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Constructing a personalized e-learning system based on genetic algorithm and case-based reasoning approach

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Abstract

The Internet and the World Wide Web in particular provide a unique platform to connect learners with educational resources. Educational material in hypermedia form in a Web-based educational system makes learning a task-driven process. It motivates learners to explore alternative navigational paths through the domain knowledge and from different resources around the globe. Consequently, many researchers have focused on developing e-learning systems with personalized learning mechanisms to assist on-line Web-based learning and to adaptively provide learning paths. However, although most personalized systems consider learner preferences, interests and browsing behaviors when providing personalized curriculum sequencing services, these systems usually neglect to consider whether learner ability and the difficulty level of the recommended curriculums are matched to each other.

Therefore, our proposed approach is based on the evolvement technique through computerized adaptive testing (CAT). Then the genetic algorithm (GA) and case-based reasoning (CBR) are employed to construct an optimal learning path for each learner. This paper makes three critical contributions: (1) it presents a genetic-based curriculum sequencing approach that will generate a personalized curriculum sequencing; (2) it illustrates the case-based reasoning to develop a summative examination or assessment analysis; and (3) it uses empirical research to indicate that the proposed approach can generate the appropriate course materials for learners, based on individual learner requirements, to help them to learn more effectively in a Web-based environment.

Keywords: Computer-assisted testing; Case-based reasoning; Genetic algorithm

1. Introduction

The Internet and the World Wide Web in particular provide a unique platform to connect learners with educational resources. Educational material in hypermedia form in a Web-based educational system makes learning a task-driven process. It motivates learners to explore alternative navigational paths through the domain knowledge and from different resources around the globe. However, the structure of the presented domain and the content are usually presented in the same way, without taking into account the learners' goals for browsing, their experience, their existing knowledge, etc. This is an issue that needs further attention, especially when it comes to Web-based instruction, where the learners' population is usually characterized by considerable heterogeneity with respect to background knowledge, age, experiences, cultural backgrounds, professions, motivation, and goals, and where learners take the main responsibility for their own learning.

Curriculum sequencing is a well-established technology in the field of intelligent tutoring system (ITS). The idea of curriculum sequencing is to generate an individualized course for each student by dynamically selecting the most optimal teaching operation (presentation, example, question, or problem) at any given moment. By optimal teaching operation we mean an operation that in the context of other available operations brings the student closest to the

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ultimate learning goal. Most often the goal is to learn a required set of knowledge up to a specific level in a minimal amount of time. However, it is easy to imagine other learning goals, such as minimizing student error rates in problem solving.

Various approaches to sequencing have been explored in numerous ITS projects. The majority of existing ITSs can sequence only one kind of teaching operation. For example, a number of sequencing systems including the oldest sequencing systems (Barr, Beard, & Atkinson, 1976; Brusilovsky, 1993) and some others (Brusilovsky, 1993; Brusilovsky & Vassileva, 2003; Rios, Millán, Trella, Pérez, & Conejo, 1999) can only manipulate the order of problems or questions, an approach usually called task sequencing. A number of systems can do sequencing of lessons – reasonably big chunks of educational material complete with presentation and assessment (Brusilovsky, 1994; Capell & Dannenberg, 1993). The most advanced systems are able to sequence several kinds of teaching operations such as presentation, examples, and assessments (Brusilovsky, 1992; Chen, Lee, & Chen, 2005; Chen, Chang, Liu, & Chiu, 2005; Khuwaja, Desmarais, & Cheng, 1996).

One could say that sequencing is an excellent technology for distance education. Indeed, sequencing is presently the most popular technology in Web-based ITS (Papanikolaou & Grigoriadou, 2002). Therefore, the proposed approach is based on a pre-test to collect incorrect learning concepts of learners through the computerized adaptive testing (CAT) (Hsu & Sadock, 1985). Afterwards the genetic algorithm and case-based reasoning are employed to construct a near-optimal learning path according to these incorrect response patterns of the pre-test.

The rest of this paper is organized as follows: Section 2 describes the related literatures review, and we present the research methodology in Section 3. This is followed by a description of the proposed system in Section 4, while the evaluation of the system is reported in Section 5. Finally, we draw our conclusion in Section 6.

2. Literature review

2.1. Mastery learning

Mastery learning is a theoretical perspective of education that has attracted much attention in the past. The article by Bloom (1968) on mastery learning is widely regarded as the classic theoretical perspective on this model of education (Bloom, 1968). Bloom's article compares two models of education: the traditional model and the mastery model. The traditional model uses the same instruction for an entire class, regardless of aptitude. The instructor presents the required information to the students who are then tested to measure the information they have retained. Students are typically given only one chance to learn the material. The course then moves on to additional material. Once tested, students may learn what mistakes they made, but they are never retested to learn whether they have learned from those mistakes. Consequently, the amount of learning in a classroom varies between students. Students with an aptitude to learn the requisite material quickly move forward while slower students fall behind and receive lower grades. In contrast, the mastery model varies instruction according to aptitude, resulting in higher levels of learning for all students. If students have not learned the material by the first test, they can repeat it until they achieve the required level of competence. Then they move on to the next module. As a result, teachers employing a mastery learning model of education should hypothetically find high levels of achievement among all students.

Mastery learning has been widely applied in levels from primary education (Crijnen, Feehan, & Kellam, 1998), and a variety of subject matter from nursing (VanArsdale & Hammons, 1998) to economics (Laney, 1999), and for skills ranging from reading (Crijnen et al., 1998) to critical thinking (Mevarech & Susak, 1993). Many meta-analytic studies have demonstrated consistent positive effects for mastery learning programs (Guskey & Gates, 1985; Guskey & Pigott, 1988). According to these researches, they believe that 80 percent or more of the students in any given class can attain the same high level of achievement that only 20 percent attain under more traditional instructional methods.

The major steps in implementing mastery learning are outlined in Fig. 1. First, teachers must review their curriculum and instructional materials to decide what concepts or ideas are most important for students to learn and at what level. The next task is planning a formative assessment which is basically a diagnostic instrument or process used by the teacher. It is also a principal aid in the planning of corrective measures to remedy learning errors. Third, activities to correct and enrich may take a variety of forms and usually vary from one unit to the next. For instance, activities to correct may involve alternative materials or resources, peer or cross-age tutoring, computer-assisted lessons, or any type of learning activity that allows for a difference in sensory or motivational preference. Enrichment activities may also include tutoring special projects, problem-solving exercises, or any learning activity that is both stimulating and rewarding for fast learners. In the fourth step, this second assessment is parallel in form to the first formative assessment for the unit, but it is usually not identical; that is, it covers the same concepts and material as the first assessment but asks questions in a slightly different way or format. If the correctives have been successful in helping students remedy their learning difficulties, then almost all students will demonstrate their mastery in the second formative assessment.

Finally, this second formative assessment also becomes a powerful motivational device by showing students directly that they can improve their learning and become successful learners. Therefore, students can move to the next unit of instruction. Finally, there is the development of a summative examination or assessment. This examina-