AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Computer and Systems Engineering Department

A Hybrid Evolutionary Algorithm For Combinatorial Optimization Problems

A Thesis
Submitted in Partial Fulfillment of the Requirements of the Degree of
Master of Science in Electrical Engineering (Computer and Systems Engineering)

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Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Computer and Systems Engineering).

The work included in this thesis was carried out by the author at the Computer and Systems Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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Abstract

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Combinatorial optimization, by definition, is the search for an optimal configuration of a set of variables to accomplish certain goals. One of the well-known and rather complicated combinatorial optimization problems is the timetabling problem which is considered an NP-hard problem. A lot of research has been conducted in the past few decades to investigate a wide variety of algorithms and methodologies to solve timetabling combinatorial optimization problems. One of the blossoming recent methodologies in the literature is hyper-heuristics, which is a search methodology that attempts to automate the algorithm design process so that it would be able to work with different sets of problem domains.

This thesis focuses on the university course timetabling problem (UCTP) as the case of study for solving combinatorial optimization problems. Aiming to solve this problem it proposes the use of a competitive iterated local search approach strengthened with an adaptive ruin-recreate hyper-heuristic. The hyper-heuristic utilizes an online adaptive heuristic generation mechanism through a variable-sized list of add and delete operations. The algorithm was enhanced with the use of a novel approach to construct a good feasible initial solution. Moreover it was strengthened with a diversifying mechanism to allow more exploration over large search spaces to find a global rather than local near optimal solution. Additionally a weighted combination of random and previously well-behaving variables was induced in the iterated search movement operator to provide a tradeoff between diversification and intensification of the search process.

The implementation of the proposed work was experimented with the widely used ITC2007 datasets as the benchmark set. Experiments show promising results and succeed at achieving a better performance when compared to recent hyper-heuristic approaches in the literature that work on similar timetabling problems by a mean factor of 1.16.

Keywords:

Combinatorial optimization; university timetabling; evolutionary algorithms; metaheuristics; iterated local search; hyper-heuristics

Summary

Thesis title: "A Hybrid Evolutionary Algorithm For Combinatorial Optimization Problems"

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This thesis studies the open research area of combinatorial optimization and focuses on solving timetabling combinatorial optimization problems. This research study introduces ADRRHH, an Adaptive Diversifying Ruin-Recreate Hyper-Heuristic framework, used within an iterated local search approach aiming to solve and find a near optimal solution to this class of problems. The work conducted here specifically focuses on the popular curriculum-based university timetabling problem. The proposed hybrid evolutionary hyper-heuristic algorithm iterates between applying a move operator using add-delete lists of variables on the solution and applying hill climbing on the perturbed solution. The algorithm maintains a history of the best recently used add-delete variables lists for use in later iterations, and induces an appropriate mixture of random and previously improving lists of variables during the iterated search move operator to achieve an appropriate balance between intensification and diversification. Moreover the algorithm applies a diversifying operator whenever the search is found to stall in a certain region in the partial search space in order to escape local optima and transition to other unexplored areas in the search space. Experimental results in this thesis study and summarize the performance of our approach with respect to a very recent add-delete hyper-heuristic approach. Computational results show that our approach achieved better results in multiple arbitrarily selected instances of the benchmark datasets used by an average factor of 1.16, which verifies its promising impact in the field of timetabling combinatorial optimization problems.

Chapter 1 introduces the thesis, gives a formal definition of combinatorial optimization and of the university course timetabling problem under study along with its main characteristics, and summarizes its contributions.

Chapter 2 presents a literature survey and comparison on the various state-of-the-art approach categories that attempt to solve timetabling combinatorial optimization problems, along with some preliminary results.

Chapter 3 presents the formulation and encoding of the university course timetabling problem, and highlights popular benchmarks used in the literature for experimentation. Following that, it presents hyper-heuristics in more depth, being the most recent solution approach category used in the literature for solving the university course timetabling problem.

Chapter 4 introduces the proposed novel approach used to generate an effective initial solution to the UCTP. It then introduces the proposed solution approach (ADRRHH) that aims to solve the UCTP and find a near optimal solution, and illustrates its building blocks along with the internal implementation details of its modules.

Chapter 5 presents the computational results of applying every module improvement on its own and applying the merged approach, and compares it to state-of-the-art approaches.

Chapter 6 gives the research work conclusions and future work.

References are given at the end of this thesis.

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