Computers and Structures 87 (2009) 267–283

Contents lists available at ScienceDirect

Computers and Structures

journal homepage: www.elsevier.com/locate/compstruc

Particle swarm optimizer, ant colony strategy and harmony search scheme hybridized for optimization of truss structures

A. Kaveh [a,*], S. Talatahari [b]

[a] Centre of Excellence for Fundamental Studies in Structural Engineering, Iran University of Science and Technology, Narmak, Tehran-16, Iran
[b] Department of Civil Engineering, University of Tabriz, Tabriz, Iran

ARTICLE INFO

Article history:
Received 18 August 2008
Accepted 6 January 2009
Available online 3 February 2009

Keywords:
Ant colony optimization
Harmony search
Particle swarm optimization
Passive congregation
Truss structures design
Size optimization

ABSTRACT

A heuristic particle swarm ant colony optimization (HPSACO) is presented for optimum design of trusses. The algorithm is based on the particle swarm optimizer with passive congregation (PSOPC), ant colony optimization and harmony search scheme. HPSACO applies PSOPC for global optimization and the ant colony approach is used to update positions of particles to attain the feasible solution space. HPSACO handles the problem-specific constraints using a fly-back mechanism, and harmony search scheme deals with variable constraints. Results demonstrate the efficiency and robustness of HPSACO, which performs better than the other PSO-based algorithms having higher converges rate than PSO and PSOPC.

1. Introduction

In the last decade, many new natural evolutionary algorithms have been developed for optimization of pin-connected structures, such as genetic algorithms (GAs) [1–5], particle swarm optimizer (PSO) [6,7], ant colony optimization (ACO) [8–10] and harmony search (HS) [11–13]. These methods have attracted a great deal of attention, because of their high potential for modeling engineering problems in environments which have been resistant to solution by classic techniques. They do not require gradient information and possess better global search abilities than the conventional optimization algorithms [14]. Having in common processes of natural evolution, these algorithms share many similarities: each maintains a population of solutions which are evolved through random alterations and selection. The differences between these procedures lie in the representation technique utilized to encode the candidates, the type of alterations used to create new solutions, and the mechanism employed for selecting new patterns.

Compared to other evolutionary algorithms based on heuristics including evolutionary algorithms (EAs), evolutionary programming (EP) and evolution strategies (ES) [15], the advantages of PSO consist of easy implementation and smaller number of parameters to be adjusted. However, it is known that the original PSO (or SPSO) had difficulties in controlling the balance between exploration (global investigation of the search place) and exploitation (the fine search around a local optimum) [16]. In order to improve this character of PSO, it is hybridized with other approaches such as ACO or HS. PSACO (a hybrid particle swarm optimizer and ant colony approach) which was initially introduced by Shelokar et al. [17] for the solution of the continuous unconstrained problems and recently utilized for truss structures [18], is applied to PSO as a global search technique and the idea of ant colony approach is incorporated as a local search for updating the positions of the particles by applied pheromone-guided mechanism. HPSO (a hybrid particle swarm optimizer and harmony search scheme) was proposed by Li et al. [7] for truss design employed the harmony memory (HM) operator for controlling the variable constraints.

The present paper hybridizes PSO, ACO and HS, and it is based on the principles of those two methods with some differences. We have applied PSOPC (a hybrid PSO with passive congregation [19]) instead of PSO to improve the performance of the new method. The relation of standard deviation in ACO stage is different with that of Ref. [17], and the inertia weight is changed in PSOPC stage. New terminating criterion is employed to increase the probability of obtaining an optimum solution in a smaller number of iterations. In the proposed method, similar to HPSO, HS is utilized for controlling the variable constraint. The resulted method has a good control on the exploration and exploitation compared to PSO and PSOPC. It increases the exploitation, and guides the exploration, and as a result, the convergence rate of the proposed algorithm is higher than other heuristic approaches.

* Corresponding author. Tel.: +98 21 44202710; fax: +98 21 77240398.
E-mail address: alikaveh@iust.ac.ir (A. Kaveh).

0045-7949/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compstruc.2009.01.003