Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences

Subject
Mining multifaceted information on the performance of metaheuristics with use of parametrized benchmarks

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Project Description

Nature-inspired metaheuristics, such as swarm and evolutionary algorithms, are an important branch of artificial intelligence. Although the search for the universally best optimizer finished when the *no free lunch* theorem ensured its non-existence, some algorithms perform much better for particular groups of tasks. One of the great research challenges is the identification of these groups. Currently, this problem is addressed by means of experience and theoretical guidelines [1]. The aim of this project is to develop a systematic method for finding effective algorithms for a given type of tasks by parameterizing standard benchmarks and coupling them with statistical analyses.

Comparing the performance of global optimization algorithms is central to their evaluation and guides the mainstream research. Commonly used benchmarks [2, 3] consist of a series of basic functions, which undergo several transformations such as rotation, scaling or shifting to create the final optimization tasks. In the proposed project, these transformations will be separated and applied in different combinations, leading to several, parameterized variants of each test function. The relations between the tasks' properties and the algorithmic effectiveness can be investigated by evaluating the optimization performance. This opens space for a variety of important analyses. For instance, several algorithms can be compared to quantitatively assess their relative strengths and weaknesses, providing insightful conclusions, for instance, *method A outperforms B for rotated tasks but is ineffective for scaled and multidimensional ones*. Decomposing the notion of "outperforming" into the influence on different properties of tasks will unpack the real mechanics of the algorithms facilitating their gradual development. Finally, swarm and evolutionary algorithms can themselves be parameterized leading to insights about the roles of their constitutive elements.

During the completion of this project, one will obtain knowledge and experience in the development of the state-of-the-art metaheuristics and advanced statistical modelling, including the design of experiments, the use of linear models as well as robust, non-parametric methods. The study can be also addressed with machine learning methods developed within the interpretable artificial intelligence trend. Benchmarking comes at a high computational cost that will be addressed by parallelization in the super-computing centres. The choice of programming technology is of secondary importance, however, most of the reference code is available in Matlab/Octave or C++. Additionally, learning R statistical package will be necessary.

Bibliography

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3. N. Hansen, A. Auger, O. Mersmann, T. Tusar, D. Brockhoff. (2016). COCO: A platform for comparing continuous optimizers in a black-box setting. *arXiv preprint arXiv:1603.08785*.

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