Towards a Generally Applicable Self-Adapting Hybridization of Evolutionary Algorithms

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Abstract. Practical applications of Evolutionary Algorithms (EA) frequently use some sort of hybridization by incorporating domain-specific knowledge, which turns the generally applicable EA into a problem-specific tool. To overcome this limitation, the new method of HyGLEAM was developed and tested extensively using eight test functions and three real-world applications. One basic kind of hybridization turned out to be superior and the number of evaluations was reduced by a factor of up to 100.

1 Introduction

When applied to real-world problems, the powerful optimization tool of Evolutionary Algorithms frequently turns out to be too time-consuming due to elaborate fitness calculations that are often based on run-time-intensive simulations. Incorporating domain-specific knowledge by problem-tailored heuristics or local searchers is a commonly used solution, but turns the generally applicable EA into a problem-specific tool. The new method of hybridization implemented in HyGLEAM (Hybrid GeneraL purpose Evolutionary Algorithm and Method) [1, 2] is aimed at overcoming this limitation and getting the best of both algorithm classes: a *fast*, *global searching* and *robust* procedure with the *convergence reliability* of evolutionary search being maintained. The basic idea of the concept can be summarized in two points:

1. Usage of generally applicable local search algorithms instead of the commonly used problem-specific ones for hybridization.
2. Usage of a convergence-dependent control mechanism for distributing the computational power between the basic algorithms for suitable kinds of hybridization.

The first point may appear simple, but it is a matter of fact that nearly all real-world applications and investigations are based on problem-specific local searchers. Appropriate local search algorithms for parameter optimization must be derivative-free and able to handle restrictions in order to be generally applicable. The Rosenbrock procedure and the Complex algorithm, two well-known powerful local searchers [3], were chosen, as they fulfill these requirements. GLEAM (General Learning Evolutionary Algorithm and Method) [4] was used as an EA, but it must be noted that the method can be applied easily to every other population-based EA.

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2 Experiments and Conclusions

The test cases comprised real, integer, and mixed parameter optimization, combinatorial and multi-objective optimization as well as parameter strings of dynamic length. They are described in more detail together with references in [2, 5]. In most cases, the results were based on an average of 100 runs per algorithm and parameterization. Four basic kinds of hybridization were investigated:

1. Pre-optimization of the start population: The idea is that the evolution can start with solutions of more or less good quality. It works pretty well (up to 24 times less evaluations) in some cases, but not always and more evaluations may be required.
2. Post-optimization of the EA results: As EAs are known to converge slowly, an improvement may result from stopping the evolution after approaching the area of attraction of the (global) optimum and leaving the rest to the local search. The appropriate switching point is determined by the convergence-dependent control procedure mentioned above. This approach improves the EA results, but does not fulfill the expectation of reliably finding the solution.
3. Direct integration: Optimizing every or the best offspring of one mating only causes the EA to operate over the peaks of the fitness landscape exclusively rather than to treat the valleys and slopes, too. The offspring's genotype can be updated (Lamarckian evolution) or left unchanged (Baldwinian evolution). This works with the Rosenbrock procedure in all cases, yielding up to 77 times less evaluations. Using the Complex procedure instead does not always work, but if it does, better results may be obtained (up to 104 times less evaluations). Lamarckian evolution and the improvement of the best offspring of one mating only proved to be the best choice in almost all cases.
4. Delayed direct integration: This variant of direct integration, where the evolution works on its own until a certain convergence of the population is reached, produced better results in some cases (e.g. up to 90 times less evaluations instead of 77).

As no common settings for important strategy parameters like population size, termination threshold of the Rosenbrock procedure or the choice of the local searcher for the (delayed) direct integration could be extracted from the experiments, a new concept of an *adaptive direct integration* has been developed. It is described in [5] and will be subject of future work.

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