Numerical methods for solving black-box global optimization problems

D. E. Kvasov\textsuperscript{a,b}, M. S. Mukhametzhanov\textsuperscript{a,b}, Y. D. Sergeyev\textsuperscript{a,b}

\textsuperscript{a}Department of Computer Engineering, Modelling, Electronics and Systems Science, University of Calabria, Italy
\textsuperscript{b}Software Department, Lobachevsky State University, Nizhni Novgorod, Russia
kvadim@si.dimes.unical.it, marat@dimes.unical.it, yaro@si.dimes.unical.it

Keywords. Global optimization, black-box problems, numerical methods.

In many practical applied problems, the best combination of parameters (geometrical sizes, electrical and strength characteristics, etc.) describing a particular optimization model should be determined. This combination provides the global optimum (minimum or maximum) of a suitable objective function subject to a set of feasibility constraints. Optimization problems characterized by multiextremal functions (the number of their local optima is often unknown and can be very high) are of a particular importance for practical applications. The functions involved in the optimization process can be black-box with unknown analytical representations and hard to evaluate, as, e.g., in simulation-based optimization (see, e.g., [1]). A high number of applied optimization problems described by multiextremal objective functions and constraints and a rapid increase of computer power in the last decades determined a growing attention of the scientific community to global optimization. This attention results in developing many approaches for solving global optimization problems (see, e.g., [1,8-10,12-15]).

Global optimization techniques should be significantly different from nonlinear local methods and they can be much more expensive from the computational point of view. Among these techniques, deterministic global optimization (see, e.g., [10,12-14]) is a well-developed mathematical theory having many important applications. One of its main advantages is the possibility to obtain guaranteed estimations of global solutions and to demonstrate (under certain analytical conditions) rigorous global convergence properties. However, the currently available deterministic models can still require too high number of functions evaluations. Stochastic approaches (see, e.g., [8,15]) can often deal with the stated problems in a simpler manner than the deterministic algorithms (being also suitable for the problems where the evaluations of the functions are corrupted by noise). But, there can be difficulties with these methods, as well. Several restarts can also be involved, requiring even more functions evaluations. Moreover, solutions found by many stochastic algorithms (especially, by heuristic methods like evolutionary algorithms, simulated annealing, etc.; see, e.g., [1,8]) can be only local solutions to the problems, far from global ones. This can preclude such methods from their usage in practice.
In this talk, some deterministic approaches developed by the authors (see, e.g., [3-7,11,12]) to construct black-box global optimization methods are presented and compared with several widely-used nature-inspired algorithms (see, e.g., [1,8]). Numerical comparison is performed on test classes and on some practical engineering problems with the usage of different criteria (see, e.g., [2,12]).

Acknowledgments. This research was partially supported by the INdAM–GNCS 2015 Research Project of the Italian National Group for Scientific Computation of the National Institute for Advanced Mathematics “F. Severi”.

References


