The Great Salmon Run Metaheuristic for Robust Shape and Size Design of Truss Structures with Dynamic Constraints

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ABSTRACT

In this investigation, the authors intend to demonstrate the applicability of a recent spotlighted metaheuristic called the great salmon run (TGSR) algorithm for shape and size design of truss structures. The algorithmic functioning of TGSR emulates the annual migration of salmons together with dangers laid through their pathways. In a previous study by the authors, it has been proved that the method is as effective as most of the state-of-the-art metaheuristics for a wide range of numerical benchmark problems. Here, the authors utilize TGSR together with some rival metaheuristics, i.e. bee algorithm (BA), scale factor local search differential evolutionary algorithm (SFLSDEA), chaotic particle swarm optimization (CPSO) algorithm, self adaptive penalty function genetic algorithm (SAPFGA) and mutable smart bee algorithm (MSBA), for optimal design of truss structures with dynamic frequency constraints. To effectively handle the constraints, the authors take the advantage of self-adaptive penalty function (SAPF) constraint handling technique to free the user from any priori penalty coefficient tuning. Therefore, an algorithm for automation of constraint shape and size design of truss structures is proposed here. Furthermore, for more elaboration, the authors consider the results of some previous reports for same problems to find out whether TGSR is capable of yielding comparative results as compared to other metaheuristics. Through the experiments, the exploration/exploitation capabilities of TGSR for truss design are investigated. It is proved that TGSR is not only able to handle the nonlinearities and decision making difficulties associated with shape and size optimization of truss structures but also can show comparative results as compared to powerful state-of-the-art metaheuristics.

Keyword: Constraint Optimization, The Great Salmon Run, Metaheuristics, SelfAdaptive Penalty Function Constraint Handling, Truss Design

DOI: 10.4018/ijamc.2014040104
1. INTRODUCTION

Generally, two different paradigms are taken into account for optimizing engineering systems such as truss design problems. These two paradigms are known as metaheuristic algorithms and mathematical programming approaches (Kaveh & Talatahari, 2010). The abovementioned strategies have been well established in literature. Nowadays, several methods of different characteristics can be placed under the umbrella of those two frameworks.

Linear programming, nonlinear programming, and integer programming are among the most practical techniques which can be considered as mathematical programming methodologies. Without any exception, the stated techniques use the information of considered problem to conduct the optimization procedure. Usually, the information of a given optimization problem is supplied through its gradient. The gradient information is then used by mathematical programming approaches to solve optimization problems. Obviously, as gradient based optimizers, mathematical programming techniques can guarantee that the obtained solution is at least a local optimum. To be more to the point, gradient information enables such techniques to converge to a local solution in a very short period of time. In spite of fast convergence of those optimizers, there is no guarantee for finding the true (global) optimum solution. This is while finding global solutions is really vital when considering real world engineering problems (Yang, 2010).

Metaheuristic computing is the second well-established optimization scenario trying to address the drawbacks associated with mathematical programming approaches. On the contrary to gradient based optimizers, metaheuristic methods use three simple rules for optimizing any problem: (1) random sampling, (2) stochastic evolutionary techniques and (3) population based computation. As it can be inferred, to fulfill the mentioned computational rules, there is no choice but to take the advantage from nature, including knowledge of swarms, Darwinian evolutionary law, physical phenomena and etc. (Yang, 2010). Nature persuades the organisms to take stride towards elements such as adaption and ideality which can be enumerated as samples of optimality. As smart stochastic optimizers (not blind stochastic optimizers such as random search), metaheuristic algorithms have the potential of finding global solutions.

In the last two decades, an obvious trend has been emerged towards using metaheuristic approaches. The main reason of such an obvious inclination can be briefly stated as:

1. Metaheuristic algorithms are kind of soft computing approaches, and thus try do not use the exact information of optimization problems. This fascinating trait enables the users to utilize metaheuristic approaches for optimal design of engineering systems. To be more precise, to implement the metaheuristic methods, one does not need to know the physics of the problem. Consequently, metaheuristic algorithms can be effectively and conveniently used for optimizing complex engineering systems (Mozaffari et al., 2013a; Samadian et al., 2013).

2. In general, the implementation of metaheuristic methods is quite simple, as we only need to couple a number of stochastic equations to produce exploration/exploitation capabilities for metaheuristics. Therefore, metaheuristics have user friendly implementation style, and can be effectively used by researchers for variety of optimization tasks (Mozaffari et al., 2012a; Yang, 2010, Mozaffari et al., 2013b; Karaboga & Akay, 2010).

3. The stochastic instinct of metaheuristic algorithms enables them to easily escape from local pitfalls and explore the decision variables’ domain for global optimum solution. This fascinating characteristic has tempted engineers and industrialists to engage metaheuristic algorithms for engineering optimization tasks in which the encountered problems are usually highly...
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