems. The learning diagnosis aims to identify learners' misconception and help them to promote the learning performance during learning processes. To help identify general misconceptions that learners might be having in a particular subject is critical and valuable to both teachers and learners in a web-based learning environment. Generally, the discovered learners' misconceptions from the learning behavior can be served as important feedback to the both learners and teachers. In the meanwhile, the web-based tutoring systems can also apply them to perform remedy learning or revise tutoring strategies.

To develop a novel learning diagnosis approach, several studies that have paid attention to the issue of learning

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diagnosis for the developed web-based learning systems are summarized and discussed herein. Chang, Liu, and Chen (1998) proposed a testing-based diagnosis system using the student's answers in the test problems to discriminate the student's misconceptions on the subject domain of DC electric circuits, thus helping teachers to tune teaching strategy. Cheng's study (Cheng, Lin, Chen, & Heh, 2005) focused on creating the concept hierarchy by embedding important concepts in a test, then analyzing the results with a hierarchical coding scheme for learning diagnosis. Cheng's study emphasized that the teacher will be able to adjust the teaching and to supply more useful learning materials as necessary by gaining insight into the students' understanding and possible misconceptions. Hwang's study (Hwang, Hsiao, & Tseng, 2003) proposed a computer-assisted approach for teachers to define and analyze concept effect relationships, thus helping them to diagnose student's learning problems. Lo's study (Lo, Wang, & Yeh, 2004) developed an adaptive hierarchical concept level courseware for English prepositions. Based on the formative evaluation results from the proposed test levels, the system diagnoses learner's error types in English prepositions learning and identifies the reasons behind their misconception. Huang et al. (2004) proposed an intelligent learning diagnosis system based on log files that records learners' past online learning behavior to support a web-based thematic learning model for expanding learners' knowledge while surfing in the theme-based learning cyberspace. Jong, Lin, Wu, and Chan (2004) proposed a remedial-instruction decisive (RID) path algorithm based on a conceptual graph to diagnose and analyze student's missing concepts. Their study shows that participants who adopt the diagnostic and remedial learning strategy have better academic performance.

Based on the survey of learning diagnosis strategies mentioned above, this study presents a novel association rule based learning diagnosis approach to support the personalized e-learning system for learning performance promotion. The personalized e-learning system (PELS) based on Item Response Theory (Baker, 1992), which considers both courseware difficulty and learner ability to provide personalized learning paths for learners, was presented in our previous study (Chen, Lee, & Chen, 2005; Chen, Liu, & Chang, 2006). However, this system lacks an intelligent mechanism to identify particular learning misconceptions for learners. Therefore, this study proposes an association rule learning diagnosis approach to analyze learner profile in order to assist PELS to explore learners' learning misconceptions. The proposed system can provide suitable remedy learning courseware to learners to perform enhanced learning according to the discovered learner's misconceptions. Moreover, this study also proposes a mechanism of courseware structure modification to slightly tune the difficulty parameters of courseware according to the discovered learning misconceptions, thus modifying the courseware recommendation sequence for the provided personalized e-learning services. Experimental results show

that the personalized e-learning system with the proposed learning diagnosis mechanism can help teachers and learners to identify learning misconceptions based on the proposed association rule learning diagnosis approach, helping learners to learn more effectively in a web-based environment.

2. System architecture

In order to discover the common learning misconceptions, this study proposes a learning diagnosis and remedy learning agent embedded in the proposed PELS, which can perform remedy learning based on learner's common learning misconceptions and modify the difficulty parameters of courseware for courseware structure modification. This section is organized as follows: first an overview of system architecture is presented in Section 2.1. Next, the learning procedure on PELS is explained in Section 2.2. Section 2.3 then describes the system components in detail.

2.1. System architecture

The PELS based on the Item Response Theory, which includes an off-line courseware modeling process, four intelligent agents and four databases, is presented in our previous study (Chen et al., 2005, 2006). The four intelligent agents are the learning interface agent, feedback agent, courseware recommendation agent and courseware management agent, respectively. These four databases include the user account database, user profile database, courseware database and teacher account database. The learner interface agent aims at providing a flexible learning interface for learners to interact with the feedback agent and the courseware recommendation agent. The feedback agent aims at collecting learner explicit feedback information from the learning interface agent and storing it in the user profile database for personalized curriculum sequencing operations. The courseware recommendation agent is in charge of recommending a personalized learning pathway to learner according to learner feedback response and concept relation degrees of courseware (Chen et al., 2005, 2006). Finally, the courseware management agent with authorized account management mechanism provides a responsive courseware management interface, aiding teachers to create new course units, upload courseware to the courseware database and delete or modify courseware from the courseware database.

However, the PELS mainly focuses on performing adaptive learning based on the difficulty parameters of courseware and learner ability for individual learner, it lacks the learning diagnosis and remedy learning mechanisms to support affectively learning. In this paper, the features of the PELS system are extended to include the test agent, testing item database, learning diagnosis and remedy learning agent in order to perform learner's misconception diagnosis for promoting learners' learning performance. In the extended PELS system, the test agent is used to