Pareto Optimization for Subset Selection: Theories and Practical Algorithms

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Abstract:

Pareto optimization is a general optimization framework for solving single-objective optimization problems, based on multi-objective evolutionary optimization. The main idea is to transform a single-objective optimization problem into a bi-objective one, then employ a multi-objective evolutionary algorithm to solve it, and finally return the best feasible solution w.r.t. the original single-objective optimization problem from the generated non-dominated solution set. Pareto optimization has been shown a promising method for the subset selection problem, which has applications in diverse areas, including machine learning, data mining, natural language processing, computer vision, information retrieval, etc. The theoretical understanding of Pareto optimization has recently been significantly developed, showing its irreplaceability for subset selection. This tutorial will introduce Pareto optimization from scratch. We will show that it achieves the best-so-far theoretical and practical performances in several applications of subset selection. We will also introduce advanced variants of Pareto optimization for large-scale, noisy and dynamic subset selection.

Outline of Tutorial Structure:

Subset selection aims to select a subset from a total set of items for optimizing some given objective function while satisfying some constraints. It is quite general, and has applications in diverse areas, including machine learning, data mining, natural language processing, computer vision, information retrieval, etc. Pareto optimization solves single-objective optimization problems by multi-objective evolutionary optimization, and has achieved best-so-far theoretical and practical performances for various applications of subset selection. This tutorial will introduce Pareto optimization for subset selection from scratch, and thus is highly relevant to the main event of IEEE CEC. The significance of this tutorial lies in the following aspects.

1. This tutorial will show an important application of multi-objective evolutionary optimization.
2. This tutorial will show that in addition to good empirical performance, multi-objective evolutionary optimization can be well theoretically grounded.
3. For the general subset selection problem (which may have a large number of audience), this tutorial introduces a new powerful solver.
4. This tutorial can motivate the application of Pareto optimization for solving single-objective optimization problems other than subset selection.

Intended audience

Potential audiences include those who are curios in theoretically grounded evolutionary algorithms, and those who are interested in subset selection as well as applying evolutionary algorithms to achieve state-of-the-art performance in machine learning, data mining, natural language processing, etc..

Organizer/Presenter

Chao Qian is an Associate Professor in the School of Artificial Intelligence, Nanjing University, China. He received the BSc and PhD degrees in the Department of Computer Science and Technology from Nanjing University. After finishing his PhD in 2015, he became an Associate Researcher in the School of Computer Science and Technology, University of Science and Technology of China, until 2019, when he returned to Nanjing University. His research interests are mainly theoretical analysis of evolutionary algorithms (EAs), design of safe and efficient EAs, and applications of EAs to solve real-world complex problems. He has published one book “Evolutionary Learning: Advances in Theories and Algorithms” and 40 papers in top-tier journals (AIJ, TEvC, ECJ, Algorithmica, TCS) and conferences (AAAI, IJCAI, ICLR, NeurIPS). He has won the ACM GECCO 2011 Best Theory Paper Award, the IDEAL 2016 Best Paper Award, and the IEEE CEC 2021 Best Student Paper Award Nomination. He is an associate editor of IEEE Transactions on Evolutionary Computation, and an editorial board member of the Memetic Computing journal. He is a member of Evolutionary Computation Technical Committee, and was the chair of IEEE Computational Intelligence Society (CIS) Task Force on Theoretical Foundations of Bio-inspired Computation. He has been invited to give an Early Career Spotlight Talk "Towards Theoretically Grounded Evolutionary Learning" at IJCAI 2022.