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Extraction of decision alternatives in construction management projects: Application and adaptation of NSGA-II and MOPSO

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ABSTRACT

The time-cost trade-off problem is a known bi-objective problem in the field of project management. Recently, a new parameter, the quality of the project has been added to previously considered time and cost parameters. The main specification of the time-cost trade-off problem is discretization of the decision space to limited and accountable decision variables. In this situation the efficiency of the traditional methods decrease and applying of the evolutionary algorithms is necessary. In this paper, two evolutionary algorithms that originally search the decision space in a continuous manner including: (1) multi-objective particle swarm optimization (MOPSO) and (2) nondominated sorting genetic algorithm (NSGA)-II, are considered as the optimization tools to solve two construction project management problems. These problems are both in discrete domain including two or tree objectives, separately. In this regard, some procedures has been suggested and then applied to adopt both algorithms capable in solving the problems in a discrete domain. Results show the advantages and effectiveness of the used procedures in reporting the optimal Pareto for the optimization problems. Moreover, the NSGA-II is more successful in determining optimal alternatives in both time-cost trade-off (TCTO) and time-cost-quality trade-off (TCQTO) problems than the MOPSO algorithm.

1. Introduction

Simulation and optimization models can provide solutions to many problems in the field of operations research. Although simulation models are based on trial and test methods followed by engineering judgment, final solutions may not be optimal. In contrast, optimization models can yield optimal/near-optimal solutions by searching a part or an entire decision space. Different single-objective optimization methods such as linear (LP), nonlinear (NLP) and dynamic programming (DP) are capable to move toward optimal solutions. However, difficulties in determining optimal solutions, especially in some discrete or nonlinear problems, as well as the curse of dimensionality in solving the large-scale problems, are disadvantages of those optimization methods.

Evolutionary algorithms are potential candidates to determine optimal/near-optimal solutions in the aforementioned problems. In these types of algorithms, random decision variables are produced as input data for a simulation model. Output data from the simulation model can be used as input data for an optimization model. In such a process, newly-generated decision variables, based on previously calculated ones, can be improved. This process continues up to the maximum number of iterations for determining the best solution. Genetic algorithm (GA), particle swarm optimization (PSO), ant colony optimization (ACO), and simulated annealing (SA) are evolutionary algorithms that have been developed for solving optimization problems.

Multi-objective problems are another type of operations research problems which include a vector of objectives instead of a single objective. The main goal of multiobjective optimization techniques is to determine a set of optimal solutions, especially when objectives are conflicting. In traditional optimization methods, techniques such as the weighting approach are used in LP and NLP to produce just a single optimal point based on the considered weights. However, evolutionary algorithms can yield a set of nondominated solutions, Pareto, as the optimal solutions. Nondominated sorting genetic algorithm (NSGA), multi-colony ACO (MOACO), and multi-objective PSO (MOPSO) are some examples of multi-objective evolutionary optimization algorithms of this type.

The time-cost trade-off (TCTO) problem is a traditional bi-objective problem with a discretized decision space. Two

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