International Journal of Applied Metaheuristic Computing
Volume 11 • Issue 2 • April-June 2020

Population Based Techniques for Solving the Student Project Allocation Problem

Patrick Kenekayoro, Niger Delta University, Amassoma, Nigeria
https://orcid.org/0000-0003-0021-6584

Promise Mebine, Niger Delta University, Amassoma, Nigeria

Bodouowei Godswill Zipamone, Niger Delta University, Amassoma, Nigeria

ABSTRACT

The student project allocation problem is a well-known constraint satisfaction problem that involves assigning students to projects or supervisors based on a number of criteria. This study investigates the use of population-based strategies inspired from physical phenomena (gravitational search algorithm), evolutionary strategies (genetic algorithm), and swarm intelligence (ant colony optimization) to solve the Student Project Allocation problem for a case study from a real university. A population of solutions to the Student Project Allocation problem is represented as lists of integers, and the individuals in the population share information through population-based heuristics to find more optimal solutions. All three techniques produced satisfactory results and the adapted gravitational search algorithm for discrete variables will be useful for other constraint satisfaction problems. However, the ant colony optimization algorithm outperformed the genetic and gravitational search algorithms for finding optimal solutions to the student project allocation problem in this study.

KEYWORDS

Ant Colony Optimization, Constraint Satisfaction, Genetic Algorithm, Gravitational Search Algorithm, Student Project Allocation

INTRODUCTION

In the majority of Higher Education Institutions (HEI), students carry out final year projects in the last year of their study. In some cases, there is an available list of possible projects, where students rank their choices in order of preference and faculty members also have their preference for students they may wish to supervise. This classic problem is known as the Student Project Allocation (SPA) problem, and techniques to solving this problem have been researched extensively (Abraham, Irving, & Manlove, 2003, 2007; Anwar & Bahaj, 2003; Iwama, Miyazaki, & Yanagisawa, 2012; Kwanashie, Irving, Manlove, & Sng, 2015; Teo & Ho, 1998). Mathematically, it has been proven that if a preference list for students to supervisors and supervisors to students exist, then a stable matching is such that no lecturer or student can get a better match than the automatically generated matching solution, which is why the classic SPA problem is also seen as a generalisation of the Hospital/Residency (Roth, 1984) problem (El-Atta & Moussa, 2009).

It has been shown that the classic student project allocation problem with student or lecturer optimal stability could be solved in polynomial time (Abraham et al., 2003, 2007) by integer programming (Anwar & Bahaj, 2003; Chiarandini, Fagerberg, & Gualandi, 2018), simulated annealing

DOI: 10.4018/IJAMC.2020040110

(Chown, Cook, & Wilding, 2018; Ghazali & Abdul-Rahman, 2015) and other techniques. The methods used in solving the classic SPA problem can also be transferred to other domains such as telecommunications that require resource sharing (Gu et al., 2015). However, a variant of the student project allocation problem with additional factors such as supervisor load balancing or some other custom constraints could be seen as a multi objective constraint satisfaction problem (Srinivasan & Rachmawati, 2008). Srinivasan and Rachmawati (2008) have used an evolutionary algorithm to find an optimal solution to a multi objective constraint SPA problem for the University Department in their case study.

Even though the no free lunch theorem (Wolpert & Macready, 1997) suggests that no algorithm is guaranteed to perform well across all problems, an evolutionary strategy will arguably perform as well as the results achieved in (Rachmawati & Srinivasan, 2005; Srinivasan & Rachmawati, 2008) for a different set of constraints. As such, this study investigates the suitability of population-based approaches for solving the multi objective constraint satisfaction SPA problem, with constraints from a real university.

Three approaches, namely, gravitational search (Rashedi, Nezamabadi-pour, & Saryazdi, 2009) based on the physical phenomenon of gravitation, the ants colony optimisation (Dorigo, Maniezzo, & Colorni, 1996) based on swarm intelligence, and the genetic algorithm (Deb, Agrawal, Pratap, & Meyarivan, 2000) based on natural evolution are investigated, and the results reported in subsequent sections. The genetic algorithm has previously been used to solve the SPA problem (Harper, de Senna, Vieira, & Shahani, 2005; Srinivasan & Rachmawati, 2008), however, based on the review of literature, there is a dearth of research that report on the use of the ants colony optimisation or the gravitational search strategies for this problem. This research fills this gap, and demonstrates a method that adapts the gravitational search algorithm for discrete variables. The gravitational search algorithm works with continuous variables (Rashedi et al., 2009) and has been adapted for binary variables (Rashedi, Nezamabadi-Pour, & Saryazdi, 2010).

STUDENT PROJECT ALLOCATION PROBLEM

The dataset for the SPA problem from the case study department contained:

1. A student list with five (5) preferred research areas for a final project in order of preference;
2. A lecturer list with specific research areas where the lecturer can supervise students;
3. A student list with their current Cumulative Grade Point Average (CGPA).

The SPA problem is thus to create a project allocation solution, where the penalty for total constraint violations are minimised. The constraint violations are as follows:

C1. **Student preference:** Students are assigned to a project in one of their most preferred research area.
C2. **Staff load balance:** Lecturers should have equal supervision load (number of students).
C3. **Academic strength balance:** The average of CGPA of students allocated to each lecturer should be the same.

Data

Table 1 reports the statistics of the SPA dataset that is solved in this study. This data is downloadable from https://doi.org/10.6084/m9.figshare.6490451.

The distribution of student project preferences per supervisor is illustrated in https://doi.org/10.6084/m9.figshare.6490451. Note that in this dataset, if a solution is formed by assigning a student to his/her most preferred project, the solution will have a penalty of 81.84, with constraint violations from staff load balance and academic strength balance. Even though this penalty may be