Evolutionary Algorithms and Hyper-Heuristics

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Abstract:

Hyper-heuristics is a rapidly developing domain which has proven to be effective at providing generalized solutions to problems and across problem domains. Evolutionary algorithms have played a pivotal role in the advancement of hyper-heuristics and is continuing to do so. The aim of the tutorial is to firstly provide an introduction to evolutionary algorithm hyper-heuristics for researchers interested in working in this domain. An overview of hyper-heuristics will be provided including the assessment of hyper-heuristic performance. The tutorial will examine each of the four categories of hyper-heuristics, namely, selection constructive, selection perturbative, generation constructive and generation perturbative, showing how evolutionary algorithms can be used for each type of hyper-heuristic. A case study will be presented for each type of hyper-heuristic to provide researchers with a foundation to start their own research in this area. The EvoHyp library will be used to demonstrate the implementation evolutionary algorithm hyper-heuristic. A theoretical understanding of evolutionary algorithm hyper-heuristics will be provided. A new measure to assess the performance of hyper-heuristic performance will also be presented. Challenges in the implementation of evolutionary algorithm hyper-heuristics will be highlighted. The tutorial will also examine recent trends in evolutionary algorithm hyper-heuristics such as transfer learning and automated design. The use of hyper-heuristics for the automated design of evolutionary algorithms will be examined as well as the application of evolutionary algorithm hyper-heuristics for the design of computational intelligence techniques. The tutorial will end with a discussion session on future directions in evolutionary algorithms and hyper-heuristics.

Outline of Tutorial Structure:

The tutorial will be divided into three parts. The first will cover introductory topics and provide researchers with a foundation to start research in this domain. The second section covers the emerging research direction of hyper-heuristics and automated design. Hyper-heuristics for evolutionary algorithm design and evolutionary algorithm hyper-heuristics for automated design. The last part is a discussion session looking at future research directions in evolutionary algorithms and hyper-heuristics.

Part I

1. An Overview of Hyper-Heuristics

The section firstly presents low-level heuristics leading to a description of hyper-heuristics. This is followed by a classification of hyper-heuristics which will introduce the four types of hyper-heuristics, namely, selection constructive, selection perturbative, generation constructive and generation perturbative. The section will conclude by examining measures for the performance of hyper-heuristic performance.

1.1 Low-Level Heuristics

1.2 Classification of Hyper-Heuristics

1.3 Assessment of Hyper-Heuristic Performance

2. Evolutionary Algorithm Hyper-Heuristics
This section will describe details of the evolutionary algorithms used and applications for each type of hyper-heuristic. A case study will be presented for each type of hyper-heuristic to illustrate how the hyper-heuristic can be applied. The EvoHyp Java evolutionary algorithm hyper-heuristic library will be used to demonstrate the implementation of evolutionary algorithm hyper-heuristics for each case study. A theoretical understanding of evolutionary algorithm hyper-heuristics will be presented. The section concludes by looking at the challenges associated with the implementation of evolutionary algorithm hyper-heuristics and potential solutions.
2.1 Selection Constructive Hyper-Heuristics
2.2 Selection Perturbative Hyper-Heuristics
2.3 Generation Constructive Hyper-Heuristics
2.4 Generation Perturbative Hyper-Heuristics
2.5 Theoretical Analysis
2.6 Transfer Learning Hyper-Heuristics
2.7 Challenges

Part II

3. Hyper-Heuristics for Evolutionary Algorithm Design
Hyper-heuristics have proven to be effective in the design of evolutionary algorithms. This has ranged from parameter tuning, selection of operators, to generation of operators and algorithm components. This section will provide a synopsis of how evolutionary algorithms can be designed using hyper-heuristics.

4. Evolutionary Algorithm Hyper-Heuristics for Design
One of the recent research directions in the area of hyper-heuristics is the use of hyperheuristics for design. This section provides an account of the use of evolutionary algorithm hyper-heuristics for design. An overview of how evolutionary algorithms can be used for the design of algorithms and techniques such as metaheuristics, and example applications will be provided.

5. Transfer Learning
The effectiveness of transfer learning in evolutionary algorithms has previously been established. The effectiveness in evolutionary algorithms will be examined and highlighting benefits for hyper-heuristics assessed in terms of both objectivity and generality.

Part III

6. Discussion Session: Future Research Directions

Intended audience
The tutorial is aimed at researchers in computational intelligence who have an interest in hyper-heuristics or have just started working in this area. A background in evolutionary algorithms is assumed.

Organizer/Presenter

This tutorial on “Evolutionary Algorithm Hyper-Heuristics” has previously been given by the presented at PPSN 2022, SSCI 2022, SSCI 2021, CEC 2021, PPSN 2020, CEC 2020, CEC 2019, CEC 2018, PPSN 2018, CEC 2017, PPSN 2016 and CEC 2015. The presenter is a Professor at the University of Pretoria, South Africa. The presenter is co-author of the first book on hyper-heuristics, “Hyper-Heuristics: Theory and Applications”, published by Springer.
She holds the Multichoice Joint-Chair in Machine Learning and SARChI Chair in Artificial Intelligence for Sustainable Development. She is chair of the IEEE Technical Committee on Intelligent Systems Applications, Vice Chair of the IEEE Technical Committee on Evolutionary Computation, chair of the IEEE Task Force on Automated Algorithm Design, Configuration and Selection and chair of the IEEE CIS WCI subcommittee. She is associate editor for IEEE Computational Intelligence Magazine, IEEE Transactions on Emerging Topics in Computational Intelligence, Swarm and Evolutionary Computation, ACM Transactions on Evolutionary Learning and Optimization and the Journal of Scheduling. Her research areas include hyper-heuristics, automated design of machine learning and search techniques, transfer learning in evolutionary algorithms, combinatorial optimization, genetic programming, genetic algorithms and deep learning. These are the focus areas of the NICOG (Nature-Inspired Computing Optimization) research group which she has established. She has published in these areas in journals, national and international conference proceedings. She has served on program committees for numerous national and international conferences and is a reviewer for various international journals.