SPECIES Project Proposal

Natural Computing Group, Leiden University

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1 CV

Thomas Bäck received the Diploma degree (1990) and Ph.D. degree (1994) in computer science from the University of Dortmund, Germany. Since 2002, he is Full Professor of computer science at the Leiden Institute of Advanced Computer Science (LIACS), Leiden University, The Netherlands. He is author of Evolutionary Algorithms in Theory and Practice (1996) and co-editor of the Handbook of Evolutionary Computation (1997) and Handbook of Natural Computing (2012). His research interests include evolutionary computation, machine learning and their real-world applications, especially in sustainable smart industry and health.

Prof. Bäck's awards and honors include membership in the Royal Netherlands Academy of Arts and Sciences (KNAW, 2021) and Academia Europaea (2022), the IEEE Computational Intelligence Society Evolutionary Computation Pioneer Award (2015), IEEE Fellow (2022), Fellow of the International Society of Genetic and Evolutionary Computation (2003), and best Ph.D. thesis award of the German society of Computer Science (GI, 1995).
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2 Research Group

The Natural Computing group at Leiden University consists of several assistant professors, post-docs and many PhD candidates, and is led by Thomas Bäck. The core research interests of the group are centered around iterative optimization heuristics and data-driven machine learning and algorithm selection methods for optimization. Research in the group covers theoretical foundations, the development of new algorithms, and interdisciplinary applications of natural computing methods. The driving force behind their research is the mission to increase the understanding of natural systems as models of computation, with a focus on the development of new algorithms and applications to challenging problems. They investigate fundamental aspects of those algorithms as well as

their applications to practical problems, including e.g. applications in automotive, aerospace, manufacturing, and health.

3 Projects

The projects listed below illustrate some of the research topics we would like to focus on, but the specifics are flexible. Please feel free to contact us to discuss other potential research directions.

3.1 Reproducibility in Differential Evolution

Differential Evolution is a popular algorithm for continuous optimization. With this popularity comes an ever-increasing space of algorithmic modifications to the core algorithm, ranging from different mutation mechanisms to parameter adaptation and everything in between [Pant et al.(2020)]. We recently created a modular version of differential evolution ("modde"), which provides a common framework for the comparison of these variants [Vermetten et al.(2023)]. In this project, we would like to select several modifications of DE, implement them into the "modde" framework, and perform a robust benchmarking study to validate the original experimental results.

3.2 Robust Comparison of Benchmarking Results

Benchmarking is a key aspect of the analysis of optimization algorithms. We have initiated the development of the IOHprofiler, which provides a robust benchmarking environment [de Nobel et al.(2021), Wang et al.(2022)]. By creating an interactive graphical interface, we aim to lower the barrier to entry for benchmarking. In this project, we will work on the analysis pipelines in the IOHanalyzer component, by integrating new statistical comparison techniques and providing a rigorous analysis of their relative strengths and weaknesses.

3.3 Warmstarting of Optimization Algorithms

Dynamic Algorithm Selection (DynAS) is built on the idea that algorithms can display complementary performance, even on a single optimization run. To exploit this complementarity, we need to be able to switch between optimizers in a way which optimally utilizes the information gained from the initial algorithm to warm-start the new algorithm. While a set of naive methods have shown the potential for DynAS, improving these warm-starting mechanisms seems to be the next step towards realizing its full potential [Schröder et al.(2022), Kostovska et al.(2022)].

References

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