Self-Adjusting Parameter Choices for Discrete Black-Box Optimization

Proposal for M2 Research Internship 2017

Supervisors: The student will be supervised by
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Place: LIP6, Université Pierre et Marie Curie or/and LIX, École Polytechnique are possible

Keywords: Randomized Algorithms, Black-Box Optimization, Search Heuristics

Prerequisites: The student should have a solid background in mathematics as well as some basic knowledge about algorithms and probability theory. Randomized algorithms courses would be a plus. The working language will be English, so fluency in written and spoken English is required.

Description of the Topic: Randomized search heuristics (RSH) such as evolutionary algorithms, simulated annealing, and randomized local search algorithms are so-called black-box optimization algorithms. That is, unlike their white-box counterparts often regarded in algorithmic research, RSH do not have (or do not exploit) access to the problem instance other than by suggesting potential solution candidates and receiving (from an oracle/the black-box) information about the quality of these search points such as, for example, their function values. Based on this information, the RSH update the policy from which the next search points are sampled. This process is repeated until some stopping criterion is met.

In discrete optimization, the most widely regarded performance measure for black-box optimizers is the number of oracle/black-box queries that an algorithm needs until it evaluates for the first time an optimal solution candidate. This number is called the runtime of the algorithm. One of the most interesting research questions in the theory of RSH addresses the question how the runtime of such a heuristic is influenced by the algorithmic choices that the user has to specify. In evolutionary computation, the subarea of black-box optimization dealing with bio-inspired search heuristics, common parameters that the user has to decide upon are, for example, the population size, the mutation strength, and the crossover rate. It is well known that the choice of these parameters can have a crucial impact on the performance of the algorithm, see, for example, [4]. It has thus to be executed with care.

In the early years of evolutionary computation there had been a quest to determine universally “optimal” parameter choices. At the same time, researchers have soon realized that different parameter choices can be optimal in different stages of the optimization process: in the beginning of an optimization process, for example, one may want to allow a larger mutation rate so as to increase the chance of finding the most promising regions of the search space (so-called “exploration phase”) while later on a smaller mutation rate guarantees the search to stay focused (“exploitation phase”). Quite surprisingly, this intuitive concept of dynamic parameter choices has never played an
important role in the evolutionary computation community—neither in empirical, nor in theoretical investigations. Most recently, the topic has been revived by a series of theoretical and experimental works proving strict superiority of dynamic parameter settings for a number of different discrete optimization process, cf. [1, 3, 2]. The aim of the proposed internship is to extend these preliminary works by investigating in more detail how a dynamic choice of the mutation rate can speed up the optimization process of typical evolutionary algorithms. The main challenge is in designing such update mechanisms. The gains will be evaluated by mathematical means via a thorough investigation of the runtime distribution. These theoretical findings will be complemented by an empirical evaluation of the proposed mechanism(s).

References


