Tutorial

Title

Preference-Based Evolutionary Multi-Objective Optimization: Steppingstone to Involve Human in the Loop

Abstract

The ultimate goal of multi-objective optimization is to help a decision maker (DM) identify solution(s) of interest (SOI) achieving satisfactory trade-offs among multiple conflicting criteria. This can be realized by leveraging DM's preference information in evolutionary multiobjective optimization (EMO). No consensus has been reached on the effectiveness brought by incorporating preference in EMO (either a priori or interactively) versus a posteriori decision making after a complete run of an EMO algorithm. In this tutorial, I will present a series of experimental results show that preference incorporation in EMO does not always lead to a desirable approximation of SOI if the DM's preference information is not well utilized, nor does the DM elicit invalid preference information, which is not uncommon when encountering a black-box system. To a certain extent, this issue can be remedied through an interactive preference elicitation. Last but not the least, we find that a preference-based EMO (PBEMO) algorithm is able to be generalized to approximate the whole PF given an appropriate setup of preference information.

Duration

The duration is expected to be around 90 mins.

Motivation

n practical multi-criterion decision-making, it is cumbersome if a decision maker (DM) is asked to choose among a set of trade-off alternatives covering the whole Pareto-optimal front. This is a paradox in conventional evolutionary multi-objective optimization (EMO) that always aim to achieve a well balance between convergence and diversity. The synergy of ideas between evolutionary multi-objective optimization (EMO) and multi-criteria decision-making (MCDM) is an exciting direction to push the boundary of multi-objective optimization and decision-making. This tutorial paves an avenue towards human-centric multi-objective optimization and decision-making by marrying EMO and MCDM.

Expected audience

The intended audience of this tutorial can be both novices and people familiar with EMO or PBEMO. In particular, it is self-contained that foundations of multi-objective optimization and the basic working principles of EMO algorithms will be included for those without experience in EMO to learn.

Outline of contents

This tutorial consists of the following parts:

1) A gentle tutorial of evolutionary multi-objective optimization (EMO) and selected applications.
2) Selected working examples of incorporating decision makers' preference in a posteriori, a priori, and interactive manner, respectively.
3) A systematic empirical study that investigates the effectiveness brought by preference incorporation in EMO for approximating different kinds of solutions of interest.
4) Discuss the future opportunities for possible further developments.

Key references

[1] K. Li, G. Lai, X. Yao, Interactive Evolutionary Multi-Objective Optimization via Learning-to-Rank, IEEE Transactions on Evolutionary Computation, accepted for publication, 2023.
[2] K. Li, H. Nie, H. Gao, X. Yao, Posterior Decision-Making Based on Decomposition-Driven Knee Point Identification, IEEE Transactions on Evolutionary Computation, 26(6): 1409-1423, 2022.
[3] K. Li, M. Liao, K. Deb, G. Min, X. Yao, Does Preference Always Help? A Holistic Study on Preference-Based Evolutionary Multi-Objective Optimisation Using Reference Points, IEEE Transactions on Evolutionary Computation, 24(6): 1078–1096, 2020.
[4] K. Li, R. Chen, D. Savic, X. Yao, Interactive Decomposition Multi-Objective Optimization via Progressively Learned Value Functions, IEEE Transactions on Fuzzy Systems, 27(5): 845–860, 2019.
[5] K. Li, R. Chen, G. Min, X. Yao, Integration of Preferences in Decomposition Multiobjective Optimization, IEEE Transactions on Cybernetics, 48(12): 3359–3370, 2018.
[6] K. Li, K. Deb, X. Yao, R-Metric: Evaluating the Performance of Preference-Based Evolutionary Multi-Objective Optimization Using Reference Points, IEEE Transactions on Evolutionary Computation, 22(6): 821–835, 2018.
[7] K. Li, Progressive Preference Learning: Proof-of-Principle Results in MOEA/D, Proc. of the 10th International Conference on Evolutionary Multi-Criterion Optimization (EMO'19), Springer LNCS, volume 11411, p. 631–643, March 2019.
[8] R. Chen, K. Li, Knee Point Identification Based on the Geometric Characteristic, Proc. of the 2021 IEEE International Conference on Systems, Man, and Cybernetics (SMC'21), IEEE, p. 764–769, October, 2021.
[9] H. Nie, H. Gao, K. Li, Knee Point Identification Based on Voronoi Diagram, Proc. of the 2020 IEEE Conference on Systems, Man and Cybernetics (SMC'20), IEEE Press: p. 1–6, December, 2020.
[10] G. Lai, M. Liao, K. Li, Empirical Studies on the Role of the Decision Maker in Interactive Evolutionary Multi-Objective Optimization, Proc. of the 2021 IEEE Congress on Evolutionary Computation (CEC'21), IEEE, p. 1–8, June, 2021.

List of speakers

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Ke Li is a Senior Lecturer in Computer Science at the Department of Computer Science, University of Exeter. His current research interests include the evolutionary multi-objective optimization, machine learning and applications in science and engineering. He was the founding chair of IEEE

Computational Intelligence Society (CIS) Task Force on Decomposition-based Techniques in Evolutionary Computation from 2019 to 2022. He currently serves as an associate editor of IEEE Transactions on Evolutionary Computation, International Journal of Machine Learning and Cybernetics and Complex & Intelligent Systems. He served as a guest editor in Neurocomputing Journal and Multimedia Tools and Applications Journal. He has been awarded a prestigious UKRI Future Leaders Fellow (FLF) and a Turing Fellow with the Alan Turing Institute. Since 2020, he has been recognized as being in the Stanford list of top 2% of scientists in the world (ranked as #2625 in the AI field). In 2021, he was awarded an Amazon Research Award for which I am 1 of only 3 winners in the UK, and he was selected in the finalist of a Facebook Research Award. In 2020, he was awarded Research Excellence Award of the CEMPS Academic Recognition Awards 2020 and Teaching Awards 2020 as Outstanding Supervisor. Only one STEM faculty can be selected for these two awards at the UoE.