Tutorial: Evolutionary Multi-objective Optimization: Past, Present and Future

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Tutorial Speaker:

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Abstract:

Genetic algorithms (GAs) were first formally demonstrated to solve optimization problems head-to-head with classical point-based methods in 1975 by Kenneth De Jong. Goldberg and Richardson demonstrated the use of GAs for finding multiple optimal solutions for a single-objective multi-modal function in 1987. All these early studies led to the suggestion of three evolutionary multi-objective optimization (EMO) algorithms during 1993-95, following a suggestion by Goldberg (1989), which marked the beginning of the EMO field. Now, there are more than 7,000 papers and reports generated every year in EMO with more than 50% of them being applied to outside computer science and engineering area. About 25% of IEEE TEVC published papers are in EMO area. The three most popular IEEE TEVC papers in the whole GEC field comes from EMO field and three of top five most cited Evolutionary Computational Journal (MIT Press) papers are from EMO area. There are at least three major software companies which survive on EMO algorithms. Every day, EMO is attracting new researchers and practitioners into the field.

In this tutorial, we shall provide a systematic and chronological account of how EMO field was started, details of a few key EMO algorithms that made the field popular, and key applications which show-case their practical importance. We shall discuss in details key current research topics which will motivate new-comers to get started with directions. Some of the topics which would be covered are: Evolutionary many-objective optimization, surrogate-assisted EMO, robust and reliability based EMO, EMO with decision-making, Multiobjectivization, EMO based knowledge extraction, theoretical advancements of EMO, and others. Finally, we shall discuss the presenter's account on immediate and futuristic research ideas of the field. Some of these topics will include EMO for dynamic problems, EMO for bilevel problems, EMO for machine learning including CNN and DNN architecture search and EMO for very large-scale problems. The tutorial will be concluded by pointing to number of different resources (books, public domain codes, key websites, and others) and by demonstrating working of a few public domain codes.

Keywords

Multi-objective Optimization, Many-objective optimization, Multi-Criteria Decision Making, Applications.

Tutorial Description

- **Multi-objective Optimization**

  To begin with, an introduction is provided to multi-objective optimization problems with a systematic definition of domination and recently proposed generalized domination principles. Description on how evolutionary computation algorithms help solve multi-objective optimization problems will be highlighted.

- **Early Evolutionary Multi-objective Optimization (EMO) Methods**

  Our discussion will start with three fundamental EMO algorithms proposed during 1993-95 to provide a good understanding of how the EMO research had started. Followed the discussion on algorithms, key research results on test problem development and performance metric suggestions will be presented.

- **Elitist EMO and Evol. Many-objective Optimization (EMaO) Methods**

  Starting with the second generation of EMO algorithms, the discussion will move to the need and description of many-objective optimization algorithms. Key research results and outcome will be discussed next.

- **Current Research Trends**

  The above discussions will set up the background to discuss current research trends in the field, so that participants are aware of the current research directions. This will include diversification of EMO concepts to various other problem solving tasks, including machine learning based EMO, Innovization, dynamic EMO, multi-level EMO, large-scale applications, etc.

- **Future Research Directions**

  A number of immediate and future research ideas on generic multi-objective optimization problem-solving methods are highlighted related to interactive EMO, decision making based EMO, handling more than 10-15 objectives, EMO to help solve machine learning algorithms, etc.

- **Demonstration of pymoo software**

  We shall end the tutorial with an introduction to fast-becoming popular public domain software for multi- and many-objective optimization algorithms.

Target Audience

Multi-objective optimization is increasingly being found to be effective in many problem-solving tasks in practice. Most of the classical optimization methods are not suitable to find multiple trade-off optimal solutions. This offers a niche to the researchers in the field of evolutionary computation to work on the development and application of efficient EMO procedures. This tutorial will provide them with necessary background materials, key past and current methodologies, and a number of future directions.

Short Biography

Kalyanmoy Deb is University Distinguished Professor and Koenig Endowed Chair Professor at the Michigan State University in Michigan USA. He is IEEE CIS EC Pioneer awardee and IEEE fellow. He has written two textbooks on optimization and more than 590 international journal and conference research papers with more than 175,000 Google Scholar citations and h-index of 129. He is a pioneer in the field of evolutionary multi-objective optimization. More information about his research can be found from http://www.egr.msu.edu/~kdeb.