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On the performance of Scatter Search for post-enrolment course timetabling problems

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Abstract This study presents an investigation of enhancing the capability of the Scatter Search (SS) metaheuristic in guiding the search effectively toward elite solutions. Generally, SS generates a population of random initial solutions and systematically selects a set of diverse and elite solutions as a reference set for guiding the search. The work focuses on three strategies that may have an impact on the performance of SS. These are: explicit solutions combination, dynamic memory update, and systematic search re-initialization. First, the original SS is applied. Second, we propose two versions of the SS (*V1* and *V2*) with different strategies. In contrast to the original SS, SS*V1* and SS*V2* use the quality and diversity of solutions to create and update the memory, to perform solutions combinations, and to update the search. The differences between SS*V1* and SS*V2* is that SS*V1* employs the hill climbing routine twice whilst SS*V2* employs hill climbing and iterated local search method. In addition, SS*V1* combines all pairs (of quality and diverse solutions) from the *RefSet* whilst SS*V2* combines only one pair. Both SS*V1* and SS*V2* update the *RefSet* dynamically rather than static (as in the original SS), where, whenever a better quality or more diverse solution is found, the worst solution in *RefSet* is replaced by the new solution. SS*V1* and SS*V2* employ diversification generation method twice to re-initialize the search. The performance of the SS is tested on three benchmark post-enrolment

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course timetabling problems. The results had shown that SS*V2* performs better than the original SS and SS*V1* (in terms of solution's quality and computational time). It clearly demonstrates the effectiveness of using dynamic memory update, systematic search re-initialization, and combining only one pair of elite solutions. Apart from that, SS*V1* and SS*V2* can produce good quality solutions (comparable with other approaches), and outperforms some approaches reported in the literature (on some instances with regards to the tested datasets). Moreover, the study shows that by combining (simple crossover) only one pair of elite solutions in each *RefSet* update, and updating the memory dynamically, the computational time is reduced.

Keywords Scatter Search metaheuristic · Explicit solutions combination · Dynamic memory update · Systematic search re-initialization · Post-enrolment course timetabling problem

1 Introduction

University course timetabling is considered as an NP-hard (Even et al. 1976) (non-deterministic polynomial-time hard) optimization type problem (see Lewis 2008). There are various metaheuristic approaches used to solve this course timetabling problem.

Metaheuristic designates a computational method that optimizes a problem iteratively. The method can be classified into two classes: population-based and local search (Blum and Roli 2008).

Some common population-based methods applied to the problem are the ant colony optimization (Socha 2003; Rossi-Doria et al. 2003; Mayer et al. 2008), swarm optimization (Turabieh et al. 2010; Sabar et al. 2011), hybrid evolutionary algorithm and memetic algorithm (Lewis et al. 2007b; Jat and Yang 2010; Abdullah et al. 2007, 2010a). The population-based method is utilized because of its capability to explore search space and to combine easily with local search method in order to enhance solution exploitation mechanism (Talbi 2002). On the other hand, some common local search methods applied to the problem are tabu search (Rossi-Doria et al. 2003), simulated annealing (Kostuch 2005; Chiarandini et al. 2006; Ceschia et al. 2011), and iterated local search (Rossi-Doria et al. 2003). The local search method is utilized because of its capability to exploit solution space (Blum and Roli 2008).

The strength of population-based method relied on the capability of recombining solutions to obtain new ones (Blum and Roli 2008). In population-based algorithms such as the Scatter Search (SS), a structured solution recombination of elite solutions is performed explicitly (which involve moving/swapping of assignments in a solution representing the information exchange between generations about an elite solution) using one or more recombination operators, such as crossover and mutation (Blum and Roli 2008). This process enables the search to perform structured solutions combinations (Blum and Roli 2008). The term explicit means that a solution is represented directly by the actual assignments (e.g. *course1-timeslot44*, *course1-room2*) and their fitness values.