The Eighth China-Japan-Korea Joint Symposium on Optimization of Structural and Mechanical Systems
Gyeongju, May 25-29, 2014, Korea

Structural Shape Optimization of Free-Form Surface Shell and Property of Solution Search Using Firefly Algorithm

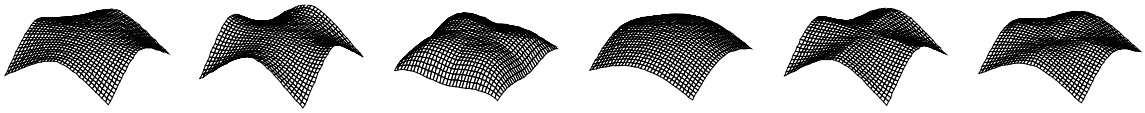
Natsuki TANAKA[1], Toshio HONMA[1] and Yohei YOKOSUKA[1]

[1] Graduate School of Science and Engineering, Kagoshima University

Abstract

In the architecture field, structural shape optimization is needed to obtain form with mechanical rationality, and any of the multiple forms obtained by structural optimization can possibly support ideas of designer. Structural shape optimization has the heuristic optimization procedures such as genetic algorithm (GA) and swarm intelligence (SI) in one of the typical solution search techniques. GA is a scheme based on the mechanism of biological evolution. SI is a scheme that uses patterns found in self-organizing phenomena observed in nature. The well-known SI techniques include the particle swarm optimization (PSO), which is based on group behavior of birds and fish [1], and the artificial bee colony (ABC), which is based on the foraging behavior of a honeybee swarm [2], and are applied to a lot of structural optimization. A lot of SI including PSO and ABC attain a global optimal solution, and diversity on the design variable space of those solutions is low. The firefly algorithm (FA) was developed recently as the optimization computational scheme using a firefly's ecology [3]. FA can attain both a global optimal solution and local optimal solutions by setting suitable computational parameters. However, the method for setting these parameters is comparatively difficult because the objective function space differs depending on the optimization problem [4]. In order to simplify the setting of these parameters in FA, we implement the computational scheme where the distance between two fireflies in the design variable space is dimensionless.

In this study, FA is applied to the structural shape optimization of a free-form surface shell. The solution forms that are obtained by FA are compared with those obtained by PSO, ABC and differential evolution (DE) [5]. DE is an evolutionary computational scheme, and performs solution search manner in similar to GA. The forms-1-3 and forms-4-6 that obtained by FA show solution forms that obtained by the total strain and bending strain energy minimization of a free-form surface shell structure, respectively. These solutions are applied to the local search [6] as an initial solution form, and it is indicated that the solution obtained by FA is extremal solution of a high estimation. In this paper, the effectiveness and the validity of FA for structural shape optimization are indicated through these numerical results.



form-1 form-2 form-3 form-4 form-5 form-6

Figure. Example of solution forms of free-form surface shell

References

1) J.Kennedy and R.Eberhart, Particle Swarm Optimization, Proc. of IEEE Inter. Conf. on Neural Network, IV (1995) 1942-1948.
2) D.Karaboga and B.Basturk, A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm, Journal of Glob Optimization 39 (2007) 459-471.
3) Xin-She Yang, Firefly Algorithms for Multimodal Optimization, Proc. 5th Inter. Conf. on Stochastic Algorithms, Foundations and Applications (2009) 169-178.
4) N.Tanaka and T.Honma, Structural Shape Optimization of Free-Form Surface Shell Using Firefly Algorithm, Proc. of IASS Symposium 2013,"BEYOND THE LIMITS OF MAN", CD-ROM1226, 1-8
5) R. Storn and K. Price, Differential Evolution - A simple and efficient heauristic fot glopbal optimization over continuous spaces, Journal of Glob Optimization 11 (1997) 341-359
6) Stuart J. Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, Second edition, Upper Saddle River, New Jersey, Prentice Hall (2002) 111-114.