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Preface

Ying Tan[1] · Yuhui Shi[2] · Xin Yao[3]

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As a branch of meta-heuristic algorithms, swarm intelligence is concerned with the collective behavior of decentralized, self-organized and populated systems. Inspired by the complex behavior of biological populations, researchers have proposed many distributed models or algorithms for problem-solving in complex environments by means of observing, abstracting, modeling, and simulating the collaborative behavior in nature biological populations. Usually, the optimization process of a swarm intelligence algorithm is a heuristic and iterative search process by constantly generating, updating, and selecting solutions. The research objective of swarm intelligence algorithm is to design optimization algorithms with the ability of problem-solving by taking inspiration from the intelligent behavior exhibited in biological communities and understanding the characteristics of the interaction mechanism in a swarm. Exploring the wisdom of collective behavior swarm intelligence algorithms have achieved great success in many practical problems, such as path planning, task scheduling, multi-robot systems, data mining and so on. Currently, swarm intelligence algorithms and their applications are widely studied.

✉ Ying Tan
ytan@pku.edu.cn

Yuhui Shi
Yuhui.Shi@xjtlu.edu.cn

Xin Yao
X.Yao@cs.bham.ac.uk

1 Peking University, Beijing, China

2 Xi-Jiao Liverpool University, Suzhou, China

3 Birmingham University, Birmingham, UK

One of the most popular swarm intelligence algorithm is the Particle Swarm Optimization (PSO), which is inspired by the social behavior of bird flocking and has been widely used in real-parameter optimization problems. Very recently, many nature-inspired algorithms have been proposed, such as the fireworks algorithm which is inspired by the fireworks explosions in the air. Besides the research on improvements of algorithms, a number of important applications of swarm intelligence algorithms, including PSO, have been reported in a variety of fields. The International Conference on Swarm Intelligence (ICSI) series conference is an important forum for researchers and practitioners to exchange latest advances in theories, technologies, and applications of swarm intelligence and related areas. The Sixth International Conference on Swarm Intelligence and the Second BRICS Congress on Computational Intelligence (ICSI-CCI'2015) were successfully held from June 26 to 29, 2015 in Beijing, China, with the goal of prompting a combination of the swarm intelligence and computational intelligence studies in BRICS countries. The theme of the ICSI-CCI'2015 was "Serving our society and life with intelligence". With the help of the technical committee of this joint event, some high-quality papers from the ICSI-CCI'2015 reflecting the latest advances in swarm intelligence algorithms and their applications were recommended for this special issue.

This special issue aims at promoting research on swarm intelligence and its applications by publishing some of the important advances in current research. A number of active researchers responded enthusiastically to our call for contributions. As the outcome of a thorough reviewing process, ten papers were chosen for this special issue.

The first paper "An Improved Dynamic Deployment Method for Wireless Sensor Network Based on Multi-swarm Particle Swarm Optimization" by Qingjian Ni, Huimin Du, Qianqian Pan, Cen Cao and Yuqing Zhai presents the dynamic deployment methods for wireless sensor network (WSN) for improving the quality of service (QoS) of the network by adjusting positions of mobile nodes. In the dynamic deployment problem model, not only the coverage rate of WSN but also the moving distance of mobile nodes are taken into consideration. This kind of model can be translated into a multi-objective optimization problem, and particle swarm optimization (PSO) is used to solve this problem. An improved dynamic deployment method is proposed based on multi-swarm PSO. More specifically, it proposes a discrete PSO to calculate the distance of mobile solutions, and a multi-swarm PSO is designed to optimize network performance for enhancing the QoS of deployment which includes higher coverage rate and lower energy consumption of mobile nodes. Experimental results demonstrate that the proposed method has a good performance in solving the WSN deployment problem.

The second paper is "A New Multi-agent System to Simulate the Foraging Behaviors of Physarum" by Yuxin Liu, Chao Gao, Zili Zhang, YuhengWu, Mingxin Liang, Li Tao and Yuxiao Lu. Physarum Polycephalum is a unicellular and multi-headed slime mold, which can form highly efficient networks connecting spatially separated food sources in the process of foraging. Such adaptive networks exhibit a unique characteristic in which network length and fault tolerance are appropriately balanced. Based on the biological observations, the foraging process of Physarum demonstrates two self-organized behaviors, i.e., search and contraction. In this paper, these two behaviors are captured in a multi-agent system. Two types of agents and three transition rules are designed to imitate the search and the contraction behaviors of Physarum based on the necessary and sufficient conditions of a self-organized computational system. Experimental results show that the system can autonomously search for food sources and then converge to a stable solution, which replicates the foraging process of Physarum. In particular, a case study of maze problem is used to estimate the path-finding ability of the foraging behaviors of Physarum. Moreover, the model inspired by the foraging behaviors of Physarum is proposed to optimize meta-heuristic algorithms for solving optimization problems. Through comparing the optimized algorithms and the corresponding traditional algorithms, it is found that the optimization strategies have a higher computational performance than their corresponding traditional algorithms, which further justifies the claim that the foraging behaviors of Physarum have a high computational ability.

The third paper "Particle Swarm Optimization with Dynamic Random Population Topology Strategies for a Generalized Portfolio Selection Problem" by Qingjian Ni, Xushan Yin, Kangwei Tian and Yuqing Zhai, proposes several feasible dynamic random population topologies based on a study of random population topology. In the PSO algorithm with dynamic random population topology, the neighborhood particles of a particle will evolve according to certain rules. More specifically, a population topology is abstracted into an undirected connected graph which could be randomly generated according to predefined rule and degree. By tuning the rule and degree, the communication mechanisms evolve in the evolutionary process and the solving performance of PSO is enhanced significantly. Furthermore, for the generalized portfolio selection model in the financial engineering field, several proposed PSO algorithms are employed to solve the problems related to the generalized portfolio selection model. The computational results demonstrate that the proposed dynamic random population topology could obviously improve the performance of PSO. It is especially worth noting that the dynamic random population topology strategy shows an excellent performance on most data sets which could find good solutions to the generalized portfolio selection problems.

The fourth paper "A Population-based Clustering Technique Using Particle Swarm Optimization and *k*-means" by Ben Niu, Qiqi Duan, Jing Liu and Lijing Tang, gives a population-based clustering technique which attempts to integrate different particle swarm optimizers (PSOs) with the famous k-means algorithm. Specifically, six existing extensively studied PSOs, which have shown promising performance for continuous optimization, are hybridized separately with Lloyd's k-means algorithm, leading to six PSO-based clustering methods. These PSO-based approaches use different social communications among neighbors to make some particles escape from local optima to enhance exploration, while k-means is utilized to refine the partitioning results for accelerating convergence. Comparative experiments on 12 synthetic and real-life datasets show that the proposed population-based clustering technique can obtain better and more stable solutions than five individual-based counterparts in most cases. Further, the effects of four different population topologies, three kinds of parameter settings, and two types of initialization methods on the clustering performance are empirically investigated. Moreover, for the first time, seven boundary handling strategies for PSOs are summarized.

The fifth paper "University Course Timetabling Using a New Ecogeography-based Optimization Algorithm" by Minxia Zhang, Bei Zhang and Neng Qian, adapted a new nature-inspired metaheuristic called ecogeography-based optimization (EBO) to solve the university course timetabling problem (UCTP). Here, the EBO enhances biogeography-based optimization (BBO) by equipping the population with a neighborhood structure and designing two new migration operators named global migration and local migration. In particular, the authors developed two discrete migration operators for efficiently evolving UCTP solutions based on the principle of global and local migration in EBO, and designed a repair process for effectively coping with infeasible timetables. The experimental results show that the proposed method exhibits a promising performance advantage over a number of state-of-the-art methods, by testing the discrete EBO algorithm on a set of problem instances from four universities in China.

The sixth paper is “Diversity Increasing Methods in PBIL-application to Power System Controller Design: A Comparison” by Komla A. Folly. Population-Based Incremental Learning (PBIL) has recently received increasing attention due to its effectiveness, easy implementation and robustness. Despite this, recent literature suggests that PBIL may suffer from issues of loss of diversity in the population, resulting in premature convergence. In this paper, three diversity maintaining PBIL methods are proposed to address the issue of loss of diversity in PBIL. The first method uses an adaptive learning rate as opposed to the fixed learning rate that is normally used in the standard PBIL. In this method, the learning rate is adapted according to the degree of evolution of the search space. That is, the learning rate is increased linearly with the number of generations. The second method uses two subpopulations and conduct independent search in parallel with the same initial probability vectors (PVs), but with fixed learning rates similar to the one used in the standard PBIL. In the third method, the concept of duality or opposition is combined with parallel PBIL as a means of controlling the diversity in the population. To evaluate the performances of these methods, they are applied to the problem of controller design in power systems to improve the small-signal stability. Simulation results show that the proposed diversity maintaining methods are able to maintain the diversity in the population longer than the standard PBIL.

The seventh paper is “A New Genetic Algorithm Based on Modified *Physarum* Network Model for Bandwidth-delay Constrained Least-cost Multicast Routing” by Mingxin Liang, Chao Gao and Zili Zhang. In this paper, a mobile ad hoc network (MANET) is a kind of popular self-configuring network, in which multicast routing under the quality of service (QoS) constraints, is a significant challenge. Many researchers have proved that such problem can be formulated as a NP-complete problem and proposed some swarm-based intelligent algorithms to solve the optimal solution, such as the genetic algorithm (GA), and bees algorithm (BA). However, a lower efficiency of local search ability and weak robustness still limit the computational effectiveness. This paper proposes a new hybrid algorithm inspired by the self-organization of Physarum, aiming to address those shortcomings. It uses an updating scheme based on Physarum network model (PM) for improving the crossover operator of traditional GAs, in which the same parts of parent chromosomes are reserved and the new offspring by the Physarum network model is generated. The simulation experiments show that PMGAs are more efficient than original GAs. More importantly, the PMGAs are more robust which is very important for solving the multicast routing problem. Moreover, a series of parameter analyses is used to find a set of better setting for realizing the maximum efficiency.

The eighth paper “Evolving Cooperation in Spatial Population with Punishment by Using PSO Algorithm” by Xiaoyang Wang, Lei Zhang, Xiaorong Du and Yunlin Sun, presents a multiplayer evolutionary game model in which agents play iterative games in spatial populations with punishment. Multi-player versions of the well-known Prisoner’s Dilemma and the Snowdrift games are used as the basis of the investigation. It presents and investigates the application of co-evolutionary training techniques based on particle swarm optimization (PSO) to evolve cooperation, and explores different parameter configurations via numerical simulations. Key model parameters include the number of players, the interaction topology, the punishment and the cost-to-benefit ratio. The simulation results reveal that the punishment can promote the levels of cooperative behaviors to some extent, the cost-to-benefit ratio and the number of players are important factors in determining the strategy evolution.

The ninth paper is “Dynamic Vehicle Routing with Time Windows in Theory and Practice” by Zhiwei Yang, Jan-Paul van Osta, Barry van Veen, Rick van Krevelen, Richard van Klaveren, Andries Stam, Joost Kok, Thomas Back and Michael Emmerich This paper is concerned with a variant of the vehicle routing problem with dynamically changing orders and time windows. In real-world applications the demands often change during operation time. New orders occur and others are canceled. In this case new schedules need to be generated on-the-fly. Online optimization algorithms for dynamical vehicle routing address this problem but so far they do not consider time windows. Moreover, to match the scenarios found in real-world problems adaptations of benchmarks are required. In this paper, a practical problem is modeled based on the procedure of daily routing of a delivery company. New orders by customers are introduced dynamically during the working day and need to be integrated into the schedule. A multiple ant colony algorithm combined with powerful local search procedures is proposed to solve the dynamic vehicle routing problem with time windows. The experimental results show that the multiple ant colony algorithm can get a much better solution for the academic benchmark problem and also can be integrated in a real-world environment.

The tenth paper is “An Improved Extremal Optimization Based on the Distribution Knowledge of Candidate Solutions” by Junfeng Chen, Yingjuan Xie, Hua Chen, Qiwen Yang, Shi Cheng and Yuhui Shi. Extremal optimization (EO) is a phenomenon-mimicking algorithm inspired by the Bak-Sneppen model of self-organized criticality from the field of statistical physics. The canonical EO works on a single solution and only employs mutation operator, which is inclined to prematurely converge to local optima. This paper develops a population-based extremal optimization algorithm to provide a parallel way for exploring the search space. In addition, a new mutation strategy named cloud mutation is proposed by analyzing the distribution knowledge of each component set in the solution set. The population-based extremal optimization with cloud mutation (PEO-CM) is characteristic of mining and recreating the uncertainty properties of candidate solutions in the search process. Finally, the proposed algorithm is applied to numerical optimization problems in comparison with other reported meta-heuristic algorithms.

These ten papers provide a snapshot of current studies on swarm intelligence which should be useful for learning about the current research in this relevant and challenging field. We hope that this special issue will stimulate new research results that can lead to progress in both theoretical insights and practical applications of swarm intelligence.

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