Editorial: Special Section on Bio-Inspired Swarm Computing and Engineering

Ying Tan and Yuhui Shi

THE inspiration from biology and nature has been one of the most important and exhaustless sources for people to develop novel algorithms and innovative techniques during the past decades. Many important paradigms under the umbrella of computational intelligence have been established by this way, such as artificial neural networks inspired from the nerve system in human brain, genetic algorithm, and evolutionary computation inspired from biological evolving processes, fuzzy logic, and system from the inaccuracy reasoning of human beings, artificial immune system inspired from the biological immune system, swarm intelligence inspired from the collective behaviors of biological swarms, etc. Among those, swarm intelligence is the hottest topic dealing with the collective behavior of decentralized and self-organized systems. A typical swarm intelligence system consists of a population of simple agents which can communicate (either directly or indirectly) locally with each other by acting on their local environment. Though the agents in a swarm follow very simple rules, the interactions between such agents can lead to the emergence of very complicated global behavior, far beyond the capability of individual agents. For example, the natural systems of swarm intelligence may include bird flocking, ant foraging, and fish schooling, bacteria foraging, and honey bees, just to name a few. Over years of study on swarm intelligence, a variety of swarm intelligence algorithms for optimization problems, such as particle swarm optimization, ant colony optimization, fireworks algorithm, etc., have been developed and promoted, and found increasingly wide applications in real-world. Very recently, the swarm intelligence algorithms have sharply emerged and received extensive attention from many researchers and practitioners, and eventually become one of the most interesting topics in the community of computational intelligence. For fostering this hot research field, the International Conference on Swarm Intelligence (ICSI) series (official website: http://www.ic-si.org) are specifically devoted to be a forum for academia, engineers, and practitioners to exchange the latest advantages in theories, technologies, and applications of swarm intelligence and related areas. This annual series conference has become one of the most important and widely-recognized international events in the community of swarm intelligence. ICSI'2014 is the fifth ICSI event successfully held in Hefei, China from October 17 to 20, 2014. This special section consists of 10 high-quality articles selected strictly from more than 200 ICSI'2014 submissions by the conference technical committee and program committee and are substantially extended by authors. All of the 10 articles undertook and passed through a vigorous peer-reviewing process just like the normal regular papers in this transactions. These articles are primarily dealing with either novel bio-inspired swarm intelligence algorithms and their improvements or some their detailed applications in multi-objective optimization, clustering, feature selection, path planning, discrete optimization, etc. The contents of all of the articles are closely related to biological systems and phenomena, showing how to be inspired from biological and natural swarms and their related processes. For the sake of simplicity and convenience, they are cataloged into four groups.

In the first group, there are four articles which discuss novel bio-inspired swam algorithms and their improvements. Specifically, in the first article "Symbiosis-Based Alternative Learning Multi-Swarm Particle Swarm Optimization", Ben Niu, Huali Huang, Lijing Tan, and Qiqi Duan proposed a novel symbiosis-based alternative learning multi-swarm particle swarm optimization that was inspired from the mutual cooperation of symbiosis in natural ecosystem. In this algorithm, a learning probability to select one exemplar out of the center positions, the local best position, and the historical best position, is used to keep the diversity of the population. In the search process, particles not only exchange social experience with others that are from their own sub-swarms, but also are influenced by the experience of particles from other fellow sub-swarms. In the second article "A New Magnetotactic Bacteria Optimization Algorithm Based on Moment Migration", Hongwei Mo, Lili Liu, and Jiao Zhao proposed a new bionic optimization algorithm named magnetotactic bacteria optimization algorithm based on moment migration, inspired by magnetotactic bacteria. In this algorithm, the moments of a chain of magnetosomes are considered as solutions. The moments of relative good solutions can migrate each other to enhance the diversity of the algorithm. The distinct biological characteristics of magnetotactic bacteria which is a kind of polyphyletic group of prokaryotes with the characteristics of magnetotaxis, are very useful to design new optimization technology. In the third article "A Cooperative Framework for Fireworks Algorithm", Shaoqiu Zheng,

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Junzhi Li, Andreas Janecek, and Ying Tan proposed a cooperative framework for Fireworks Algorithm (FWA) invented in 2010 by Tan et al. inspired from the explosion of fireworks in air. This cooperative framework of FWA not only overcomes the limitations of the state-of-the-art FWA variants, but also can greatly enhance the exploitation ability of non-core fireworks by means of independent selection strategy and increase the exploration ability by crowd-avoiding cooperative strategy among fireworks. In the fourth article "Fireworks Algorithm with Enhanced Fireworks Interaction", Bei Zhang, Yu-Jun Zheng, Min-Xia Zhang, and Sheng-Yong Chen made great effort to improve FWA by enhancing fireworks interaction in three aspects: 1) developing a new Gaussian mutation operator to make sparks learn from more exemplars; 2) integrating the regular explosion operator of FWA with the migration operator of biogeography-based optimization (BBO) for increasing information sharing; and 3) adopting a new population selection strategy that enables high-quality solutions to have high probabilities of entering the next generation without incurring high computational cost. The combination of the three strategies can significantly enhance fireworks interaction thus improve solution diversity.

In the second group, there are two articles which discuss multi-objective particle swarm optimization (MOPSO) by either incorporating new mechanism and strategy or applying for cost-based feature selection in classification. Especially, in the fifth article "An Effective Application of Bacteria Quorum Sensing and Circular Elimination in MOPSO", Shan Cheng, Long-Long Zhao, and Xiao-Yu Jiang deals with MOPSO by incorporating a turbulence mechanism and a circular elimination strategy for enhancing its performance. In particular, the turbulence mechanism derived from bacteria quorum sensing behavior is introduced to MOPSO for preserving the diversity of the swarm. Meanwhile, the circular elimination strategy is used to select particles for next iteration for better distribution of the Pareto-optimal solutions. In the sixth article "Multi-Objective Particle Swarm Optimization Approach for Cost-Based Feature Selection in Classification", Yong Zhang, Dun-wei Gong, and Jian Cheng also studied the MOPSO specifically for cost-based feature selection in classification, which is to generate a Pareto front of non-dominated solutions, i.e., feature subsets, to meet different requirements of decision-makers in real-world applications. It is well-known that feature selection is an important data-preprocessing technique in classification problems such as bioinformatics and signal processing. In order to enhance the search capability, the authors incorporate the proposed algorithm with a probability-based encoding method and an effective hybrid operator, together with the ideas of the crowding distance, the external archive, and the Pareto domination relationship.

In the third group, there are two articles which discuss clustering and feature selection in terms of PSO. In particular, in the seventh article "A Novel Cluster Head Selection Algorithm Based on Fuzzy Clustering and Particle Swarm Optimization", Qingjian Ni, Qianqian Pan, Huimin Du, Cen Cao, and Yuqing Zhai pointed out that an important objective of wireless sensor network (WSN) is to prolong the network life cycle in means of topology control. In order to select cluster heads in hierarchical topology control, a solution based on fuzzy clustering preprocessing and particle swarm optimization was proposed. The fuzzy clustering is used to the initial clustering of nodes. The fitness function is designed by considering both the energy consumption and distance factors of WSN. Compared to traditional methods, the proposed method achieved the goal of reducing the mortality rate of nodes and extending the network life cycle. In the eighth article "A Gene Selection Method for Microarray Data Based on Binary PSO Encoding Gene-to-Class Sensitivity Information", Fei Han, Chun Yang, Ya-Qi Wu, Jian-Sheng Zhu, Qing-Hua Ling, Yu-Qing Song, and De-Shuang Huang presented an improved gene selection method based on binary particle swarm optimization (BPSO) and prior information for improving the interpretability of the selected genes and prediction accuracy. In the method, the gene-to-class sensitivity information extracted from the samples by extreme learning machine (ELM), is encoded into the selection process so that the functional gene subsets which are significantly sensitive to the samples' classes can be selected efficiently. With the few discriminative genes selected by the proposed method, ELM, K-nearest neighbor (KNN), and the support vector machine (SVM) classifier achieve much high prediction accuracy on five public microarray data.

In the fourth group, there are also two articles which show two real-world applications of novel bio-inspired swarm intelligence algorithms. In the ninth article "Three-Dimensional Path Planning for Uninhabited Combat Aerial Vehicle Based on Predator-Prey Pigeon-Inspired Optimization in Dynamic Environment", Bo Zhang and Haibin Duan proposed a novel bio-inspired predator-prey pigeon-inspired optimization (PPPIO) for solving uninhabited combat aerial vehicle (UCAV) three-dimension path planning problem in dynamic environments. In this algorithm, models for map and compass operator and landmark operator are used to search the best solution. The prey-predator concept is adopted to improve global best and enhance the convergence speed. In the tenth article "Solving NP-Hard Problems with Physarum-Based Ant Colony System", Yuxin Liu, Chao Gao, Zili Zhang, Yuxiao Lu, Shi Chen, Mingxin Liang, and Li Tao proposed a physarum-based ant colony system (ACS) for solving NP-Hard problems which exist in many real-world applications, for instance, traveling salesman problem (TSP) and 0/1 knapsack problem (0/1 KP). In the physarum-inspired mathematical model, a unique characteristic is the critical tube which is able to be reserved in the process of network evolution. The optimized updating strategy employs the unique feature to accelerate the positive feedback process in ACS, which contributes to the quick convergence of the optimal solution considerably.

This special section could be regarded as the epitome or a snapshot of the state of art bio-inspired swarm intelligence studies and applications in biological science and engineering, for attracting more and more researchers who are interested in swarm intelligence and its applications in biological science and engineering, to join and do the SI related researches so that much more excellent achievements and breakthroughs could come out timely. The guest editors hope this special section in this transactions will stimulate more and more new directions and solutions that can lead to both theoretical insights and practical

applications in swarm intelligence research as well as biological science. In such a way, they hope swarm intelligence can serve our society and life better and more efficient in near future. They are grateful to Associate editor-in-chief, Prof. Dong Xu, and editor-in-chief, Prof. Ying Xu, for giving us this opportunity to organize this timely special section. Then, they also appreciate all of the reviewers for their in-depth reviews of these articles. At last, that want to thank all of the authors who worked hard in writing and revising their papers carefully and earnestly by incorporating valuable comments from reviewers and editors in the past months. This work was supported by the Natural Science Foundation of China (61375119) and Beijing Natural Science Foundation (4162029), and partially by National Key Basic Research Development Plan (973 Plan) Project of China (2015CB352302).

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Guest Editors

Ying Tan is a professor at Peking University and the director of the Computational Intelligence Laboratory at Peking University. He invented the fireworks algorithm which has received extensive attention. He serves as the editor-in-chief of the *International Journal of Computational Intelligence and Pattern Recognition* and as an associate editor of the *IEEE Transactions on Cybernetics*, *IEEE Transactions on Neural Networks and Learning Systems*, etc. He also served as an editor of *Springer's Lecture Notes on Computer Science* for 19+ volumes, and guest editor of referred journals including *Information Science*, *Neurocomputing*, etc. He is the general chair of the ICSI-CCI 2015 joint conference, and was the founding general chair of the ICSI Series Conference (ICSI 2010-2014), program committee cochair of IEEE WCCI'2014, etc. His research interests include computational intelligence, swarm intelligence, machine learning, data mining for information security, etc. He has published 200+ papers, and authored six books and 10+ chapters in book, and received three invention patents.

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