

DM811 (5 ECTS - 1st Quarter)

Heuristics for

Combinatorial Optimization

Heuristikker og lokalsøgningsalgoritmer for kombinatorisk optimering

DM812 (5 ECTS - 2nd Quarter)

Metaheuristics

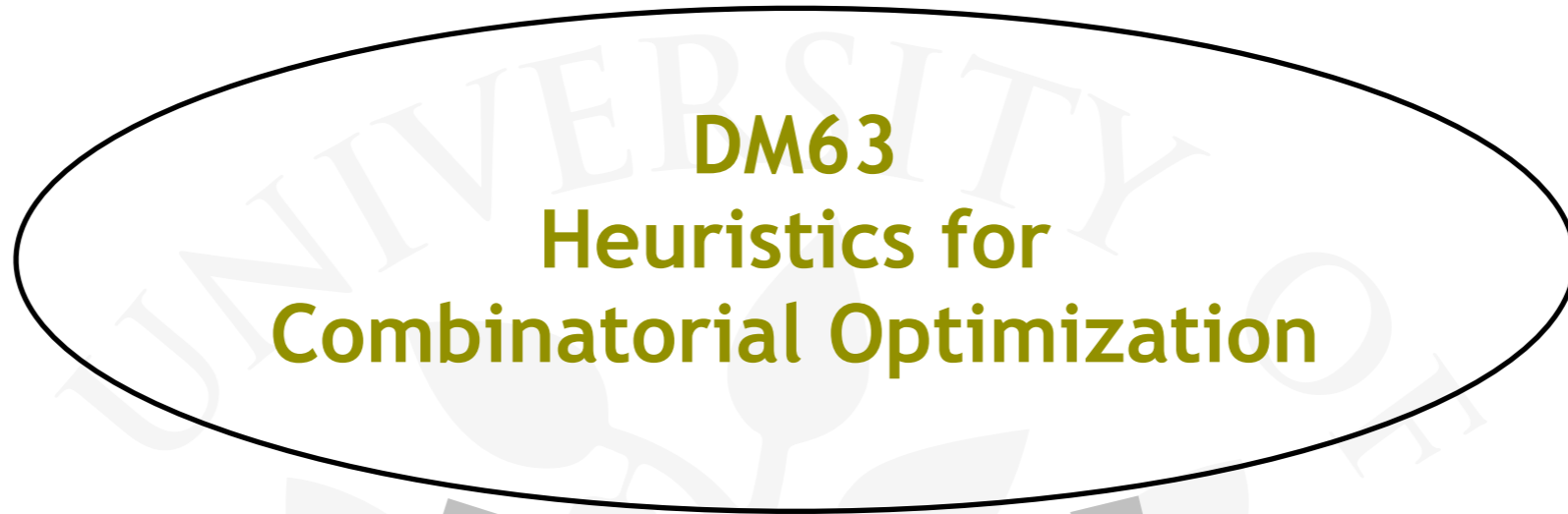
Metaheuristikker

Marco Chiarandini

adjunkt, IMADA

www.imada.sdu.dk/~marco/

semester course



2000-2007

2008



1st quarter



2nd quarter

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Prerequisites

- ▶ Officially
 - none
- ▶ “Unofficially”
 - DM507 - Algorithms and data structures
 - Programming A and B

Programming in an efficient language: C, C++, Java...

Combinatorial Optimization

Combinatorial optimization problems:
select a “best” configuration or set of variables.

Examples:

- ▶ Shortest path
- ▶ Minimum spanning tree
- ▶ Matching
- ▶ Max-flow

Others are NP-hard:

- ▶ finding shortest/cheapest round trips
- ▶ finding models of propositional formulae
- ▶ finding variable assignments satisfying constraints
- ▶ 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
- ▶ and by apparent simplicity of processes in nature
 - evolutionary theory, swarm intelligence

Heuristics: algorithms to compute, efficiently, good or optimal solutions to a problem, but not guaranteed to do so.

Heuristics as Science

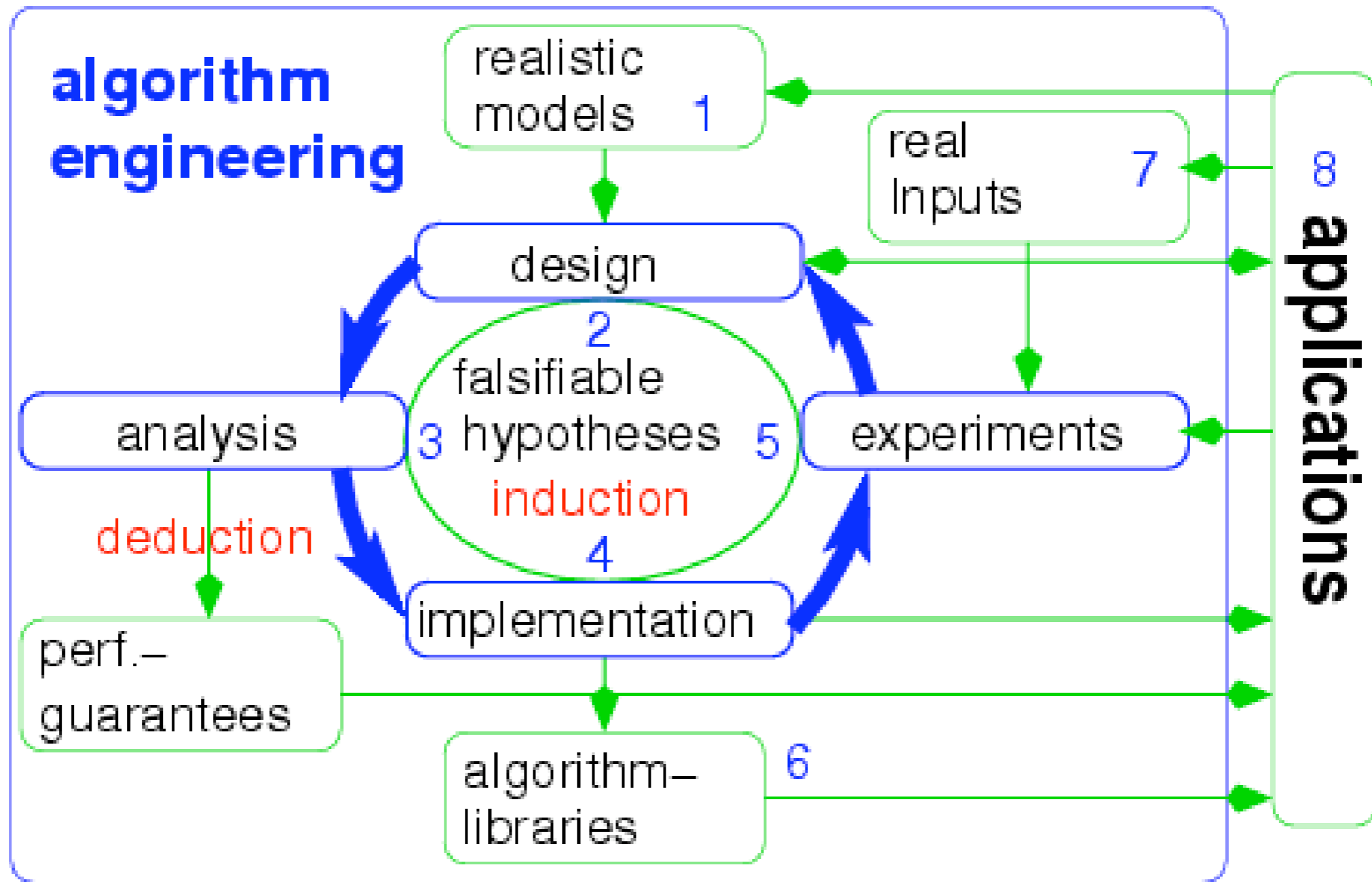
Empirical studies

Theoretical studies

They aim at understanding:

- ▶ general and/or 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, Overview and Terminology
2. Basic Methods and Algorithms
3. Integer Programming, Branch and Bound, LP Rounding
4. Constraint Programming and Complete Search
5. Approximation Algorithms
6. Greedy Methods and Extensions
7. Local Search
8. Very Large Scale Neighborhoods
9. Stochastic Local Search
10. Stochastic Local Search II
11. Experimental analysis and configuration tools
12. Stochastic optimization and local search

12-14 lectures + 6-8 laboratory sessions

Aims of the course

Learn problem solving:

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

Final Assessment (5 ECTS)

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

Course Material

▶ Text book

- *Search methodologies: introductory tutorials in optimization and decision support techniques* E.K. Burke, G. Kendall, 2005, Springer, New York
- *Handbook of Approximation Algorithms and Metaheuristics*. T.F. Gonzalez, Chapman & Hall/CRC Computer and Information Science) 2007.
- *Stochastic Local Search: Foundations and Applications*, H. Hoos and T. Stützle, 2005, Morgan Kaufmann

▶ Literature (articles, photocopies)

▶ Slides

▶ Source code and data sets

▶ www.imada.sdu.dk/~marco/DM811

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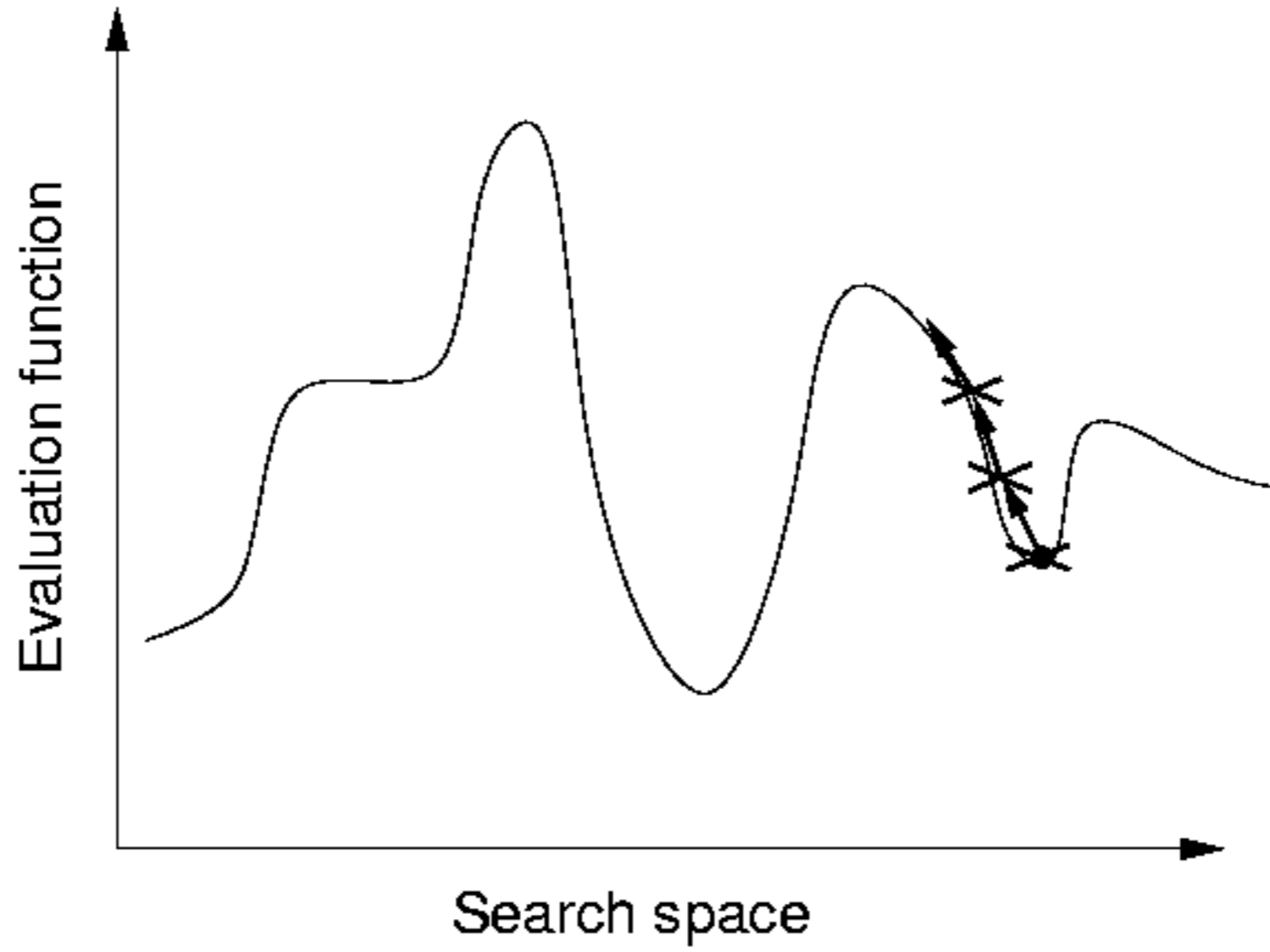
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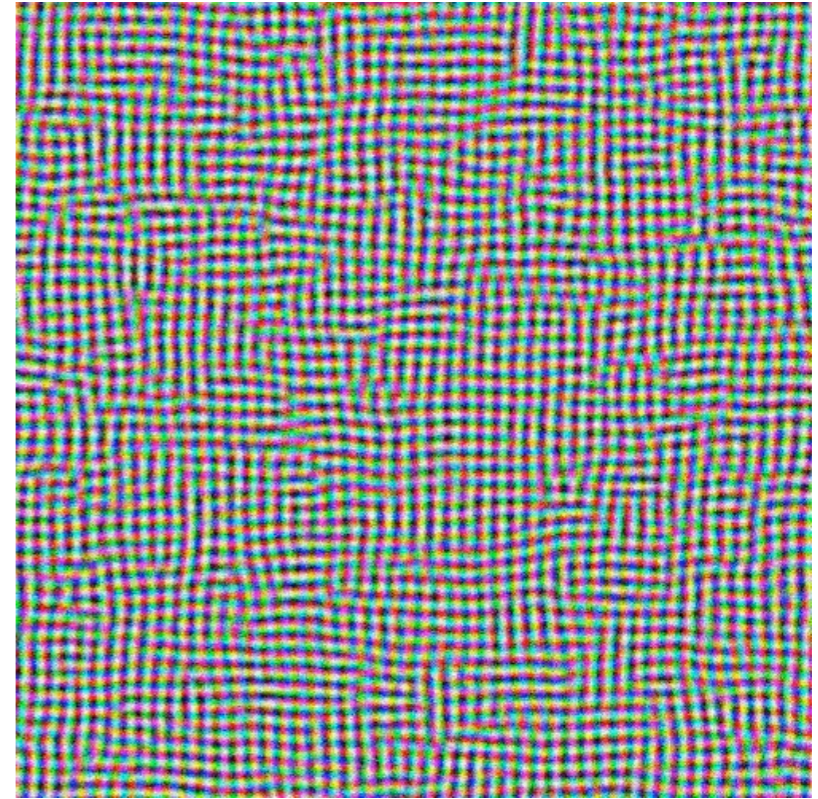
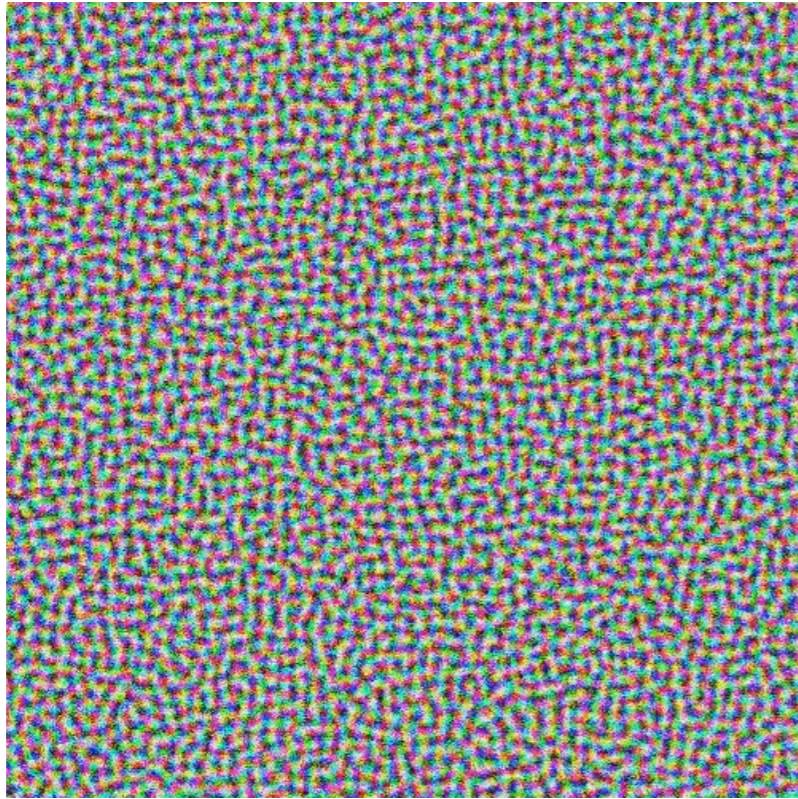
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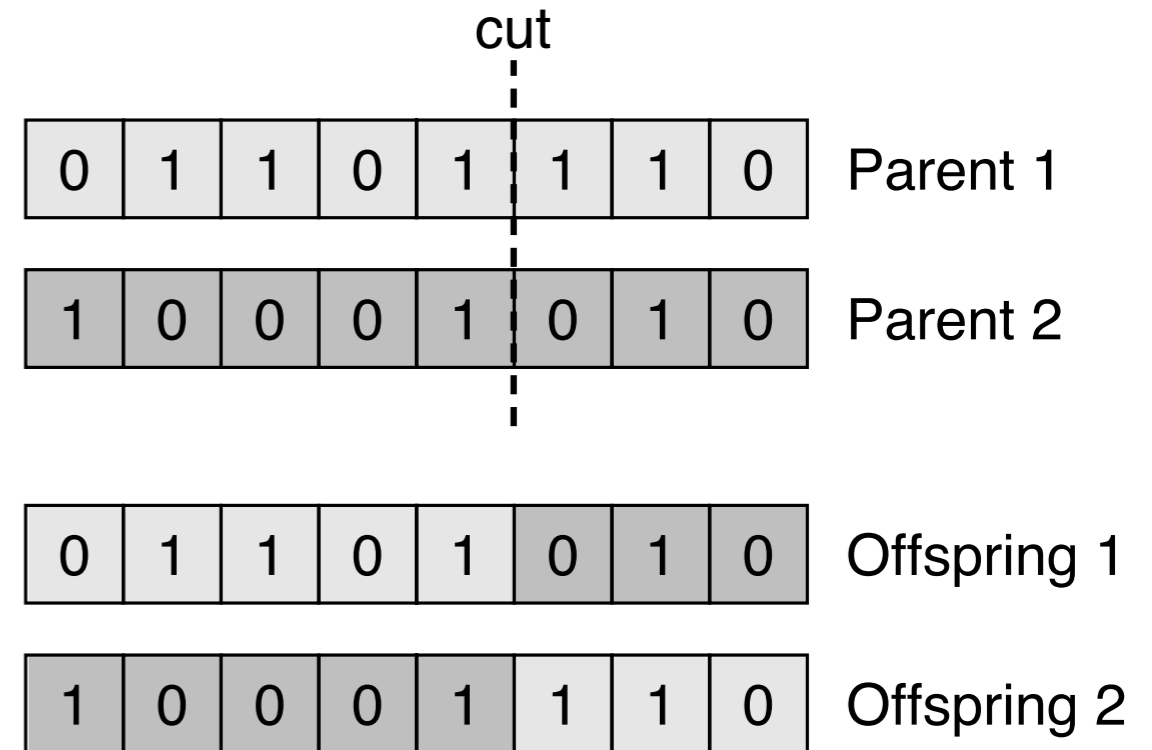
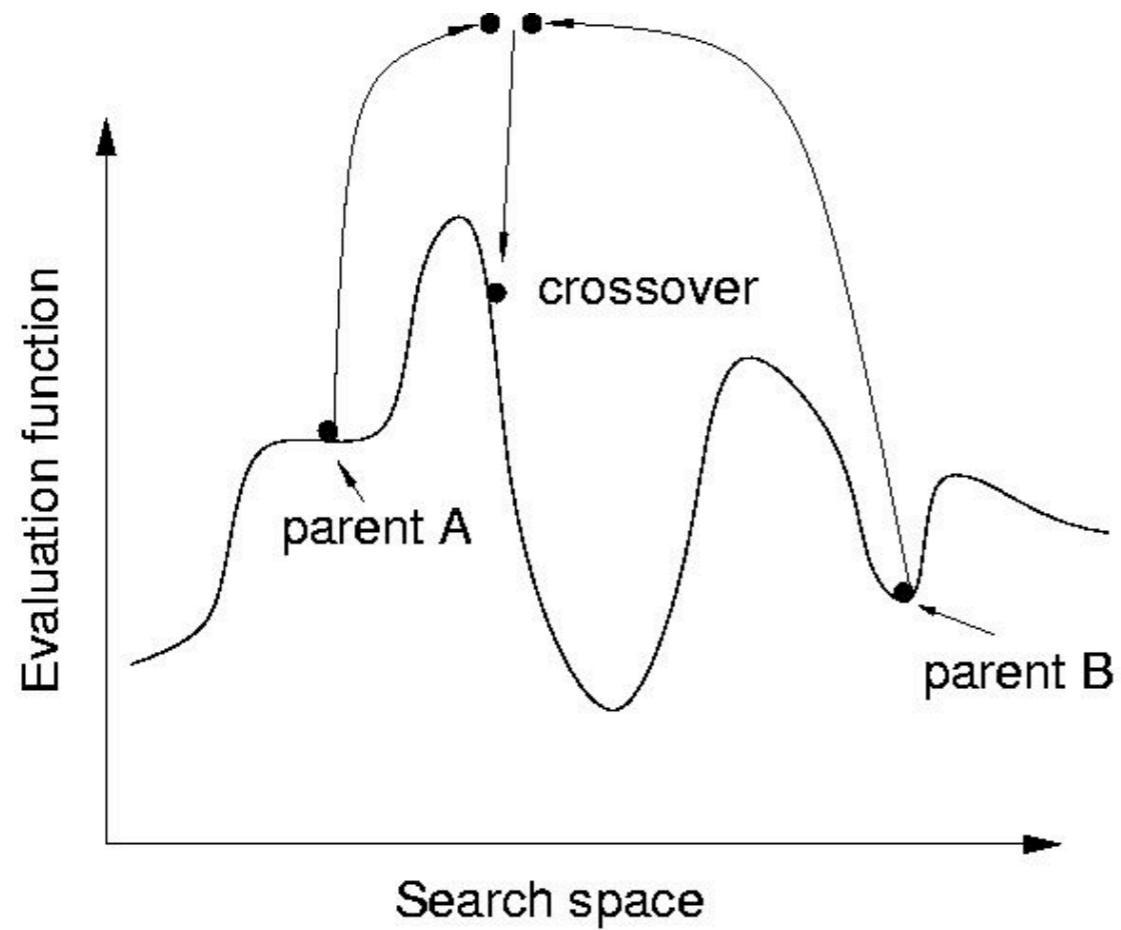
Tabu Search



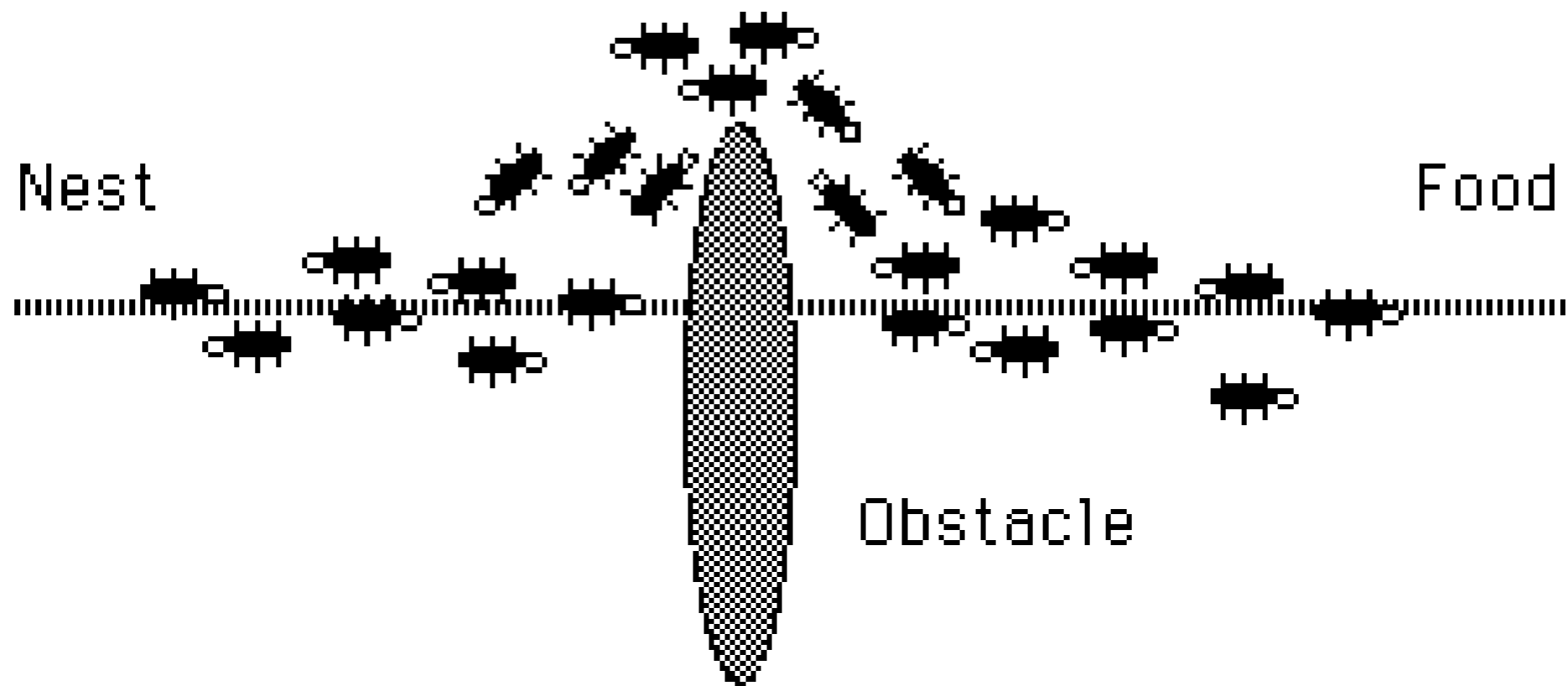
Simulated Annealing



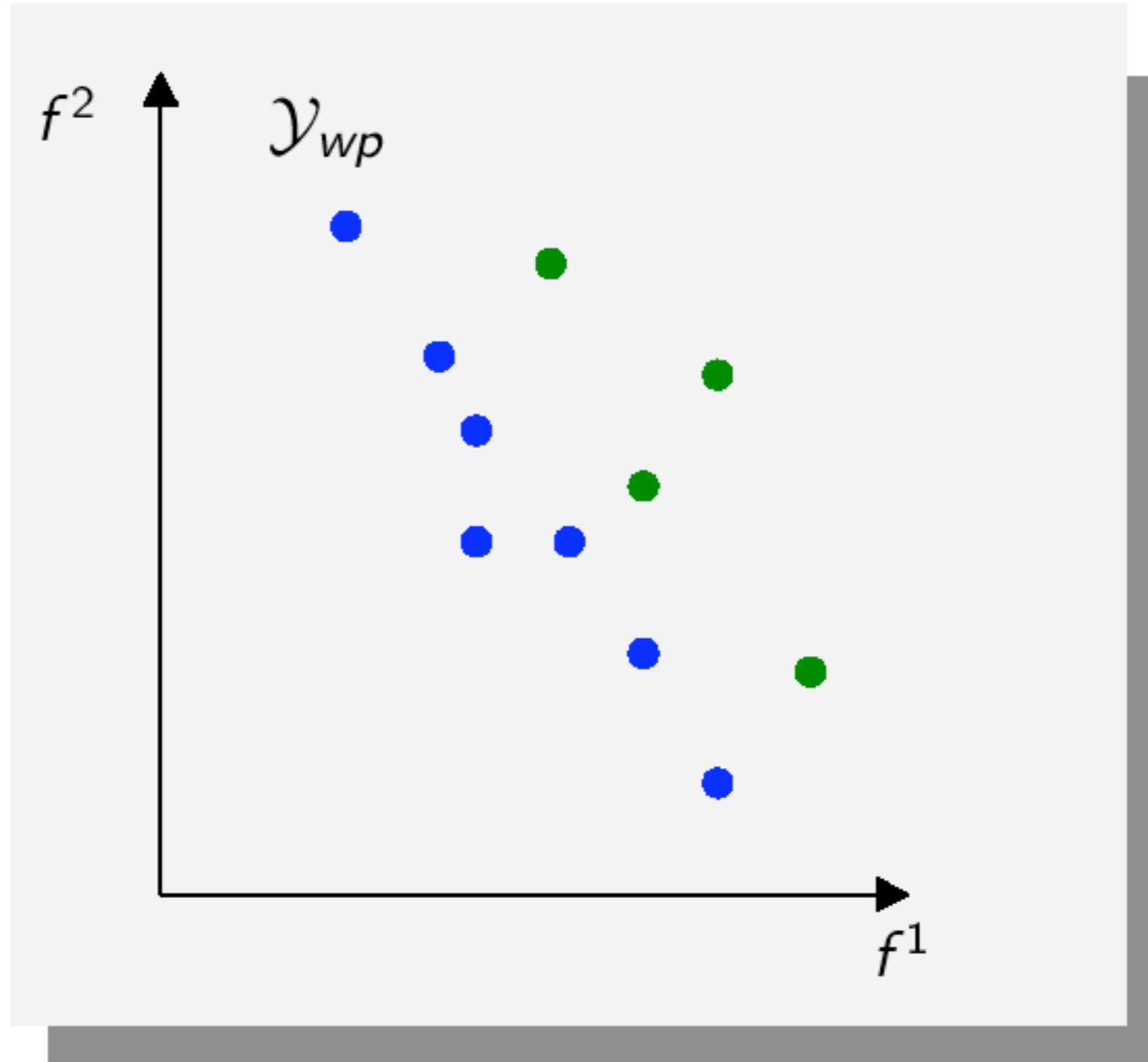
Evolutionary Algorithms



Ant Colony



Multiobjective Optimization



Prerequisites

The content of DM811 must be known

Final Assessment (5 ECTS)

- ▶ Individual project:
 - “Implementation and analysis of heuristics”
 - deliverables: written report + program
- ▶ External examiner

Contents of the course

1. Tabu Search
2. Simulated Annealing
3. Scatter Search and Path Relinking
4. Experimental Analysis and Configuration Tools
5. Machine Learning and the No Free Lunch Theorem
6. Evolutionary Algorithms
7. Ant Colony Optimization
8. Estimation Distribution Algorithm and Cross Entropy
9. Metaheuristics in Continuous Non-Convex Optimization
10. Hybrid/Parallel Metaheuristics
11. Multiobjective Optimization by Local Search
12. Multiobjective Optimization by Evolutionary Algorithms

12-14 lectures + 6-8 laboratory sessions

Course Material

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