Proposal for a tutorial at CEC 2025

Title: Structural bias in optimisation algorithms **Type and duration**: introductory, 2 hours

Description

Benchmarking heuristic algorithms is vital for understanding under which conditions and on what kind of problems certain algorithms perform well. Most benchmarks are performance-based, to test algorithm performance under a wide set of conditions. Resourceand behaviour-based benchmarks test resource consumption and algorithm behaviour. In this Tutorial, we focus on behaviour benchmarking of algorithms and more specifically, we focus on Structural Bias (SB).

SB is a form of bias inherent to the iterative heuristic optimisers in the search space that also affects the performance of the optimisation algorithm. Detecting whether, when, and what type of SB occurs in a heuristic optimisation algorithm can provide guidance on what needs to be improved in these algorithms, as well as help to identify conditions under which such bias would not occur.

In the tutorial, we start by defining the problem of detecting and identifying different types of structural bias, including many visual examples. We then introduce state-of-the-art methods for bias detection. We follow up with SB results for several well-known and popular optimisation heuristics, give insights and show best practices to avoid SB in algorithm development. We conclude with a *live demo* of the Python-based BIAS toolkit which analyses a few well-known optimisation heuristics. Participants will be provided with links to live tools, necessary code and data.

Aims and learning objectives of this tutorial:

- convey the importance of benchmarking heuristic algorithms to comprehend their performance across different problem scenarios;
- concentrate on behaviour benchmarking, specifically delving into the concept of Structural Bias in iterative heuristic optimisers;
- enable participants to detect, analyse, and understand the occurrence and impact of Structural Bias in heuristic optimisation algorithms;
- provide insights into how detecting SB can lead to improved algorithm development and refinement;
- showcase the functionality and usage of developed toolkits as practical tools for detecting and addressing Structural Bias;
- share findings from analysing structural bias across well-known optimisation heuristics, offering insights and patterns.

Prerequisite Knowledge of Audience:

- familiarity with standard heuristic optimisation algorithms and benchmarking practices accepted in the community

- ability to follow programming examples in Python

Target audience: researchers who develop heuristic optimisation algorithms or analyse/benchmark such algorithms

Previously held versions of the proposed tutorial:

1. 15th International Conference on Evolutionary Computation Theory and Applications (ECTA 2023), Rome, Italy

2. 18th Parallel Problem Solving from Nature (PPSN 2024), Hagenberg, Austria

Organizer(s)

Anna V. Kononova (a.kononova@liacs.leidenuniv.nl) is Assistant Professor at the Leiden Institute of Advanced Computer Science, Leiden University (The Netherlands) where, since December 2019, she has led her group on Efficient Heuristic Optimisation (EcHO) within the Natural Computing cluster and acts as a member of the cluster management team. Her research concentrates on identifying and delivering order-of-magnitude efficiency improvements to solving heuristic optimisation problems with elements of machine learning. She received her MSc degree in Applied Mathematics from Yaroslavl State University (Russia) in 2004 and her PhD degree in Computer Science from the University of Leeds (UK) in 2010. After 5 years of postdoctoral experience at Technical University Eindhoven (Netherlands) and Heriot-Watt University (Edinburgh, UK), Anna spent 5 years working as an engineer and a mathematician in industry, before returning to academia in December 2019. Her current research interests include analysis of the behaviour of optimisation algorithms and machine learning. Dr Kononova is the author of over 75 peer-reviewed publications, she serves as an editorial board member of the Evolutionary Computation journal and is an active contributor to the organisation of conferences like PPSN, EMO, FOGA and GECCO. She serves as a vice-chair of the Benchmarking Task Force, IEEE Computational Intelligence Society.

Moreover, Dr Kononova introduced the term 'structural bias' in 2015 and delivered multiple presentations and publications on the topic.

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Assistant Professor in the Natural Computing Group of Leiden University the Netherlands. Niki van Stein received her PhD degree in Computer Science in 2018, from the Leiden Institute of Advanced Computer Science (LIACS), Leiden University, The Netherlands. From 2018 until 2021 she was a Postdoctoral Researcher at LIACS, Leiden University and she is currently an Assistant Professor at LIACS. Her research interests lie in explainable AI for EC and ML, surrogate-assisted optimisation and surrogate-assisted neural architecture search, usually applied to complex industrial applications.