Solving the Adaptive Curriculum Sequencing Problem with Prey-Predator Algorithm

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ABSTRACT

Adaptive curriculum sequencing (ACS) is still a challenge in the adaptive learning field. ACS is a NP-hard problem especially considering the several constraints of the student and the learning material when selecting a sequence from repositories where several sequences could be chosen. Therefore, this has stimulated several researchers to use evolutionary approaches in the search for satisfactory solutions. This work explores the use of an adaptation of the prey-predator algorithm for the ACS problem. Pedagogical experiments with a real student dataset and convergence experiments with a synthetic dataset have shown that the proposed solution is suitable for the problem, although it is a solution not yet explored in the adaptive learning literature.

KEYWORDS

Adaptive Curriculum Sequencing (ACS), Adaptive Learning, Evolutionary Computing, Intelligent Tutoring System

INTRODUCTION

The technological development of recent times has facilitated access to information. People started to look for new products, services and new forms of knowledge. Online Education takes advantage of this new proactive paradigm of search for knowledge, providing learning materials, which comprise complete courses.

For many years, the technologies based on the improvement of education had as main objective the transfer of information from the central figure of a teacher whose main activity is to provide learning materials to be passively consumed by the students. Most of the courses offered on traditional Virtual Learning Environments (VLE) and Massive Open Online Courses (MOOCs) are still based on the passive form of content delivery. Thus, a learning concept is taught in the same way, with the same learning materials for all students (da Silva Lopes & Fernandes, 2009; Acampora et al., 2011). Therefore, relevant omissions, such as the student learning experience has been considered one of the main obstacles to the adoption of these systems (Acampora et al., 2011; Dwivedi et al., 2018).

Adaptive Learning (AL) is a set of techniques aimed at providing students with a personal and unique experience seeking to maximize their learning performance (Phobun & Vincheanpanya, 2010). Therefore, it may be considered to addresses some of the aforementioned issues. One of the most researched field in AL is the learning material recommendation (Dwivedi & Bharadwaj, 2013; Erdt et al., 2015). However, the recommendation by itself does not guarantee overall understanding

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(Dwivedi et al., 2018), since it does not consider a sequential organization in which each learning material must be in agreement with the previous and the next one (Durand et al., 2013). Therefore, curriculum sequencing – or Adaptive Curriculum Sequencing (ACS) – is a crucial issue in which the purpose is to help the system to find the best sequence of learning materials that meet the student profile (Premlatha & Geetha, 2015). The challenge lies in the construction of this sequence, since unsuitable sequences can lead to an increase in failure and dropout rates in the course (Xie et al., 2017).

Learning materials repositories, used by e-learning systems, are getting larger due to the ease of creation and access to digital content and the Open Educational Resources (OERs) movement. Moreover, several parameters are involved in the adaptive process, making the decision process more difficult. Thus, finding an optimal curriculum sequence is a combinatorial problem falling in the NP-Hard class of problems (Pushpa, 2012). It is worth noting that this fact motivated several authors to use heuristics and metaheuristics, especially of Evolutionary Computation approaches, to address the ACS problem, since in a classical manner, they are alternatives to similar problems (Al-Muhaideb & Menai, 2011; Wang & Wu, 2011, Pushpa, 2012; Khamparia & Pandey, 2015). New evolutionary approaches have been introduced in recent years with promising results in similar problems. Exploring such new approaches can bring benefits in solving ACS problem.

The process of adapting at the curriculum sequencing level relies heavily on the fitness criteria. Recently, several papers have explored solutions using a variety of parameters (Al-Muhaideb & Menai, 2011; Wang & Wu, 2011; Pushpa, 2012; Khamparia & Pandey, 2015). These works have shown that most of the learning materials parameters, such as the difficulty and the average time of learning are defined through consensus of experts. On the other hand, modeling student’s profile is more complex and is usually based on pretests or even on logs associated with the student’s past behavior in the system. There is also the complexity of associating student’s model with knowledge domain, for instance, by trying to associate the student’s Learning Style (LS) with learning material features. Due to these difficulties, it is noticed that the intrinsic parameters related to students are not used in the majority of the works.

As the ACS problem is considered one of the greatest challenges in the context of AL and that there are still issues that need attention, this paper presents an innovative solution to the problem, considering the student’s learning goals, their intrinsic and extrinsic information. The authors intend to show an adaptation of the Prey-Predator Algorithm (PPA) (Tilahun & Ong, 2015) for ACS problem although it has not yet been explored in the literature.

Experiments was carried out to validate the proposed solution. First, a convergence analysis was made with a set of learning materials repositories. The convergence analysis showed that PPA is a viable solution strategy to ACS problem. These repositories were made available for use in future proposals and reproducibility of the solution. Second, a comparison was made between the performances of the students who received the proposed adaptation and the students who did not receive it. In fact, through some analyzes it was possible to perceive that the proposed adaptation culminated in better pedagogical results. In addition, an analysis of student motivation was made based on dropout rates.

The remaining of this paper is organized as follows: Section 2 describes the problem addressed by this work. Section 3 reviews the related works through a comparison model. Section 4 presents the proposed process in detail. Section 5 presents the evaluation process, results and discussions. Finally, Section 6 concludes the paper.

THE ADAPTIVE CURRICULUM SEQUENCING PROBLEM

The research and development of Intelligent Tutoring Systems (ITS) seeks to combine techniques of Artificial Intelligence, Cognitive Psychology and Educational Learning Theories towards learning environment systems able to know what to teach, to whom to teach and how to teach (Silva et al., 2018). The problem of selecting the optimal sequence of learning materials that considers the student’s individuality is one of the most interesting and crucial goal in AL (Muhammad et al., 2016). There is
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