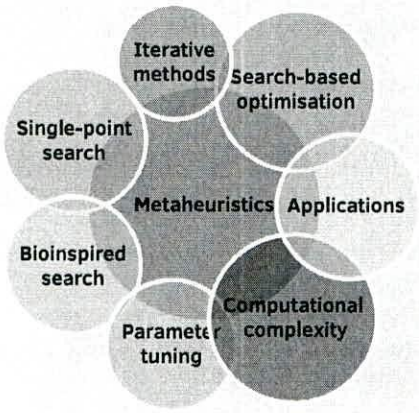
Metaheuristics Tools & Techniques

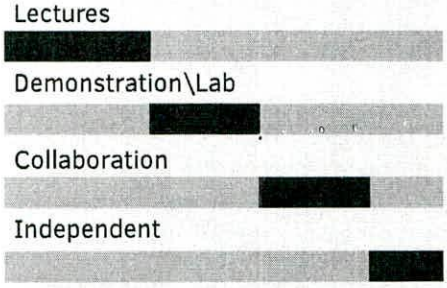
Credit hours: 2

A graduate module syllabus
by Sergio A. Rojas, PhD.
✉ srojas@udistrital.edu.co

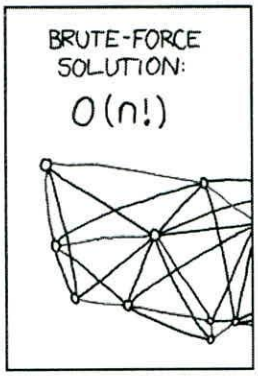
The Big Picture

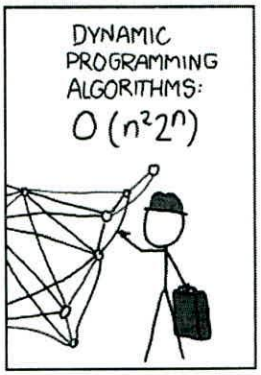


Teaching method



Bottom line





Cartoon credit: xkcd.com.

Overview

Metaheuristics are general procedures to search for sufficiently suitable solutions to optimisation problems. That is, in contrast to exact methods that find the optimum of a cost function, these procedures iteratively apply heuristics (intuitions) to get close to a good enough solution (although probably not the best, but a local optima). This scenario is common in many engineering applications, were optimisation problems are usually combinatorial or ill–defined and hence, exact methods are not feasible. Therefore, this field is currently a relevant and hot topic of research.

This module will introduce graduate students to the fundamental tools and techniques of metaheuristics, from a computational perspective with a view to business and industrial applications; it will provide advice on computational concepts needed to appropriately apply and tune metaheuristcs on engineering projects.

Why this module?

The core idea of these techniques is to randomly generate solutions that are progressively improved with variation operators; a metaheuristic performs some sort of stochastic optimisation and as such, it uses rules to guide the search over a large set of feasible solutions with less computational effort. This is why metaheuristics are mainly empirical approaches implemented and tuned with computer experiments. Mastering their basic tools and implementation techniques would enable practitioners and researchers not only to apply them on real-world engineering problems but also to experiment with new versions of operators, representations, hybridisations or completely novel metaheuristics.

Course outline

Unit 1 **Basic concepts of metaheuristics** 8h

- Intractability and complexity
- Exact vs approximate search-based methods
- Representations and cost functions
- Constraints and parameter settings
- Experimental design, quality of solution and effort measuring
- Software tools and programming languages for metaheuristics

Unit 2 **Single–point based metaheuristics** 12h

- Hill Climbing
- Simulated Annealing
- Tabu Search
- Further topics for independent research

Unit 3 **Population–based metaheuristics** 12h

- Genetic Algorithms
- Ant Colony Optimisation
- Estimation of Distribution Algorithms
- Further topics for independent research

Bibliography

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- Bozorg-Haddad, Solgi & Loiciga. *Metaheuristic and Evolutionary Algorithms for Engineering Optimization*, Wiley, 2017.
- Patrick Siarry. *Metaheuristics*, Springer, 2016.
- Ke-Lin Du & M. N. S. Swamy. *Search and Optimization by Metaheuristics*, Birkhäuser, 2016.
- El-Ghazali Talbi. *Metaheuristics: From Design to Implementation*, Wiley, 2009.
- Michel Gendreau & Jean-Yves Potvin. *Handbook of Metaheuristics*, 2nd. Edition, Springer, 2010.