Optimization using metaheuristics

Doctoral course - 6 credits

Course description

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1 General aims

Metaheuristics are high-level algorithmic frameworks that provide guidelines for the design of heuristic optimization algorithms. Research in this field focuses on the development of effective methods for various challenging optimization problems. For many real-life optimization problems, metaheuristics are the best, or even the only choice if one wishes to develop state-of-the-art approaches that are able to tackle problems of real-life size and complexity.

This course aims to deepen the participants' knowledge of this challenging research field. In four or five sessions, the participants will be introduced to the most important methods that have been developed in the literature, and learn how they can be effectively applied. The course will give ample attention to the various pitfalls that "*metaheuristicians*" must overcome when developing an effective optimization method. The main focus will be on applications in the field of logistics, such as vehicle routing and facility location, . . . , but other application domains will be discussed too.

2 Practical information

The lectures will take place on four days between March and June 2026 (*tentative dates* **26/3, 2/4, 23/5, and 30/5**), **between 10:00 and 16:00** (exact times will be communicated), at the **City Campus (room TBD)** of the University of Antwerp, Prinsstraat 13, 2000 Antwerp Belgium.

Following the course on-line is not possible.

An "exam" session (see below) will be organized later in 2026 at the City Campus (room TBD).

Students can register for this course by contacting phd.fbe@uantwerpen.be

3 Evaluation

Evaluation will be based on an assignment prepared by the student. The assignment consists of two parts:

1. A *literature assignment*, in which the student reviews a paper on metaheuristics
2. A *development assignment*, in which the student develops an actual metaheuristic for a specific optimization problem, tests his/her approach and reports its results

For both assignments, both a written report is submitted, as well as a recorded presentation.

The report on the development assignment contains detailed explanations of:

1. the problem that is solved;
2. the heuristic that is developed;
3. the instances that were used for testing;
4. the results of the tests on the instances.

It is encouraged to write the report in the format of a scientific journal article.

The paper review report contains the following items:

1. short summary of the paper;
2. major remarks;
3. minor remarks;
4. a recommendation.

Both assignments are additionally presented by the student in a single recorded presentation of about 30 minutes. The format of the recording can be freely chosen (e.g., recording of the student presenting, screencast, animated video, document cam, …).

The average student without prior experience in metaheuristics (but with some programming experience) should count on at least four weeks of development time. Students without programming experience should add the time necessary to acquire the necessary programming skills.

4 Topics

The list below outlines some of the topics that will be discussed during the lectures. The list is subject to change.

1. **Introduction**

   Optimization principles, a primer on complexity theory, metaheuristics terminology and basic principles, a taxonomy of metaheuristics, the component-based view on metaheuristics

2. **Local search metaheuristics**

   Various types of metaheuristics based on local search (iterated local search, tabu search, variable neighborhood search, …)

3. **Constructive metaheuristics**

   Constructive metaheuristics (GRASP, pilot method, ant colony optimization, …)

4. **Population-based metaheuristics**

   Population-based metaheuristics (evolutionary algorithms, scatter search, …)

5. **Matheuristics and other advanced topics**

   Combinations of exact methods and metaheuristics, integration of machine learning and metaheuristics, …

6. **Designing and testing metaheuristics**

   Metaheuristic "engineering": how to develop and test an effective metaheuristic for a given problem

5 Further reading

Taillard, Éric D. Design of heuristic algorithms for hard optimization: with python codes for the travelling salesman problem. Springer Nature, 2023. (open access book)

6 Contact

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