Applied Mathematics and Computation 263 (2015) 332–341

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

Ant colony optimization for competency based learning objects sequencing in e-learning

A. Priya Dharshini [a,*], S. Chandrakumarmangalam [b], G. Arthi [c,*]

[a] KCT Business School, Kumaraguru College of Technology, Coimbatore 641 049, India
[b] Department of Management Studies, Anna University - Regional Centre, Coimbatore 641 047, India
[c] Department of Mathematics, PSGR Krishnammal College for Women, Coimbatore 641 004, India

ARTICLE INFO

Keywords:
Swarm intelligence
Optimization
Knowledge management
E-Learning
Learning object sequencing

ABSTRACT

E-learning is a knowledge management concept where content creators have to arrange a set of learning resources, to present them in a clear and comprehensive way to the learners. In this paper, we formulate a new approach for obtaining better learning paths for different learners groups as a constraint satisfaction problem (CSP) in which meta-data and competencies are used to define the relationships between the learning objects (LOs), where the course materials are used to formulate LOs sequence. The main aim of this paper is to obtain a dynamic learning path for the considered CSP problem by using the swarm intelligence technique, which is a sub-set of the artificial intelligence technique. Further, the proposed model is tested in a simulated environment, which gives an optimized LO sequencing. The simulation results reveal that the artificial ants gives solution to the proposed problem in an optimized way. More precisely, suitable learning path can be obtained by applying ant colony optimization (ACO) technique. From the obtained results it is concluded that the proposed model supports the e-learning portal administrator in getting benefits in terms of less processing time and minimal sequencing cost.

1. Introduction

It is well known that the activity of designing a learning path, namely learning design is a complex task especially in e-learning which got the much attention of the researchers during the past few years [3,23,25]. E-learning refers to using the electronic applications and processes to learn, where contents are delivered via internet, intranet, extranet, satellite TV, CD-ROM with multimedia capabilities *etc*. The applications and processes include web-based learning, computer-based learning, virtual classrooms and digital collaboration [4–6,21]. Further, e-learning is defined as the individualized instruction delivered over public or private computer networks. One strength of online learning is that the students can access the e-learning material anywhere, anytime and at any space they want. Moreover, space commitment is not relevant and students can freely study whenever they have time [13]. Manochehr [22] compared the e-learning and its effects with traditional instructor-based learning, the results reveal that the learning style in traditional learning was irrelevant but the e-learning is relevant and more significant. Carver [8] outlined how to enhance student learning by addressing different learning styles through course hypermedia.

More precisely, internet based learning has seen a major growth than the conventional class room teaching in recent years. The researchers in the knowledge management field who works on e-learning are taking advantage of two fundamental characteristics

* Corresponding authors.
E-mail addresses: pridha@gmail.com (A. Priya Dharshini), arthimath@gmail.com (G. Arthi).

http://dx.doi.org/10.1016/j.amc.2015.04.067
0096-3003/

of the internet which are the small delays in communications and huge number of users [16,18]. Social systems try to imitate the behavior of students group in real life and try to extract some information on the behavior of a group of students and use it to get some benefit for them (for example, a better learning path, a better selection of materials, *etc*). In other words, they take advantage of the interactions between the different members of the learning community to help each of its members. But, the pedagogical techniques preferred by a group of learners may differ from another set of learners. By providing different pedagogical approaches through e-learning, it is possible to satisfy the need of the learners, thereby improving the quality of learning. Cheng et al. [9] employed a PSO algorithm to select tailored questions for each learner from a large-scale item bank and simultaneously satisfy multiple assessment requirements. Morariu et al. [20] used genetic algorithm in e-learning to optimize scheduling of workload according to a set of conditions.

In the existing literature, many works based on artificial intelligence techniques have been developed to achieve personalized learning environments [14]. On the other hand, ACO is one of the swarm intelligence techniques, which has shown a good performance for solving wide variety of optimization problems in real environments. In particular, ACO algorithms are especially appreciated for their robustness and adaptability. Recently, researchers have been dealing with the relation of ACO algorithms to other methods for learning and optimization [10]. An adaptation of the ACO technique and its application to the sequencing of learning activities is presented and analyzed in [27]. Further, evolutionary algorithms are proposed to find quality approximate solutions with a reasonable time, which are useful in effectively achieving the requirements of adaptive e-learning environments in artificial intelligence techniques [7]. Even though most of the e-learning portal provides a lot of study materials to the learners, they do not consider the learning ability and competitiveness of the learners before assigning them the course materials. Internet based adaptive courses and systems should be able to substitute teachers and other student support system in e-learning processes. For this purpose many methods are developed and subsequently applied in the e-learning process [2,11]. One such method is using the curriculum sequencing technique which provides the learners with the most suitable content that is being individually planned and delivered according to the requirement of the learner. But, if this has to be achieved, the course provider will incur more cost and hence this style of providing content according to the requirement of the user has been not feasible.

Based on the above discussions, to overcome this disadvantage, we consider the automatic LO sequencing based on the swarm intelligence technique. Also, the concepts like reusability, interoperatability, and adaptability are considered while designing the e-learning courses. In this paper, we proposed a new approach to obtain a better learning path based on CSP which incorporates the concepts of learning objects, meta data and competency to define the relationships between the LOs. The main aim here is to employ the ACO technique to obtain the optimal path through the LO sequencing of the considered CSP. As a result, the optimal sequence within the solution space of CSP is developed by considering the constraints with the help of ACO approach. Finally, the paper concludes by presenting the results that the users are benefited by receiving better learning objects on the basis of their preference and capacity at a lower cost.

2. Learning object sequencing

In e-learning domain, the creation of small reusable learning units is called LOs, which are arranged in certain order to create the units of instruction like lessons, courses, tutorial, lectures etc. Before the online course begins, LOs must be arranged in the suitable sequence so that it could be delivered to the learners. Usually, this process of sequencing is done by the course instructors. Since this task is complicated, they do not opt for sequencing the LOs in a personalized manner, ie. how the learner wants the course. So, the course instructors code this process for a general LO sequencing, which creates generic courses, irrelevant of the characteristics of the learners. The coding of these sequences use a standard specification called shareable content object reference model (SCORM) to ensure interoperatability [11].

SCORM uses web as it's primary medium and hence development work gets eliminated for the online course designer. It uses application programming interface (API) for communicating information about a learner's interaction with content objects. Also, it has a defined data model for representing this information. SCORM contains a content packaging specification that enables interoperability of LOs, a standard set of metadata element and a set of standard sequencing rules. Actually using SCORM hinders the automatic LO sequencing, since it has a system centered view. Further, the properties of SCORM model such as reusable learning objects, develop new content models, develop learner assessment models, create new models for sequencing content, create learning 'knowledge' repositories and interoperatability makes it a most preferred model. Moreover, few other characteristics of SCORM such as reusability, adaptability, accessibility, durability and cost-effectiveness makes it a famous model.

SCORM's role in E-learning industry: It describes a content aggregation model and a run-time environment for LOs to support adaptive instruction based on learner's objectives, preferences, performances and other factors like instructional techniques. It also describes 'Sequencing and Navigation' model for the dynamic presentation of learning content based on learner's need. Other meta-data driven approaches offer better possibilities and appropriate combination of meta-data and competencies will allow personalized and automatic content sequencing. The following section explains how this problem is done by defining a conceptual data model for LO sequencing using competencies.

2.1. Competency and meta-data

One of the major criteria while sequencing the courses automatically is to use the components like competency, meta-data along with the learning objects [1,26]. This section deals about the essence of the term 'competency' in the e-learning