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Cost optimization of steel structures by a hybrid meta-heuristic algorithm

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Abstract

Optimization in the field of civil engineering problems, is performed so that both technical issues are satisfied and the least construction cost is achieved. As mateiral cost constitiutes a major part of steel structures cost, its minimization is taken here the problem objective in presence of stress and displacement constraints. Jaya as a recent meta-heuristic is utilized to solve this problem. It is further enhanced with a passive congregation strategy so that shared information of the search agents helps better convergence toward global optimum. Numerical experiments is conducted on a number of benchmark structures to validate the proposed hybrid method.

Keywords: Jaya, passive congregation, hybrid algorithm, structural sizing optimization

1. INTRODUCTION

Optimization has been a classic rewarding task for investigators since early 1910's due to its wide application in the real world problems. In this regard, optimal structural design is characterized with narrow feasible search space and high number of possible alterantives. It brings about several behavior constraints that usually include code-specific stress and deflection limits. As these constraints should be implicitly evaluated via structral analyses, zero-order optimization methods are best suited for structual problems rather than mathematical programming which requires calculation of gradients or Hessian matrices.

Meta-heuristics consitute a subset of zero-order methods that have received considerable attention during recent decades. Every meta-heurstic algorithm, offers its special way to sample the design space by utilizing some intinsifying and diversifying operators. Every such algorithm is designed to reveal an approximation of optimal solution for complex optimization problems in practical time. As no single method is best suited for all types of problems, developing more powerful algorithm is still an active field of research.

Some of the meta-hueristic algorithms utilize several control parameters that should be tuned for every specific problem. In the other hand, there are parameter-less methods which reduces extra computational efforts in such a tuning process.

In this regard, Jaya algorithm [1] is concerned here for weight minimization of pin-jointed steel structures. It is a recent meta-heuristic algorithm which has shown acceptable performance by utilizing a very simple operators [1]. Standard Jaya is further modified and hybridized with a passive congregation strategy [2] so that its performance is enhanced in stochastic search. The proposed JayaPC is then developed and compared with the Jaya algorithm in a set of benchmark truss examples and the statistical results are reported.

2. PROBLEM FORMULATION

Every optimization problem is defined via its formulation by determining the design vector, objective function and constraints. As a common structural design problem, consumed steel material is taken here the cost function to be minimized. Consequently, the sizing optimization problem is formulated as given by Eq.(1):