Theory and applications of soft computing methods

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The guiding principle of soft computing (SC) is to exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness, and low solution cost. The principal constituents of SC are fuzzy logic (FL), neural computing (NC), evolutionary computation (EC), and probabilistic reasoning (PR) with the latter subsuming belief networks, chaos theory, and parts of learning theory. We believe that the series of works in this special issue provide a useful reference for learning the current research progresses on SC. In total, ten papers have been selected to reflect the call of the thematic vision. The guest editors expect that the readers will benefit from the papers presented in the issue. The contents of these studies are briefly described as follows.

Nature-inspired algorithms usually use some form of attraction and diffusion as a mechanism for exploitation and exploration. In this paper, ‘Attraction and diffusion in nature-inspired optimization algorithms,’ X. S. Yang et al. investigate the role of attraction and diffusion in the nature-inspired algorithms and their ways in controlling the corresponding behaviors and performances. Different ways of implementations of the attraction in these algorithms, such as the firefly algorithm, charged system search, and gravitational search algorithm, are highlighted, and the diffusion mechanisms, e.g., random walks for exploration, are analyzed as well. It is clear that attraction can be an

effective way for enhancing exploitation, while diffusion is a common way for exploration. Furthermore, the role of parameter tuning and parameter control in the modern metaheuristic algorithms and some key topics for further research are discussed.

In nature, the eastern North American monarch population is known for its southward migration during the late summer/autumn from the northern USA and southern Canada to Mexico, covering thousands of miles. By simplifying and idealizing the migration of the monarch butterflies, in this paper, ‘Monarch butterfly optimization,’ G. G. Wang, S. Deb, and Z. Cui proposed a new kind of nature-inspired metaheuristic algorithm, called Monarch Butterfly Optimization (MBO). In the MBO, all the monarch butterfly individuals are located in two distinct lands, viz. southern Canada and northern USA (Land 1) and Mexico (Land 2). Accordingly, the positions of the monarch butterflies are updated in two ways. Firstly, the offsprings are generated (position updating) by migration operator, which can be adjusted using the migration ratio. It is followed by tuning the positions for other butterflies by means of butterfly adjusting operator. In order to keep the population unchanged and minimize fitness evaluations, the sum of all the butterflies newly generated in these two ways remains equal to the original population. To demonstrate the superior performance of the MBO algorithm, a comparative study with five other metaheuristic algorithms through 38 benchmark problems is carried out. The results clearly exhibit the distinguishing capability of the MBO method toward finding the optima on most of the benchmark problems.

In the classic evolutionary algorithms (EAs), solutions communicate with each other in a very simple way so that the recombination operator design is simple. However, it is not in accord with the nature, in which the species have various kinds of relationships and may affect each other in many ways. These relationships include competition, predation, parasitism, mutualism, and pathogenesis. In this paper, ‘Species co-evolutionary algorithm: a novel evolutionary algorithm based on the ecology and environments for optimization,’ Wuzhao Li et al. consider the five

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relationships among solutions to propose a co-evolutionary algorithm termed species co-evolutionary algorithm (SCEA). In the SCEA, five operators are designed to recombine individuals in population. A set including several well-known benchmarks are used to test the proposed algorithm. The comparison results show that it can yield excellent optimization performances.

Multi-focus image fusion is a process of combining a set of images that have been captured from the same scene but with different focuses in order to construct an additional sharper image. This process plays an important role in the image processing and machine vision fields. Numerous algorithms have been developed during the past decade. The key challenge in the design of multi-focus image fusion algorithms is how to evaluate the local content information of each image from the source images. Simple, but effective, block-based techniques at pixel level are widely used for multi-focus image fusion. However, a fixed block size may not be applicable to every application. A block size that is too small or too large is also not desirable. Hence, optimization of the block size is necessary in obtaining a fused image that comprises the sharper parts of the source images. Recently, a number of techniques based on evolutionary computation have been applied to block-based multi-focus image fusion. The artificial bee colony (ABC) algorithm is one of these approaches used to find an optimal solution. In this paper, ‘Multi-focus image fusion using best-so-far ABC strategies’ authored by Anan Bannharnsakun, an efficient and robust block-based multi-focus image fusion method on the basis of the optimal selection of sharper image blocks from source images using best-so-far ABC strategies is proposed. Experiment results show that the proposed method can provide good results and outperform other conventional algorithms, both visually and quantitatively.

Dynamic optimization has become an increasingly important aspect of chemical processes in the recent years. To solve such chemical dynamic optimization problems (DOPs), in this paper, ‘Self-adaptive differential evolution with multiple strategies for dynamic optimization of chemical processes,’ Bin Xu et al. put forward a modified differential evolution algorithm named XADE, which integrates the self-adaptive principle and multiple mutation strategies together. In the XADE, four mutation strategies with different characteristics are introduced instead of using a single strategy. Meanwhile, the mutation strategies and DE two control parameters are gradually and adaptively adjusted with the aid of the knowledge learned from the previous searches in generating improved solutions. The advantageous performance of the XADE is validated by comparisons with several *state-of-the-art* adaptive DE variants on a total of 24 complex test instances. Experimental results show that it is an efficient approach to

dealing with global numerical optimization problems. Moreover, the effectiveness of the XADE is examined using four real-world complex DOPs with different characteristic in the chemical engineering field.

An accurate estimation of exchange rate return volatility is an important step in financial decision making problems. In this paper, ‘A new NN-PSO hybrid model for forecasting Euro/Dollar exchange rate volatility,’ Ehsan Hajizadeh et al. aim at enhancing the ability of the GARCH-type family models in forecasting the Euro/Dollar exchange rate volatility. A new neural-network-based hybrid model is developed, in which a predefined number of simulated data series generated by the calibrated GARCH-type model along with other explanatory variables are used as input variables. The optimum number of these data series and other parameters of the network are tuned by an efficient particle swarm optimization algorithm. Using two datasets of Euro/Dollar rates, how the proposed hybrid model can reasonably enhance the results of the GARCH-type models and traditional neural networks in terms of different performance measures are demonstrated.

The urban green wave traffic control system is one of the widely applied means to handle the problems of urban traffic jams and vehicle delay. Aiming at the problems of traditional green wave traffic control, in this paper, ‘Green wave traffic control system optimization based on adaptive genetic-artificial fish swarm algorithm,’ C. Ma and R. He introduce the adaptive mechanism and crossover and mutation operators to the artificial fish swarm algorithm (AFSA) in order to adjust the evolution group. Based on the bulletin board measure and retention strategy, the individual status of the optimal artificial fish is recorded. The paper further employs this algorithm to green wave traffic control in five continuous intersections on Jianning Road, Lanzhou, China, which shows to be better than the traditional method. The feasibility and effectiveness of the adaptive genetic AFSA in optimizing green wave traffic control system are also verified.

In this paper, ‘Development of prediction models for shear strength of SFRCB using a machine learning approach,’ Masoud Sarveghadi et al. derive a new design equation for the assessment of shear resistance of steel fiber-reinforced concrete beams (SFRCB) utilizing the multi-expression programming (MEP). The superiority of the MEP over conventional statistical techniques is due to its ability in modeling the mechanical behavior without a need to pre-define the model structure. The MEP models are developed using a comprehensive database obtained through an extensive literature review. New criteria are checked to validate these models. Moreover, a sensitivity analysis is carried out and explored. The MEP models can provide good estimations of the shear strength of the

SFRCB, and the proposed models significantly outperform several equations reported in the literature.

The survival of the fittest is a major principle selecting the superior and eliminating the inferior in the nature. This principle has been used in many fields, especially in optimization problem-solving. Clustering in data mining community endeavors to discover unknown representations or patterns hidden in datasets. Hierarchical clustering algorithm (HCA) is a method of cluster analysis, which searches the optimal distribution of clusters by a hierarchical structure. The strategies for hierarchical clustering generally have two types: agglomerative with a bottom-up procedure and divisive with a top-down procedure. However, most of the clustering approaches have two disadvantages: the use of distance-based measurement and the difficulty of the cluster integration. In this paper, ‘OPE-HCA: an optimal probabilistic estimation approach for hierarchical clustering algorithm,’ J.C. Fan proposes an optimal probabilistic estimation (OPE) technique by exploiting the survival of the fittest principle. The author devise a new HCA based on the OPE, namely OPE-HCA, which combines optimization with probability and agglomerative HCA. Experimental results show that it has the ability of searching and discovering patterns at different description levels and can also obtain better performances than many clustering algorithms concerning the NMI and clustering accuracy measures.

Cubic-Plus-Association (CPA) equations of state (EoSs) are often used in describing thermodynamic properties of associating fluids. In the CPA EoSs, the association contribution proposed by Wertheim is added to cubic EoSs, such as Soave–Redlich–Kwong (SRK) and Peng–Robinson

(PR). In different developments of the CPA EoSs, adjusting the pure component properties, such as critical temperature and critical pressure, in addition to the association parameters has been examined in the literature. In this work, ‘Development of a novel Peng–Robinson plus association equation of state for industrially important associating compounds’ (authored by Leila Eslami and Behnam Khadem–Hamedani), the PR EoS has been extended to water, phenol, and a number of alcohols (methanol up to dodecanol) by addition of the Wertheim association contribution. In contrast to other CPA EoSs, the experimental values of the critical properties are used. The energy and co-volume parameters of the PR EoS are modified by introducing a correction factor correlated as a function of reduced temperature. The results show that this model is capable of reproducing experimental saturated liquid density and vapor pressure data accurately.

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