Size and topology optimization of trusses using hybrid genetic-particle swarm algorithms

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Abstract

Optimal design of truss structures is an active branch of research in optimization. Three main classes of truss optimization include size, geometry and topology. Extensive research in a range of different types of optimizing methods have been done. Nowadays many of optimization algorithms are inspired by natural phenomena such as genetic algorithm, particle swarm and ants colonies. These, so-called metaheuristic algorithms, produce random initial solutions and improve their efficiency during the process of optimizing, and search for global optimum. In order to overcome the disadvantages of genetic algorithm (high computational cost of the slow convergence rate in solving engineering optimization problems) and particle swarm algorithm (falling into local optimum and premature convergence), these two algorithms are combined to reach better solutions and increased stability. In hybrid algorithms, the main advantages of using the particle swarm optimization include directing the agents toward the global best (obtained by the swarm) and the local best (obtained by the agent itself) so that the genetic algorithm is improved in performance. In this paper, size and topology of trusses are optimized using hybrid genetic-particle swarm (HGAPSO) algorithms. To optimize truss weight, complex design variables, cross section of members and node connectivity, are selected as discrete design variables, so that desired constraints such as stress and displacement restrictions and buckling of members are satisfied. Finally, some design examples are tested using the new method compared to other heuristic algorithms to demonstrate the effectiveness of the present work.

Keywords: size/topology optimization, trusses, genetic algorithm, particle swarm algorithm, hybrid algorithm.

1. INTRODUCTION

Recently, evolutionary algorithms (EAs) such as genetic algorithms (GAs), evolutionary programming (EP), ant colony optimization (ACO) and particle swarm optimization (PSO) have become more attractive. These methods do not require conventional mathematical assumptions and thus increase probability of locating the global optimum than the conventional optimization algorithms [1]. For non-convex design spaces or for discontinuous objective functions, the superiority of GA becomes apparent. However, the parameters of GA such as population size, cross-over rate and mutation rate, should be carefully selected and appropriate penalty and fitness functions have to be incorporated in order to avoid local optimums. The high number of operations is another drawback of GA. Goldberg is one of the pioneers in developing the Genetic Algorithm [2]. Early papers on structural optimization using GA are due to Goldberg and Samtani [3], Jenkins [4], Adeli and Cheng [5] and Rajeev and Krishnamoorthy [6]. Many others have published papers improving the results and increasing the speed of GA in the last decade. The PSO algorithm is introduced in the literature as a local optimizer with advantages relative to other EAs [7]. The numbers of capabilities that attractively increase this evolutionary algorithm, are its lower number of parameter necessary to set and its floating point treatment for the design variables. Fourie and Groenwold [8] successfully applied the PSO to the optimal shape and size design of structures. It is shown that PSO is a suitable tool for structural optimization. But, when dealing with discrete variables, the discrete PSO model is easily trapped into local minimum. Therefore, the applications of the PSO in discrete search space are relatively much less than those in continuous problem spaces.

In this paper, an efficient method is presented to optimize size and topology of the trusses subject to displacement and stress constraints. The proposed method is designed by combining GA and PSO,