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# Time-Cost-Quality Optimization using an Invasive Weed Algorithm with Activity Preemption in Construction Projects

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**ABSTRACT:** In the last decade, various methods are created to optimize time, cost, and quality. Solving such a problem on large scale is too hard using traditional methods in logical time. Recently, researchers are focused on a meta-heuristic algorithm to solve time-cost-quality tradeoff problems. How to make a balance among time, cost, and quality parameters is so critical in construction project management. In this study, an invasive weed optimization algorithm is applied to solve the problem. In the proposed model, activity time is changed so that maximum usage of resources is obtained. In other words, it is possible to perform some activity simultaneously if their duration is increased which causes to decrease time, cost and increase project quality. Obtained results indicate the advantages of the proposed algorithm. Finally, to validate the proposed model a small size instance problem is created and solved by GAMS software optimally and compared with proposed algorithm results in MATLAB software. Results show that both Pareto solution obtained is almost identical, then it validates the algorithms for large scale problem.

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## 1. Introduction

According to the complexity of projects, it seems unlikely that project goals will be achieved without planning. Project planning and controlling is one the most important part of project management. Project scheduling to gain maximum quality and minimum cost in the least time is project management. Thus, the planning process is one the most significant principles in construction projects successful [1]. To generate a balance between time and cost of the project and increasing efficiency several ways to solve time-cost tradeoff problems and find an optimum combination of activity modes are developed such as mathematical programming models [2,3,4], heuristic methods [5,6], and meta-heuristic techniques [7,8].

In multi-objective and multi-mode project scheduling problems solution space is increased exponentially in medium and large-scale problems due to different execution modes that available for activities. These kinds of multi-objective problems are known as NP-hard [9]. Therefore, the meta-heuristic algorithm is used to solve the problem. Many meta-heuristic algorithms are developed to solve time-cost-quality trade-off problems optimally, for example, simulated annealing algorithm by Taheri Amiri, et al. [10], and genetic algorithm by Mungle, et al. [11].

In this study, time, cost, and quality with activity preemption are considered. Activity preemption, as the principle of the lean thinking approach, is considered to remove waste. The proposed model is solved by the invasive weed optimization algorithm. Furthermore, to validate the proposed model a small size instance problem is created and solved by GAMS software optimally and compared with proposed algorithm results in MATLAB software.

## 2. Results and discussion

As said above, an invasive weed optimization algorithm is developed to solve the time, cost, and quality tradeoff problem. To do this end, a three-objective model considering activity preemption is developed. Then, two instance problems are solved by the proposed algorithm for performance evaluation. On the other hand, a small size problem is used to assess a meta-heuristic algorithm. Afterward, an e-constraint method is applied to solve the problem exactly due to the multi-objective model. Each objective is optimized separately and the best value is recorded as well as the upper bound of each one. Then, one main objective is considered and others are set as constraints.

In this study, the total cost is considered as the main objective function and two others are set as a constraint. To obtain the Pareto solution, different values of objectives are considered. It is possible some combination of objective points does not have a feasible solution. This problem is solved by GAMS software less than one minute on a dual-core system with CPU 3GHz and RAM 2GB. Moreover, the proposed algorithm able to find a Pareto solution in less than about 40 seconds. Results obtained from two methods are compared that indicate the suitable performance of the invasive weed

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optimization algorithm. Furthermore, the completion time and total cost of the project states the mathematical model validation.

## 3. Conclusions

In a construction project, time, cost and quality management are the most important goals of project management so that it performs in minimum completion time with the least cost and acceptable quality. By taking advantage of the systemic approach and using new management tools, faster steps can be taken to achieve these goals. A scheduling planning tried to reduce time, cost and maximize quality and decrease job preemption, then resource unemployment and cost is declined. The invasive weed optimization algorithm has presented a set of solutions that makes manager take decision more suitable.

To validate the proposed method, two examples as a case study are considered and solved by it which is obtained acceptable results. The results state that a proper and efficient solution is achieved. It can be inferred that a suitable combination of activity execution mode and its sequence-based on precedence relationships should be set to obtain a solution with balanced completion time, execution cost, and delay time in resources. Finally, after activity mode selection scheduling planning should be set so that preemption is minimized. Furthermore, the proposed problem is solved exactly with GAMS software on the small size and compared by the developed algorithm. Results indicate the appropriate performance of the proposed algorithm. For future work direction, resource-constrained, multi-mode activity, and multi-skilled one are suggested.

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