IEEE CEC 2025 Tutorial Proposal

Tutorial Title: New EMO Algorithm Framework with an Unbounded External Archive: Basic Ideas and Research Directions

Abstract: In the field of evolutionary multi-objective optimization (EMO), early EMO algorithms in the 1990s are called non-elitist algorithms where no solutions in the current population are included in the next population. That is, the next population is the offspring population of the current population. This non-elitist algorithm framework is clearly inefficient since we cannot preserve good solutions during the execution of EMO algorithms. As a result, almost all EMO algorithms in the last two decades are based on the elitist framework where the next population is selected from the current population and its offspring population. In both frameworks, the final population is presented to the decision maker as the final output from EMO algorithms. Recently, some potential difficulties of the elitist framework have been pointed out. One is that the final population is not always the best subset of all the examined solutions. It was demonstrated in the literature that some solutions in the final population are dominated by other solutions generated and deleted in previous generations. It is also difficult to utilize solutions in previous generations to generate new solutions. Offspring are always generated from solutions in the current population. Another difficulty is that only a limited number of solutions (i.e., only solutions in the final population) are obtained. A new framework with an unbounded external archive can easily handle these difficulties since the final solution set is selected from all the examined solutions. In this framework, we can select an arbitrary number of solutions as the final output from EMO algorithms. Stored solutions in the external archive can be used to create new solutions and also to select solutions for the next population. In this tutorial, some interesting research issues in the new EMO algorithm framework are explained.

Tutorial Keywords: New EMO algorithm framework, unbounded external archive

Potential audiences: The potential audience includes researchers who are currently working in evolutionary multi-objective optimization (EMO) and those who are interested in the EMO field. This tutorial is designed to provide EMO researchers with a comprehensive understanding of how to effectively utilize unbounded external archives in EMO algorithms using the new framework. This tutorial will also discuss some interesting issues in the EMO algorithm framework, which will provide the audience with new ideas for designing high-performance EMO algorithms.

Name, affiliation, and emails of tutorial presenters:

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- 2. Hisao Ishibuchi, Southern University of Science and Technology, hisao@sustech.edu.cn

Biographies of speakers:

Lie Meng Pang received her Bachelor of Engineering degree in Electronic and Telecommunication Engineering and Ph.D. degree in Electronic Engineering from the Faculty of Engineering, Universiti Malaysia Sarawak, Malaysia, in 2012 and 2018, respectively. She is currently a research associate with the Department of Computer Science and Engineering, Southern University of Science and Technology (SUSTech), China. Her current research interests include evolutionary multi-objective optimization and fuzzy systems.

Hisao Ishibuchi is a Chair Professor at Southern University of Science and Technology, China. He was the IEEE Computational Intelligence Society (CIS) Vice-President for Technical Activities in 2010-2013 and the Editor-in-Chief of *IEEE Computational Intelligence Magazine* in 2014-2019. Currently he is an IEEE CIS Administrative Committee Member, an IEEE CIS Distinguished Lecturer, and an Associate Editor of several journals such as *IEEE Transactions on Cybernetics* and *ACM Computing Surveys*. He is also General Chair of IEEE WCCI 2024. He received a Fuzzy Systems Pioneer Award from IEEE CIS in 2019, an Outstanding Paper Award from *IEEE Transactions on Evolutionary Computation* in 2020, an Enrique Ruspini Award for Meritorious Service from IEEE CIS, and Best Paper Awards from FUZZ-IEEE 2009, 2011, EMO 2019, and GECCO 2004, 2017, 2018, 2020, 2021. He also received a JSPS prize in 2007. He is an IEEE Fellow.

Other info

The speakers have been actively involved in the development of the new EMO framework in recent years and have observed its increasing attention within the EMO community. Below, we provide a list of papers related to the content of this tutorial:

[1] H. Ishibuchi, L. M. Pang, and K. Shang, "A new framework of evolutionary multi-objective algorithms with an unbounded external archive," in *Proceedings of the 24th European Conference on Artificial Intelligence (ECAI 2020)*, pp. 283-290, 2020.

[2] K. Shang, T. Shu, H. Ishibuchi, Y. Nan, and L. M. Pang, "Benchmarking large-scale subset selection in evolutionary multi-objective optimization," *Information Sciences*, vol. 622, pp. 755-770, 2023.

[3] T. Shu, K. Shang, H. Ishibuchi, and Y. Nan, "Effects of archive size on computation time and solution quality for multi-objective optimization," *IEEE Transactions on Evolutionary Computation*, vol. 27, no. 4, pp. 1145-1153, 2023.

[4] Y. Peng and H. Ishibuchi, "A diversity-enhanced subset selection framework for multimodal multiobjective optimization," *IEEE Transactions on Evolutionary Computation*, vol. 26, no. 5, pp. 886-900, 2022.

[5] W. Chen, H. Ishibuchi, and K. Shang, "Fast greedy subset selection from large candidate solution sets in evolutionary multiobjective optimization," *IEEE Transactions on Evolutionary Computation*, vol. 26, no. 4, pp. 750-764, 2022.

[6] Y. Nan, T. Shu, and H. Ishibuchi, "Effects of external archives on the performance of multiobjective evolutionary algorithms on real-world problems," in *Proceedings of IEEE Congress on Evolutionary Computation (CEC 2023)*, pp. 1-8, 2023.

[7] L. Chen, L. M. Pang, H. Ishibuchi, and K. Shang, "Periodical weight vector update using an unbounded external archive for decomposition-based evolutionary multi-objective optimization," *in Proceedings of 2021 IEEE Symposium Series on Computational Intelligence (SSCI)*, pp. 1-8, 2021.

[8] L. Chen, L. M. Pang, H. Ishibuchi, and K. Shang, "Periodical generation update using an unbounded external archive for multi-objective optimization," *in Proceedings of 2021 IEEE Congress on Evolutionary Computation (CEC)*, 2021, pp. 1912-1920.

[9] L. M. Pang, H. Ishibuchi, and K. Shang, "Decomposition-based multi-objective evolutionary algorithm design under two algorithm frameworks," *IEEE Access*, vol. 8, pp. 163197-163208, 2020.

[10] L. M. Pang, H. Ishibuchi, and K. Shang, "Algorithm configurations of MOEA/D with an unbounded external archive," in *Proceedings of 2020 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, 2020, pp. 1087-1094.

As additional information, the speakers have experience in delivering tutorials at multiple prestigious international conferences, as outlined below:

IEEE International Conference on Systems, Man, and Cybernetics (SMC 2024)

Tutorial title: Introduction to Evolutionary Multi-Objective Optimization Speakers: Hisao Ishibuchi and Lie Meng Pang

IEEE World Congress on Computational Intelligence (WCCI) 2024

Tutorial title: New EMO Algorithm Framework with an Unbounded External Archive: Basic Ideas and Research Directions Speakers: Lie Meng Pang, Ke Shang, and Hisao Ishibuchi

IEEE World Congress on Computational Intelligence (WCCI) 2024

Tutorial title: Fair Performance Comparison of Evolutionary Multi-Objective Algorithms Speakers: Lie Meng Pang, Ke Shang, and Hisao Ishibuchi

The Genetic and Evolutionary Computation Conference (GECCO) 2024

Tutorial title: New Framework of Multi-Objective Evolutionary Algorithms with Unbounded External Archive Speakers: Hisao Ishibuchi, Lie Meng Pang and Ke Shang

IEEE 2023 Congress on Evolutionary Computation (CEC)

Tutorial title: How to Compare Evolutionary Multi-Objective Optimization Algorithms: Parameter Specifications, Indicators and Test Problems Speakers: Lie Meng Pang, Ke Shang and Hisao Ishibuchi

The Genetic and Evolutionary Computation Conference (GECCO) 2022

Tutorial title: Difficulties in Fair Performance Comparison of Multiobjective Evolutionary Algorithms Speakers: Hisao Ishibuchi, Lie Meng Pang, and Ke Shang

IEEE World Congress on Computational Intelligence (WCCI) 2022

Tutorial title: How to Compare Evolutionary Multi-Objective Optimization Algorithms: Parameter Specifications, Indicators and Test Problems Speakers: Hisao Ishibuchi, Lie Meng Pang, and Ke Shang