Global optimization: analytical and simulation-based approaches

A Ph.D. level course given within the framework of the Ph.D. program in *Pure and Applied Mathematics*

LECTURER

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AIM

Extremely efficient algorithms are available for convex optimization problems, but the picture is more complicated for non-convex optimization. Many engineering design problems call for global, rather than local optimization algorithms. Non-convex problems must also be solved in financial models calibration, which is a form of inverse problem, as well as in some statistical estimation problems. Efficient methods may be applied to specific cases featuring some structure (e.g., minimization of a concave function on a convex set), whereas the general problem is quite challenging. In some cases, function evaluation is cheap, and flexible stochastic search procedures may be applied if we just need a good solution. However, in other cases the performance measure to be optimized is estimated by a costly simulation experiment, and we need suitable way to squeeze the most information we can out of each function evaluation. Finally, we might wish to find a provably optimal solution, which may be obtained by branch-and-bound methods.

We consider continuous non-convex optimization, but many concepts may be applied to integer programming as well. The aim of the course is to give an overview of these algorithms, using MATLAB as a demonstration tool. Knowledge of basic optimization theory (nonlinear programming) is assumed.

Prerequisites: Some familiarity with standard nonlinear programming concepts (convexity, first-order optimality conditions, Lagrange multipliers, etc.), as well as a working knowledge of MATLAB. We will also use AMPL (www.ampl.com) to build and solve optimization models (a free, time-limited license will be provided).

CONTENT

- Classes of global optimization problems and algorithms
- Methods for specific problems (concave optimization, dc programming, etc.)
- Branch and bound methods for Lipschitzian optimization
- Stochastic and direct search methods (pattern search, genetic algorithms, particle swarm optimization)
- Simulation-based optimization and metamodeling

References

- Ignacio E. Grossmann (ed.). *Global Optimization in Engineering Design*. Springer, 1996.
- J. Pinter. *Global Optimization in Action. Continuous and Lipschitz Optimization: Algorithms, Implementations and Applications*. Springer 1996.
- R. Horst, Panos M. Pardalos, Nguyen Van Thoai. *Introduction to Global Optimization* (2nd ed.). Springer, 2008.
- Jack P.C. Kleijnen. *Design and Analysis of Simulation Experiments*, Springer, 2008
- Y.D. Sergeyev, D.E. Kvasov. *Deterministic Global Optimization: An Introduction to the Diagonal Approach*. Springer, 2017.

Journal papers will be uploaded on the course web page.

ASSESSMENT
In order to formally record the associated credits, **individual** homework will be assigned during the course, with firm deadlines along the way. You are required to write MATLAB code (possibly, AMPL scripts, too).

SCHEDULE
Lectures will be given at Dipartimento di Scienze Matematiche (DISMA), Politecnico di Torino, in Aula Buzano (the internal lecture/seminar room of DISMA, third floor).

Lecture	Date	Time
1	Wednesday, May 2nd	10:00 - 13:00
2	Wednesday, May 9th	10:00 - 13:00
3	Wednesday, May 16th	10:00 - 13:00
4	Wednesday, May 23rd	10:00 - 13:00
5	Wednesday, May 30th	10:00 - 13:00