University Course Timetabling Using a New Hybrid Genetic Algorithm

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***Abstract*—The university course timetabling problem (UCTP) is a classical, old and famous problem in the field of optimization problems. The purpose of UCTP is to schedule a number of events (courses) in proper timeslots and suitable rooms. In this problem, there are some hard and soft constraints. A feasible timetable must satisfy all hard constraints. In addition, each soft constraint violation causes a penalty. As far as UCTP is an NP-complete problem, it is reasonable to use population-based metaheuristic algorithms and evolutionary algorithms (EA). Although various methods have been presented the best results are referred to as hybrid evolutionary algorithms (HEA) and metaheuristics. The proposed method is a hybrid genetic algorithm (HGA). In our innovative HGA, the initial population which comes from heuristics is stored into red-black tree data structure. After that, our HGA creates new offsprings from previous individuals by its operators. Moreover, to improve local exploitation, we used hill climbing. The results were compared with other available ones using the 11 datasets of Socha *et al*. The results were promising and showed that the proposed HGA method is a good method to solve UCTP.**

Keywords-Hybrid Genetic Algorithm (HGA); Local Search; university course timetabling problem (UCTP); optimization

I. INTRODUCTION

In the timetabling articles, there are various definitions for UCTP. UCTP is a multi dimensional problem in which teachers, students and courses are assigned to timeslots and located in suitable rooms [1]. Because human timetabling is a sophisticated job, and in many cases it is impossible to create proper timetables, it has been about five decades that researchers have been working on automated timetabling [2]. Since 1962 when Gotlieb presented the first article about this problem, many articles have been offered in different journals [3].

Since UCTP can be reduced to a graph coloring problem, it is an NP-complete problem [4, 5]. Consequently, it is reasonable that most of the attempts to solve this problem are affiliated with population-based approaches (e.g., ant colony optimization [6-9], bee colony optimization [10], and particle swarm optimization (PSO) [11, 12]), evolutionary algorithms (e.g., genetic algorithms (GAs) [13-17], memetic algorithms (MAs) [18-20]), local searches (e.g., hill climbing, variable neighborhood search (VNS) [21, 22]), metaheuristic methods (e.g., harmony search algorithm (HSA) [23], great deluge and simulated annealing [24]) and heuristic-based approaches (e.g. tabu search) [25], etc.

Among above methods, HEA and HGA are the most interesting approaches because these algorithms use both properties of global search and local search. In fact, HEA and HGA use both exploration and exploitation ability of global and local search to find proper timetables in search space [23]. Having taken these reasons into account, we used an HGA method to solve UCTP in this article.

In our HGA method in this paper, there are some innovations. A new formula has been designed for selection operator in HGA to prevent premature convergence. Red-black tree data structure has also been used to reduce the time complexity of our algorithm. Moreover, a new concept is introduced named group of timeslots (GOT) and with GOT a new crossover algorithm has been innovated.

In the last decade, three famous timetabling competitions have been held [23]. The first one was held in 2002 (TTComp 2002). The second one was held in 2007 (TTComp 2007), and the last one was held in 2011 and continues until 31st August 2012 [23]. Metaheuristics network (MN) institute, created 11 datasets defined as Socha dataset, with the same format as TTComp 2002 datasets. The Socha dataset, is divided into 5 small, 5 medium and one large dataset. Socha dataset has the most famous one among other datasets in UCTP [23]. Besides, it offers a clear and simple definition of UCTP. Many articles compare their results with this dataset (e.g. [3, 6, 13]). So for those reasons, we used the definition offered from Socha dataset.[1]

The paper is organized as follows: The next section describes the university course timetabling problem. Section III describes our HGA method. Experimental results and Comparison between other literatures are presented in Section IV. Section V devoted to conclusion and future works.

II. THE UNIVERSITY COURSE TIMETABLING PROBLEM

The problem definition considered in this paper is Socha's dataset. It is a reduction of a typical university course timetabling problem. It consists of a set of events to be scheduled in 45 timeslots (5 days of 9 hours each), a set of rooms in which events can take place, a set of students who attend the events, and a set of features satisfied by rooms and required by events. Each student attends a number of events and each room has a size. A feasible timetable is one in which all events have been assigned a timeslot and a room so that the following hard constraints are satisfied [23]:

[1] For details, see http://iridia.ulb.ac.be/~msampels/tt.data.