Guest Editorial Special Issue on Large-Scale Evolutionary Multiobjective Optimization and Its Practical Applications

COMPLEX optimization problems with hundreds or even thousands of decision variables and dozens of conflicting objectives are not uncommon in the real world. In the past five years, increased research efforts have been dedicated to large-scale multiobjective optimization problems (LSMOPs) by using a variety of search strategies, including variable grouping, variable analysis, problem transformation, dimensionality reduction, and novel recombination operators. Despite the success of these efforts in solving some general LSMOPs, there still remains a big gap between the LSMOPs that have been addressed and those encountered in real life, such as sparse, highly constrained, dynamic, and expensive LMOPs, as well as very large-scale and many-objective optimization problems that are widely seen and of paramount importance for solving scientific and engineering problems. Due to the significant practical importance of large-scale multiobjective optimization, there is a high demand for computationally efficient and effective evolutionary algorithms for solving LSMOPs.

This special issue has brought together researchers to report state-of-the-art contributions and development of theories and methodologies on large-scale evolutionary multiobjective optimization (EMO). For the record, a total of 32 submissions were received in response to our call for papers. Following a rigorous peer review process, four papers have been accepted for publication in this special issue. In what follows, we provide a brief summary of these papers.

The first paper by Liu et al. [A1] proposes a new test suite and a new EMO algorithm for large-scale multiobjective optimization. To better mimic the problems in real life, more realistic characteristics are captured in the new test suite, such as mixed formulation of objective functions, mixed linkages in variables, and imbalanced contributions of variables to the objectives. The newly proposed algorithm embeds a decision variable grouping-based learning strategy, which enables to generate high-quality solutions effectively. Experimental results show that problems in the new test suite are challenging and can comprehensively evaluate the performance of existing algorithms for evolutionary large-scale multiobjective optimization. The experimental results also validate the superiority of the newly proposed algorithm over several representative competitors, including the algorithms based on decision variable analysis, the algorithms based on problem reformulation, and the algorithms based on novel strategies.

The second paper by Yao et al. [A2] proposes an EMO algorithm for solving a problem with many objectives and a large number of decision variables. The proposed algorithm first clusters and aggregates the objectives with high correlation by a dimensionality reduction method of objective functions based on correlation. Then, the algorithm solves the objective-reduced large-scale many-objective optimization problems using a solution knowledge-guided evolutionary strategy, which consists of a mirror partitioning-based population initialization method and a solving knowledge-guided sampling method. Experimental results indicate that the proposed algorithm is superior to seven advanced algorithms on three representative benchmark test suites.

The third paper by He et al. [A3] introduces an EMO algorithm to solve the flowshop sequence-dependent group scheduling problems with the energy efficiency indicators. To address this issue, a multiobjective mixed-integer linear programming (MILP) problem incorporating an energy indicator is defined in this work. An EMO algorithm is suggested to solve the formulated multiobjective MILP problem, where an accelerated inserting strategy based on the problem-specific knowledge is proposed to save computational effort, and a greedy energy-saving strategy is adopted to adjust the processing speed of machines. The experimental results show that the proposed algorithm significantly outperforms the existing classic multiobjective algorithms on the formulated multiobjective MILP problem, which is due to the usage of problem-related knowledge.

The fourth paper by Yang et al. [A4] proposes an EMO framework to solve a MOP with a large number of decision variables. Different from existing EMO algorithms, the proposed method blurs the decision variables of the original solutions to reduce the search range of each variable for achieving quick convergence in solving LSMOPs. In the proposed framework, the fuzzy evolution substages division method is used to divide the fuzzy evolution stage into multiple substages with a gradually decreasing degree of fuzzification of the decision variable range. The experimental results show that the proposed framework can significantly accelerate the

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convergence speed of general EMO algorithms in solving LSMOPs with 500–5000 decision variables.

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APPENDIX: RELATED ARTICLES

[A1] S. Liu, Q. Lin, K.-C. Wong, Q. Li, and K. C. Tan, "Evolutionary large-scale multiobjective optimization: Benchmarks and algorithms," *IEEE Trans. Evol. Comput.*, early access, Jul. 26, 2021, doi: 10.1109/TEVC.2021.3099487.

[A2] X. Yao, Q. Zhao, D. Gong, and S. Zhu, "Solution of large-scale many-objective optimization problems based on dimension reduction and solving knowledge guided evolutionary algorithm," *IEEE Trans. Evol. Comput.*, early access, Sep. 7, 2021, doi: 10.1109/TEVC.2021.3110780.

[A3] X. He, Q.-K. Pan, L. Gao, L. Wang, and P. N. Suganthan "A greedy cooperative co-evolutionary algorithm with problem-specific knowledge for multi-objective flowshop group scheduling problems," *IEEE Trans. Evol. Comput.*, early access, Sep. 27, 2021, doi: 10.1109/TEVC.2021.3115795.

[A4] X. Yang, J. Zou, S. Yang, J. Zheng, and Y. Liu, "A fuzzy decision variables framework for large-scale multiobjective optimization," *IEEE Trans. Evol. Comput.*, early access, Oct. 7, 2021, doi: 10.1109/TEVC.2021.3118593.

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