# Transfer Learning in Evolutionary Spaces

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## Abstract:

Evolutionary algorithms have been effectively applied to various search spaces. Traditionally evolutionary algorithms explore a solution space. However, since their inception the application of evolutionary algorithms has been extended to other spaces including the program, heuristic and design spaces. More recently the potential of transfer learning in evolutionary algorithms, focusing predominantly on the solution and program spaces, has been established. This tutorial examines the use of transfer learning in the application of evolutionary algorithms to four spaces, namely, the solution, program, heuristic (hyper-heuristics) and design (automated design of machine learning and search algorithms) spaces. The tutorial will provide an overview of transfer learning for the four spaces in terms of what to transfer, when to transfer and how to transfer knowledge. A case study for each of the spaces will be presented. The benefits of transfer learning for each of the four spaces will be highlighted. Determining what knowledge to transfer, when to transfer the knowledge and how to transfer the knowledge for the different spaces is itself an optimization problem. Traditionally this has been done manually. The tutorial will also look at how this process can be automated. A Python library ATLEA (Automated Transfer Learning for Evolutionary Algorithms) for the automated design of transfer learning in evolutionary algorithms will be presented.

## Outline of Tutorial Structure:

1. Evolutionary Spaces

This tutorial firstly provides an overview of the evolutionary spaces that it will be focussing on:

1.1 Solution space
1.2 Program space
1.3 Heuristic space
1.4 Design space

2. Introduction to Transfer Learning in Search

The tutorial will then provide an overview of the use of transfer learning in search:

2.1 An overview of transfer learning
2.2 How can transfer learning be used in search?
2.2 Benefits of using transfer learning in search

3. Transfer learning in the solution space

This part of the tutorial will focus on transfer learning in evolutionary solution space:

3.1 An overview of transfer learning in the evolutionary solution space (ESS)
3.2 A case study of transfer learning in the ESS

4. Transfer learning in the program space

This part of the tutorial will focus on transfer learning in evolutionary program space:

4.1 An overview of transfer learning in the evolutionary program space (EPS)

4.2 A case study of transfer learning in the EPS

5. Transfer learning in the heuristic space
This part of the tutorial will focus on transfer learning in evolutionary heuristic space:
5.1 An overview of transfer learning in the evolutionary heuristic space (EHS)
5.2 A case study of transfer learning in the EHS

6. Transfer learning in the design space
This part of the tutorial will focus on transfer learning in evolutionary design space:
6.1 An overview of transfer learning in the evolutionary solution space (EDS)
6.2 A case study of transfer learning in the EDS

7. Transfer learning for different evolutionary spaces
Based on 3-6, this part of the tutorial will highlight differences and similarities between transfer learning in the four different spaces, namely, ESS, EPS, EHS and EDS, and introduce the concept of inter-space transfer learning.

8. Automated transfer learning in evolutionary spaces
This part of the tutorial will focus on the automated design of transfer learning in evolutionary spaces:
8.1 An overview of the automated design of transfer learning
8.2 Demonstration of ATLEA (Automated Transfer Learning in Evolutionary Algorithms) Python library for the automated design of transfer learning

9. Future research directions and discussion

## Intended audience

Researchers that are working in or have an interest in transfer learning in evolutionary algorithms as well as researchers in the fields of hyper-heuristics and automated design in of machine learning and search techniques. Transfer learning in these fields is currently a growing area which is attracting much interest.

## Organizer/Presenter

This tutorial on “Transfer Learning in Evolutionary Spaces” has previously been presented at GECCO 2022. The presenter is a Professor at the University of Pretoria, South Africa. 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.