Advanced Optimization
Lecture/Exercise 2: The Travelling Salesperson Problem

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Master AIC

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Course Overview

	Date		Topic
1	Wed, 27.11.2019	Dimo	Randomized Algorithms for Discrete Problems
2	Wed, 4.12.2019	Dimo	Exercise: The Travelling Salesperson Problem
3	Wed, 11.12.2019	Dimo	Evolutionary Multiobjective Optimization I
4	Mon, 16.12.2019	Dimo	Evolutionary Multiobjective Optimization II
5	Wed, 18.12.2019	Dimo	Looking at Data
	Vacation		
6	Wed, 8.1.2020 (morning!)	Anne	Continuous Optimization I
7	Wed, 22.1.2020 (morning!)	Anne	Continuous Optimization II
	Wed, 5.2.2020		oral presentations (individual time slots)

Assignment of Papers

1) Two-dimensional subset selection for hypervolume and epsilon-indicator
2) RM-MEDA: A regularity model-based multiobjective estimation of distribution algorithm. Gaetano, Francesco
3) A universal catalyst for first-order optimization. Simon, Wafa
4) Optimized Approximation Sets for Low-Dimensional Benchmark Pareto Fronts.
5) Efficient optimization of many objectives by approximation-guided evolution. Gérémy
6) A Mean-Variance Optimization Algorithm. Ramine
7) Theoretical foundation for CMA-ES from information geometry perspective.
8) Population Size Adaptation for the CMA-ES Based on the Estimation Accuracy of the Natural Gradient. Florian, Théo
9) CMA-ES with Optimal Covariance Update and Storage Complexity. Eric, Clément
10) Challenges of Convex Quadratic Bi-objective Benchmark Problems
11) Ansaar

Exercise:
Pure Random Search
and the (1+1)EA

`http://www.cmap.polytechnique.fr/~dimo.brockhoff/advancedOptSaclay/2019/exercises.php`

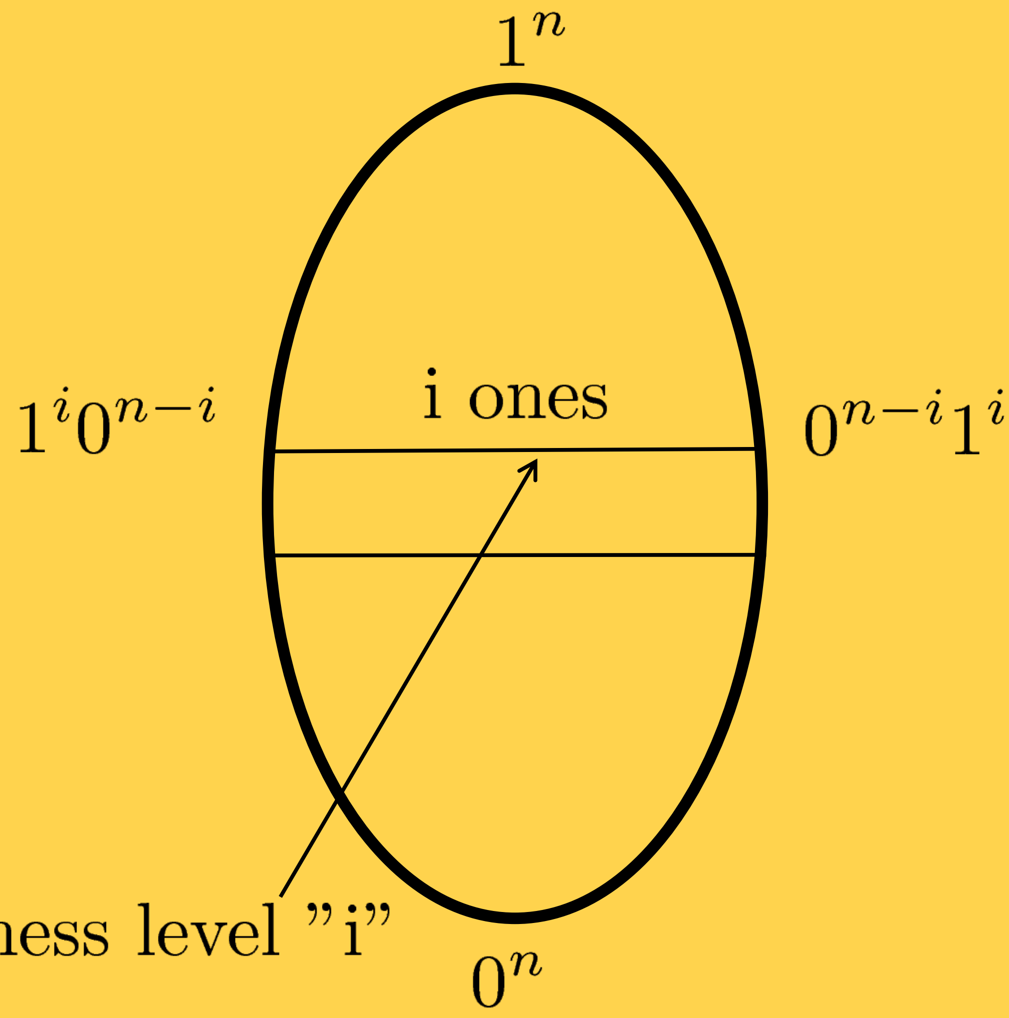
Proof Technique Fitness-based Partitions

$$\Omega = \{0,1\}^n$$

$$f(x) = \sum_{i=1}^{n} x_i$$

$$P_i = \{x | f(x) = i\}$$

$$\Omega = \bigcup_{i=0}^{n} P_i$$



Upper Runtime Bound for (1+1)EA on ONEMAX

$$T = \inf\{t \in \mathbb{N}, X_t = (1, \ldots, 1)\}$$

X_t estimate of solution at iteration t
T_i time to leave fitness level "i"

$$E(T) \leq \sum_{i=0}^{n-1} E(T_i)$$

$\text{Prob}(\text{leave}P_i) \geq \frac{1}{n}(1 - \frac{1}{n})^{n-1} \times (n-i)$ (proba to flip one and only one of the $(n-i)$ remaining 0)

$$(1 - \frac{1}{n})^{n-1} \geq \frac{1}{e}$$

$\text{Prob}(\text{leave}P_i) \geq \frac{n-i}{en}$

Upper Runtime Bound for (1+1)EA on ONEMAX

$$E(T_i) \leq \frac{en}{n-i}$$

$$E(T) \leq \sum_{i=0}^{n-1} \frac{en}{n-i} \leq e.n(\log n + 1)$$

Today's Lecture

❶ Exercise: The Travelling Salesperson Problem (TSP)

- reminder: problem definition + evolutionary algorithms
- rest of the day: exercise

Motivation:

- Motivation 1: show that it is easy to implement a working randomized search heuristic for the TSP
- Motivation 2: in research, you need to
  - prototype often (i.e. quickly)
  - try out many things
- hence: good idea to train this in python ☺

The Traveling Salesperson Problem (TSP)

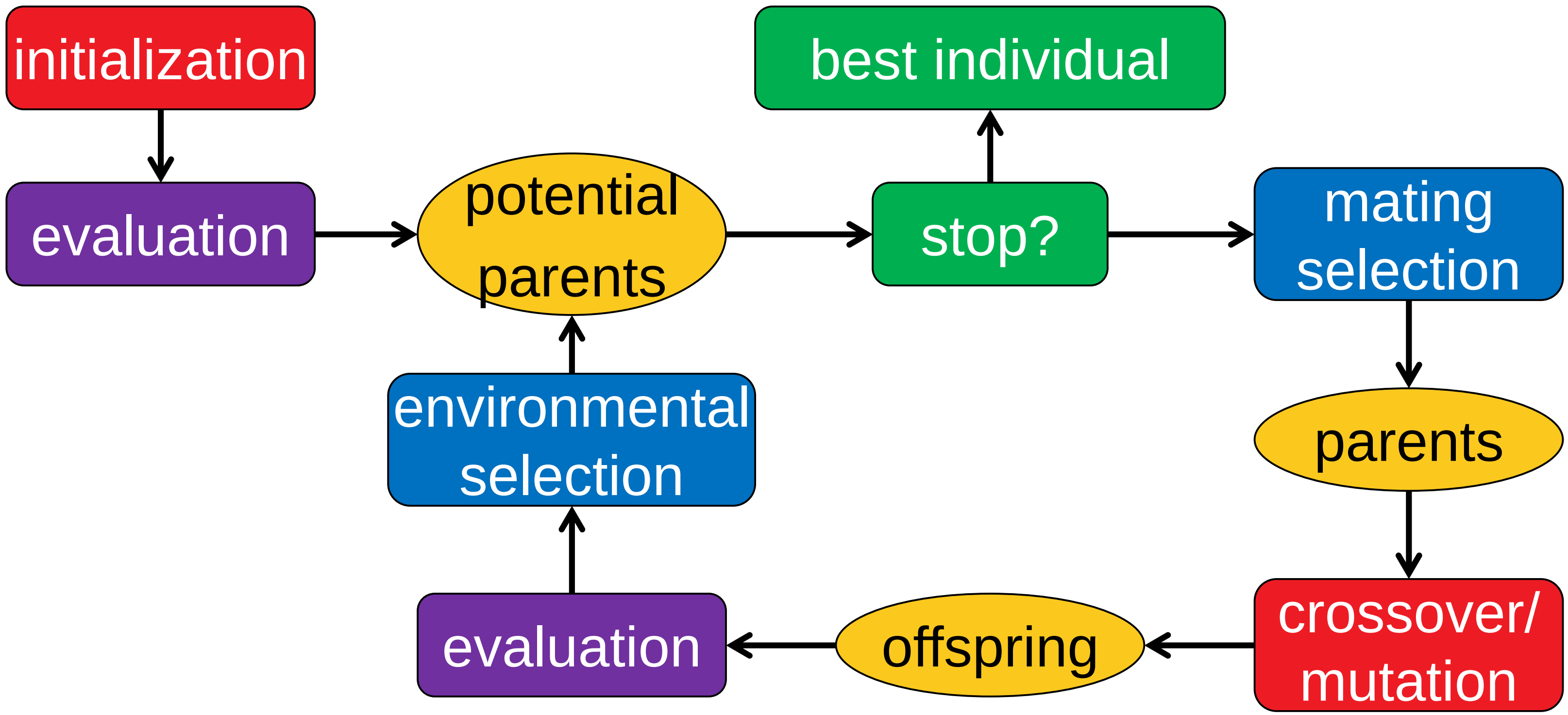
Reminder: TSP

Traveling Salesperson Problem (TSP)

- Given a set of cities and their distances
- Find the shortest path going through all cities
- Actually several variants:
  - Symmetric vs. asymmetric
  - Euclidean TSP

$$\Omega = S_n \text{ (set of all permutations)}$$

Reminder: Generic Framework of an EA



stochastic operators

“Darwinism”

stopping criteria

Important:
representation (search space)

Exercise:
An Evolutionary Algorithm for the TSP

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