DM811 (5 ECTS - 1st Quarter)
Heuristics for Combinatorial Optimization

Heuristikker og lokalsøgningsalgoritmer for kombinatorisk optimering

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Combinatorial Optimization

Combinatorial optimization problems:
find optimal value to a set of discrete variables.

Examples:
- Shortest path
- Minimum spanning tree
- Matching
- Max-flow

Others are NP-hard:
- finding shortest/cheapest tours (traveling salesman, TSP)
- finding models of propositional formulae (SAT)
- finding variable assignments satisfying constraints (CSP)
- partitioning graphs or digraphs
- coloring graphs
- partitioning, packing, covering sets
- ...

Heuristic Solution

How can we solve NP-hard problems?

- Get inspired by approach to problem-solving in human mind
  - trial and error
  - heuristics, common sense rules
- and by apparent simplicity of processes in nature
  - simulated annealing, evolutionary theory

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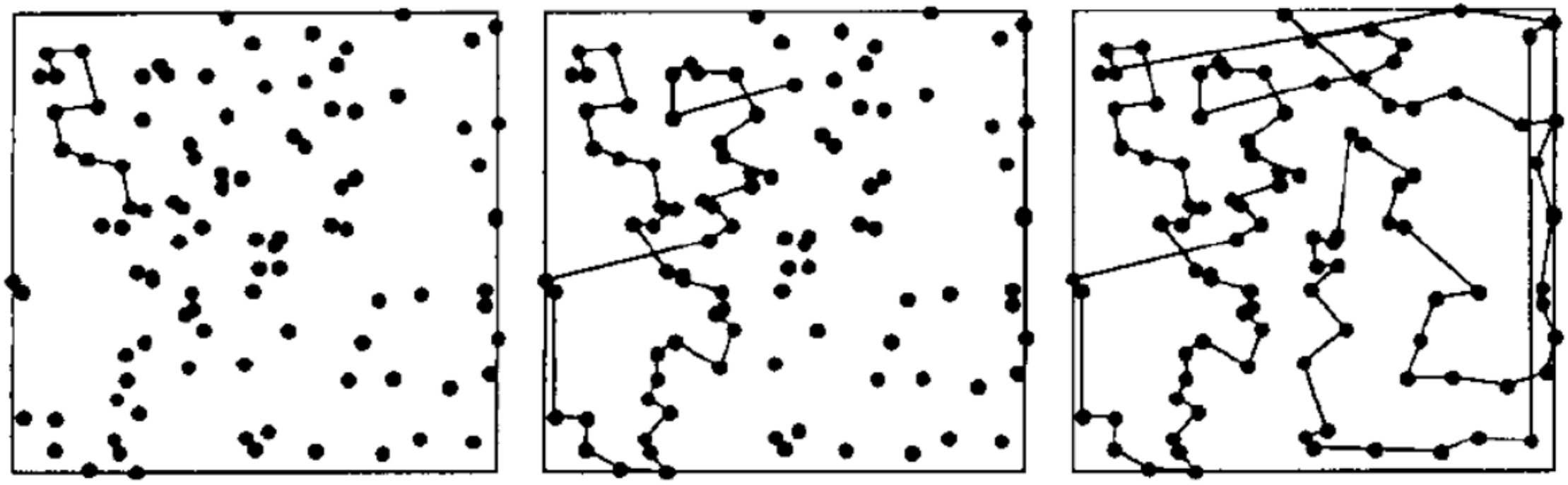
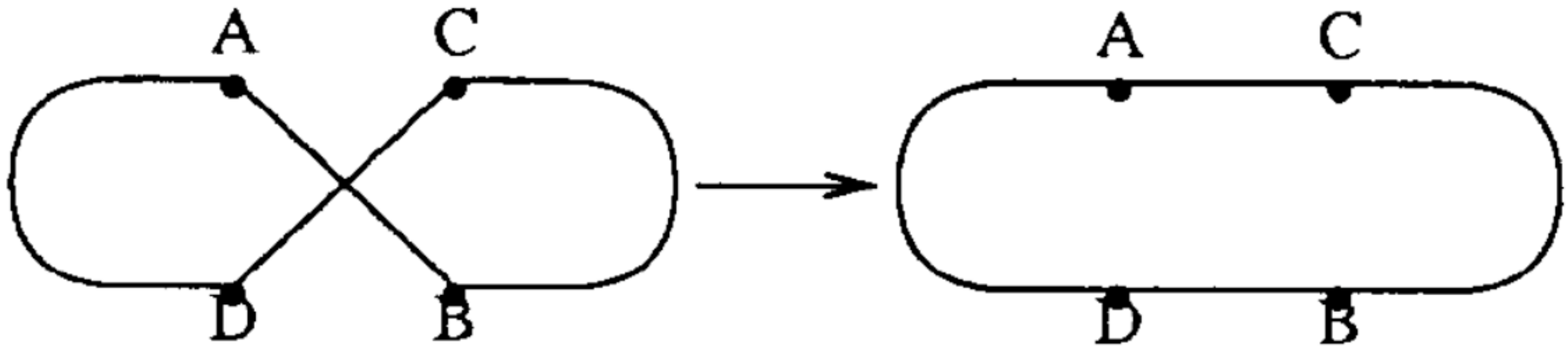
Heuristic algorithms: compute, efficiently, good solutions to a problem with no guarantee of optimality.

Construction Heuristics



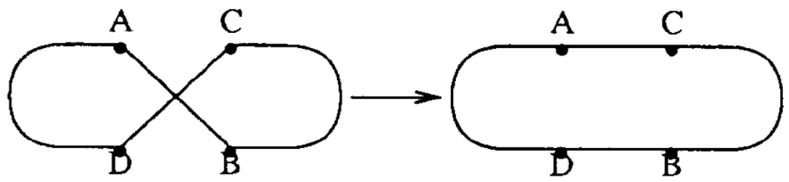
Extend always going to the nearest neighbor

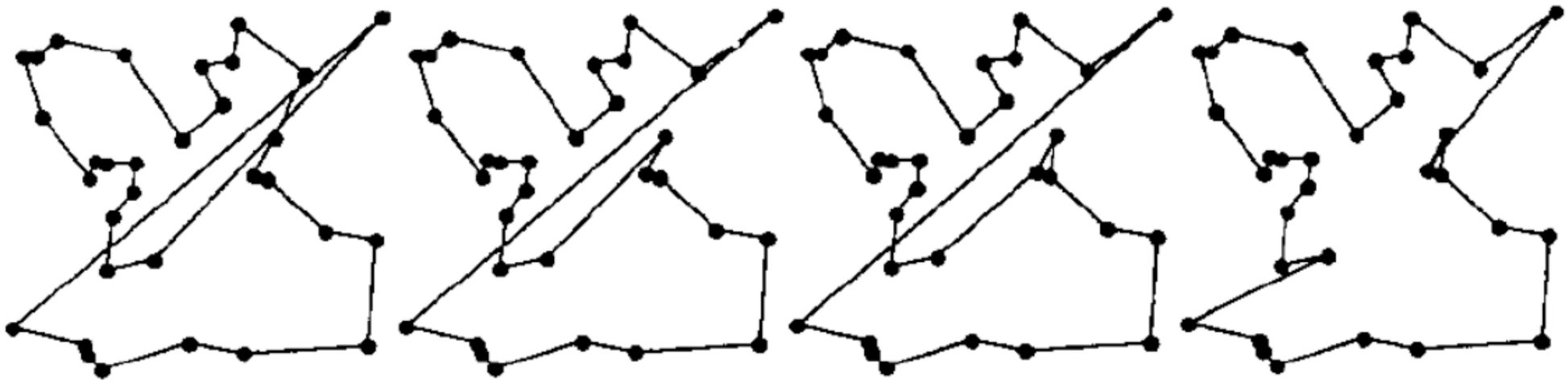
Local Search

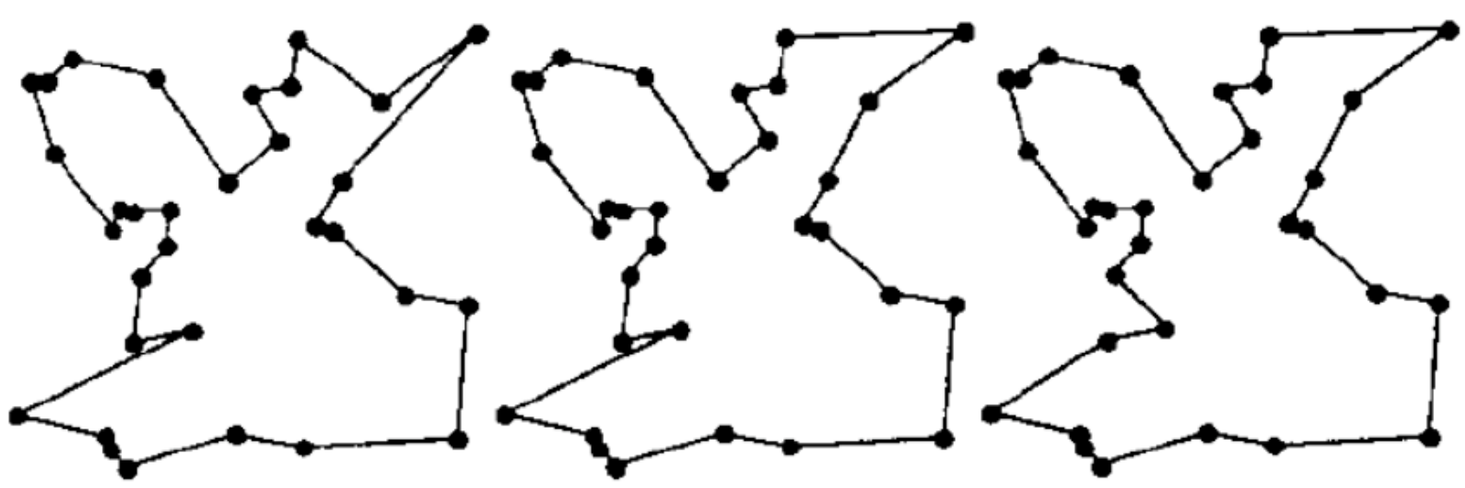


Change two edges of the tour with two new ones

Local Search







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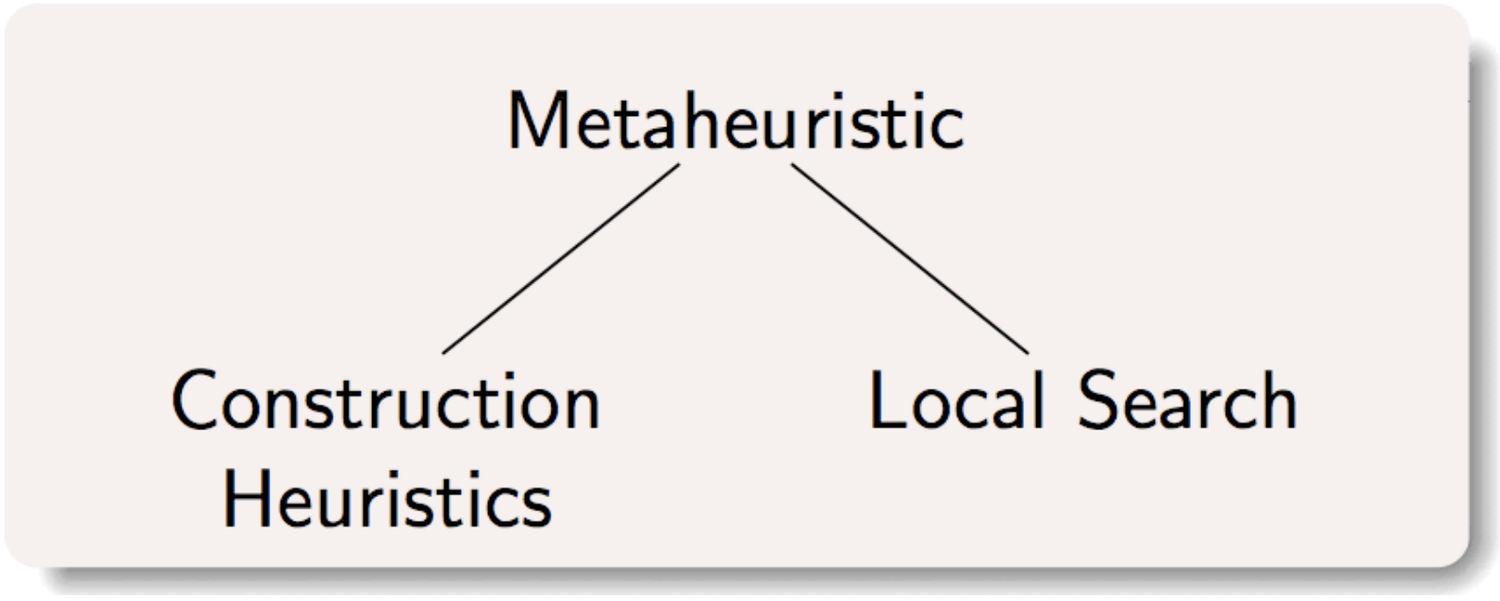
Metaheuristics



Heuristics as Science

- Theoretical analysis
- Empirical analysis

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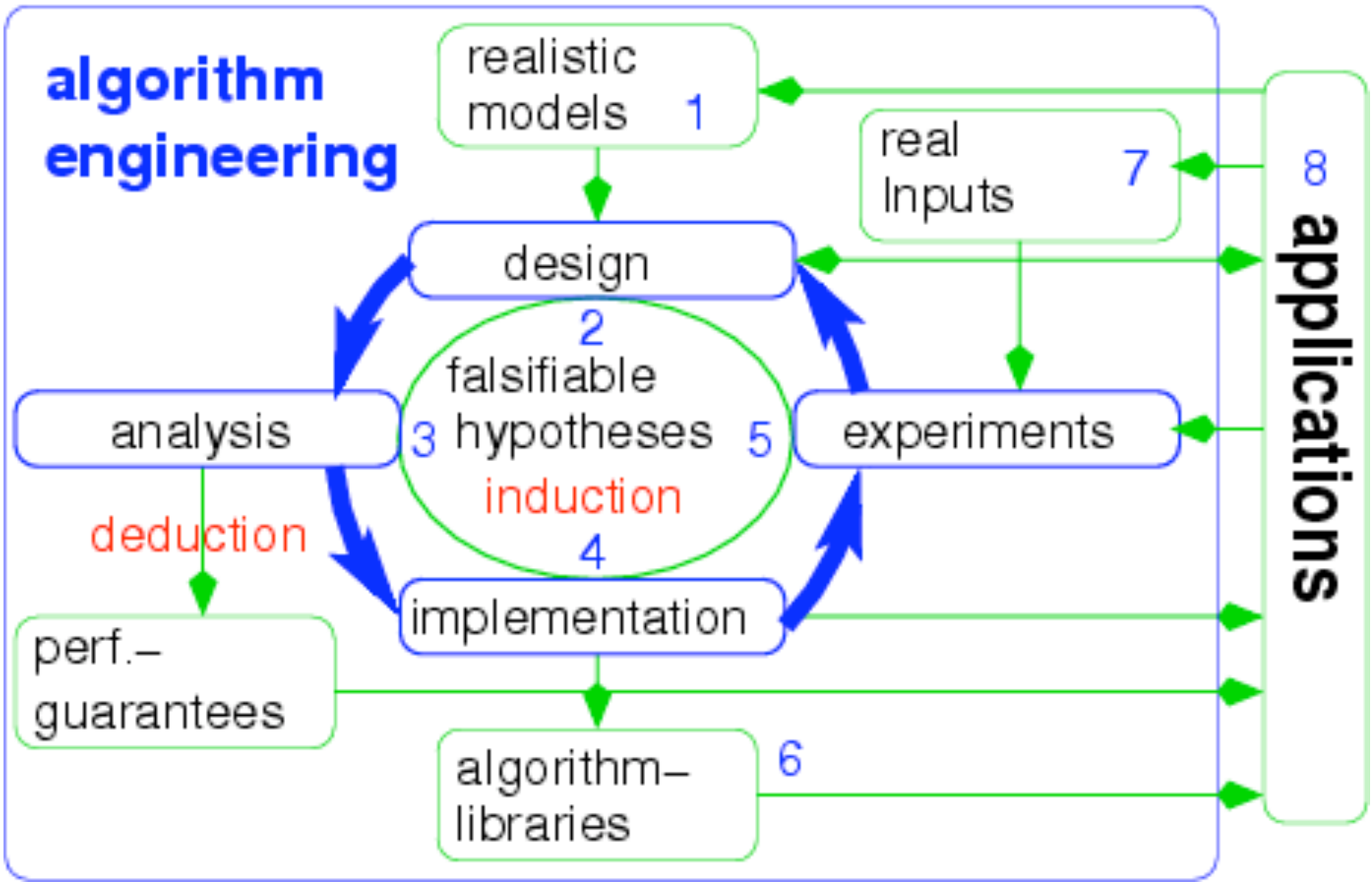
- Empirical analysis

They aim at understanding:

- general and problem specific ideas that work
- how they can be efficiently implemented in computers
- what makes one succeed and some not
- which are the theoretical limits

Heuristics as Engineering



Contents of the course

1. Introduction to Combinatorial Optimization
2. Construction Methods, Greedy Algorithms
3. Improvement methods, Local Search
4. Stochastic Local Search and Metaheuristics
5. Very Large Scale Neighborhoods
6. Experimental analysis and configuration tools
7. Introduction to COMET, a constraint-based local search system

14 lectures + practical experience

Aims of the course

Learn to solve problems:

- understand the problem
- design a solution algorithm
- implement the algorithm
- assess the program
- describe with appropriate language

Prerequisites

- ✓ DM507 - Algorithms and data structures
- ✓ DM502, DM503 - Programming A and B

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Final Assessment (5 ECTS)

- Individual project:
  - Design, implementation and experimental analysis of heuristics for a given problem
  - Perfomance matters!
  - Deliverables: written report + program
- Internal examiner

Course Material

- Text books
  - *Theoretical Aspects of Local Search. Michiels, W.; Aarts, E. & Korst, J. Springer Berlin Heidelberg, (2007).*
  - *Constraint-Based Local Search, P. Van Hentenryck and L. Michel. The MIT Press (2005).*
- Supplementary articles
- Slides
- Source code and data sets
- www.imada.sdu.dk/~marco/DM811