Editorial

Editorial for the special issue of *Information Sciences Journal* (ISJ) on "Nature-inspired algorithms for large scale global optimization"

In the past few decades, many nature-inspired optimization algorithms have been developed successfully for solving a wide range of optimization problems. Evolutionary Algorithms (EAs), Simulated Annealing, Differential Evolution (DE), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Estimation of Distribution Algorithms (EDA) are just some representative examples among many others. These meta-heuristic algorithms do not rely on gradient information, and are less likely to be stuck on local optima because of their use of a population of candidate solutions, thereby offering significant advantages over traditional single-point and derivative-dependent methods. Although these techniques have demonstrated excellent search capabilities for solving small or medium-sized optimization problems, they still encounter serious challenges when applied to solve large scale optimization problems, i.e., problems with several hundreds to thousands, or millions of variables. Only very few attempts have been made by nature-inspired optimization algorithms on problems with millions of variables [1,2].

Many real-world optimization problems involve a large number of decision variables. For example, in shape optimization, a large number of shape design variables are often used to represent complex shapes, such as turbine blades, aircraft wings, and heat exchangers, etc. With the arrival of big data, there is an unprecedented demand to solve optimization problems with a large number of feature variables, training instances, and classes [3]. The recent advance in the area of machine learning has witnessed very large scale optimization problems encountered in training deep neural network architectures (so-called deep learning), some of which are involved in optimizing over a billion of connection weights in a very large neural network [4]. This is something unheard of even 10 years ago. How well nature-inspired optimization algorithms handle this kind of real-world large scale global optimization (LSGO) problems still remains an open question.

In recent years, researches on scaling up nature-inspired optimization algorithms such as EAs to tackle large scale optimization problems have gathered momentum on both theoretical and empirical studies. LSGO has attracted an increasing attention in the optimization research community. Most noticeable are the LSGO special sessions, competitions, and tutorials organized at the IEEE flagship conference Congress on Evolutionary Computation (CEC) since 2008. Several LSGO benchmark test function suites specifically designed to cater for the LSGO competitions have been highly cited [5,6]. This special issue aims to highlight the latest development in the area of nature-inspired algorithms for handling LSGO problems. We have received over 50 submissions to this special issue. All of the submissions were rigorously peer-reviewed by LSGO experts. Only 9 papers were finally recommended for publication. The first paper "Non-rigid Multi-modal Medical Image Registration by Combining L-BFGS-B with Cat Swarm Optimization" by Yang et al., proposes a cooperative coevolutionary model hybridizing the classic L-BFGS-B method with the cat swarm optimization method, for tackling the non-rigid multi-modal image registration problem. The L-BFGS-B method is used here as an efficient local search method. An important contribution of this work is the adoption of a block grouping method which is much more effective in capturing the interdependency among variables. The second paper "Decomposition-based Evolutionary Algorithm for Large Scale Constrained Problems" by Sayed et al., proposes VIIC (Variable Interaction Identification Technique for Constrained problems), which aims specifically for solving constrained LSGO problems. The paper also proposes a set of constrained LSGO benchmark functions, and develops DEVIIC (decomposition-based EA optimization model and VIIC). A challenging industrial LSGO problem with constraints is used for evaluating the proposed DEVIIC method. The third paper "Solving the large-scale hybrid flow shop scheduling problem with limited buffers by a hybrid artificial bee colony algorithm" by Li and Pan, combines an artificial bee colony (ABC) with tabu search (TS) for solving the large scale hybrid flow shop (HFS) scheduling problem with limited buffers. A self-adaptive neighbourhood strategy is adopted to balance the exploitation and exploration capabilities of the algorithm. The fourth paper "Greedy discrete particle swarm optimization for large-scale social network clustering" by Cai et al., proposes a new discrete PSO method for discovering community structures in social networks. More specifically in

this discrete PSO, the particle position and velocity terms are redefined in discrete forms to allow consideration of the network topology. A greedy local search method is designed for the particle position update rule in order to handle a large scale real-world social network. The fifth paper "A comprehensive comparison of large scale global optimizers" by LaTorre et al., carries out a comparative study on 10 most recently proposed LSGO algorithms, using several existing LSGO benchmark function suites. In particular, the complexity of the compared algorithms, the suitable statistical tests, and the measures on exploration and exploitation capabilities of the algorithms, are carefully examined. The sixth paper "Patterns from nature: distributed greedy colouring with simple messages and minimal graph knowledge" by Xu and Jeavons, develops two simple and efficient distributed algorithms for solving the distributed greedy graph colouring problem. Since there is no centralized control, the proposed algorithms only assume a minimal knowledge of global information. These algorithms can be employed to identify colourings with a small number of colours in distributed networks. The seventh paper "Evolutionary compact embedding for large-scale image classification" by Liu et al., presents a framework combining Genetic Programming with a boosting trick for dimensionality reduction, so called evolutionary compact embedding (ECE). More specifically, ECE is used for task-specific compact coding for large scale image classification. The ECE method achieves better or comparable performances when compared with existing reduction methods. The eighth paper "Optimising complex pylon structures with grammatical evolution" by Byrne et al., investigates the use of grammatical evolution for large scale structural optimization. Grammatical techniques are used for decomposing an architectural design effectively and for generating large scale structures. A grammar is specifically devised for the electricity pylon structure design problem. The ninth paper "A Novel Hybrid Column Generation-Metaheuristic Approach for the Vehicle Routing Problem with General Soft Time Window" by Beheshti and Hejazi, proposes a hybrid method combining column generation and meta-heuristic to solve the vehicle routing problem with general soft time window. Two phases are adopted, the integrative phase where a quantum-inspired EA is employed to solve the subproblems of column generation, and the collaborative phase where the column generation and electromagnetism algorithms are parallelized, with information exchanged in order to find better solutions.

Acknowledgements

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