ITMO UNIVERSITY

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Lecture 3: Selection

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Components

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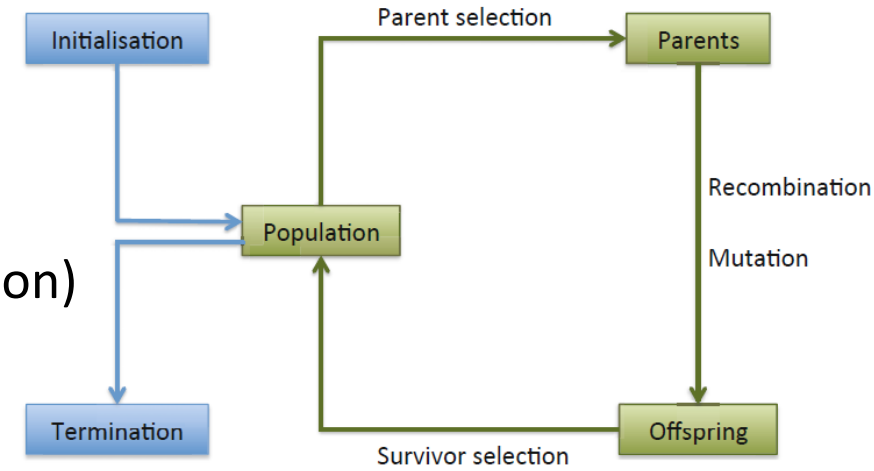
- Representation of individuals
- Population of individuals
- Evaluation function (fitness function)
- Parent selection mechanism
- Variation operators (recombination, mutation)
- Survivor selection mechanism
- Terminate conditions



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Selection

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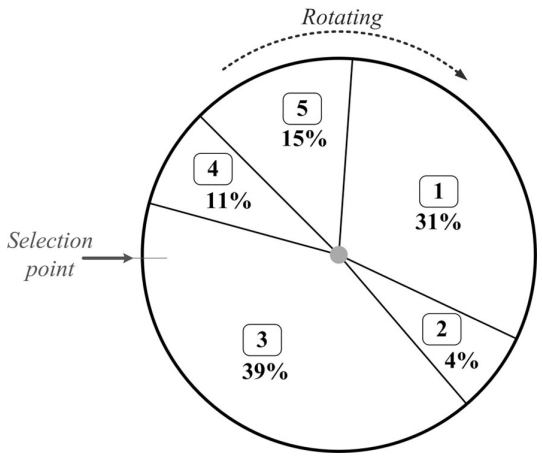
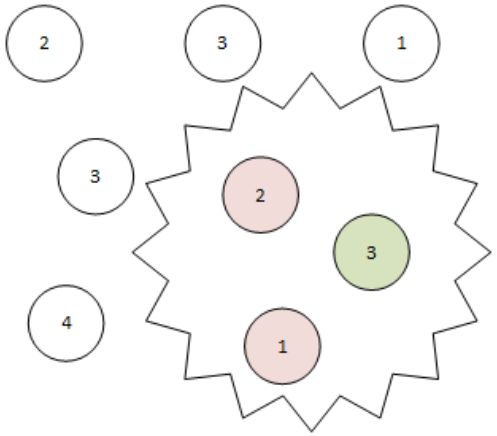
- Roulette wheel



- Tournament



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Ranking

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- Transform fitness into another values (ranks)
- Works for roulette wheel
- Examples:
  - Fitnesses: 101, 102, 103
    - Rank?
    - (101 – 100), (102 – 100); (103 – 100) => 1, 2, 3
  - Fitnesses: 100, 5, 4, 6
    - Rank?

$$P_{lin-rank}(i) = \frac{(2-s)}{\mu} + \frac{2i(s-1)}{\mu(\mu-1)}$$

    - 0.375, 0.210, 0.125, 0.290

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Selection

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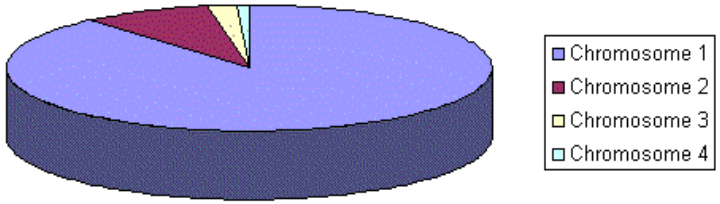
Distinction between

- **selection operators:** define selection probabilities
- **selection algorithms:** define how probabilities are implemented

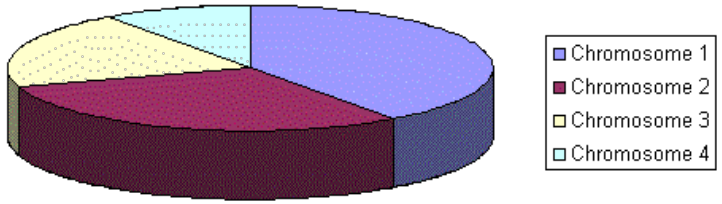
Situation before ranking (graph of fitnesses)



Solving problems:

- premature convergence
- selection pressure

Situation after ranking (graph of order numbers)



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Overselection

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- When population is extremely large
- Population is divided into two groups:
  - Top x% fittest
  - Other
- During selection, 80% of parents selected from the 1st group, and 20% from other.

Population size	Proportion of population in fitter group (x)
1000	32%
2000	16%
4000	8%
8000	4%

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Preserving diversity

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- Avoid premature convergence
- Niching – set of methods to divide population into several subgroups
- Find several local optimums instead of one global
- Explicit:
  - Fitness Sharing, Crowding, Speciation
- Implicit:
  - Island model, Cellular model

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Fitness sharing

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- Number of individual within a given niche is controlled by sharing their fitness.
- Based on distances between individuals (genotype or phenotype)
- Fitness F of each individual is shred with other individuals within predefined distance σ_{share}

$$F'(i) = \frac{F(i)}{\sum_j sh(d(i,j))}$$

$$sh(d) = \begin{cases} 1 - \left(\frac{d}{\sigma_{share}}\right)^{\alpha}, if\ d \leq \sigma_{share} \\ 0, otherwise \end{cases}$$

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Crowding

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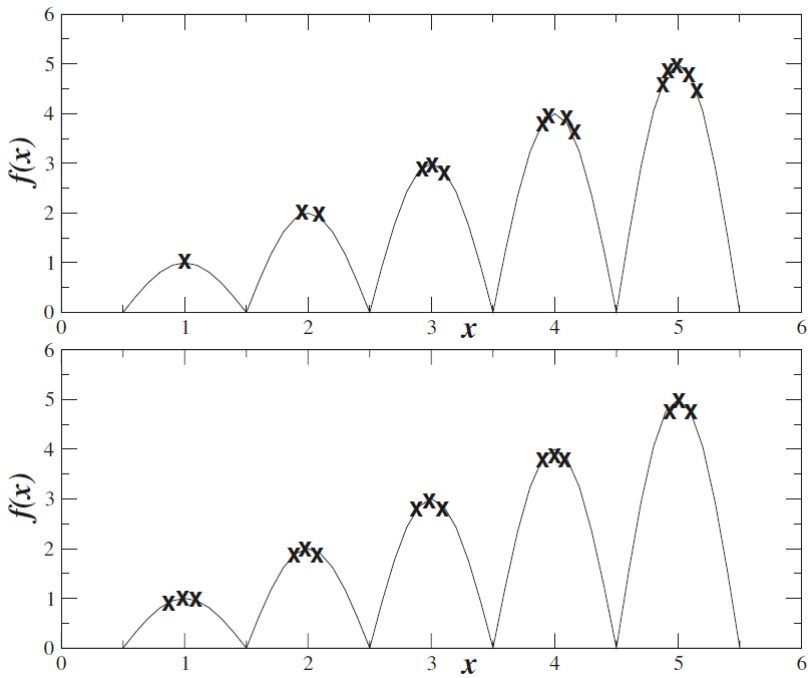
- Offspring (children) replace the most similar parents.
  - Parent population is randomly paired
  - Each pair produces two offspring via recombination
  - These offspring are mutated and evaluated
  - Four pairwise distances between offspring and parents are calculated
  - Offspring competes for survival in a tournament with parents

Fitness sharing and crowding



- Idealized population distributions for:
- Fitness sharing
  - Allocate individuals to peaks in proportion to their fitness
- Crowding
  - Distributed amongst peaks

Speciation

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- Biological analogy, when someone specifically interfering the reproduction of individuals
- Population may contains several species, and during recombination individuals mate only with same species
- Species can be defined via distance or special tag

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Island based model

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- Population contains several subpopulations
- Each subpopulations may be evolved by different strategies
- Some individuals migrate between population every n generations
- Can be parallelized

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Frameworks for EAs

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- JMetal. (Java, 2015). http://jmetal.sourceforge.net/index.html.
- A full-contained framework containing a huge variety of algorithms (evolutionary, population) for single-criteria and multi-criteria optimization. Provides mechanisms for configuring, monitoring, managing the algorithm.
- Watchmaker. (Java, 2010). https://watchmaker.uncommons.org.
- Simple and user-friendly framework. Powerful evolution engine with parallelization and island models. Monitoring and control of the algorithm. Interactive mode.
- Jenetics. (Java, Live). https://jenetics.io.
- Fresh and modern framework. Uses new Java functionality (stream). Coding solutions through the *Genotype: Chromosome: Gene.*
- HeuristicLab. (C#, Live). https://dev.heuristiclab.com/trac.fcgi/wiki.
- Supported platform for developed problems and algorithms. Graphical interface. Less flexible, complex algorithm development for non-standard problems.
- GeneticSharp. (C#, 2019). https://github.com/giacomelli/GeneticSharp
- A simple framework with basic functionality and capabilities for developing efficient algorithms.
- Deap. (Python, ~2019). https://deap.readthedocs.io/en/master/
- The most popular, simpler Python framework. Convenient implementation of your solutions, parallelization, statistics monitoring.

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Lab 1

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- Function optimization
  - Take the template script
  - Change dimension of the problem (dim = 100)
  - Develop your version of algorithm (modify mutation, crossover, selection, …)
  - The best result for provided function is *10.0*. Try to get at least *9.5*.
  - Prepare a Jupyter Notebook report.
  - Send me to mihail.melnik.ifmo@gmail.com with topic *ec_lab1_**surname***
  - Deadline is like 2 weeks, but not hard.

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Function optimization

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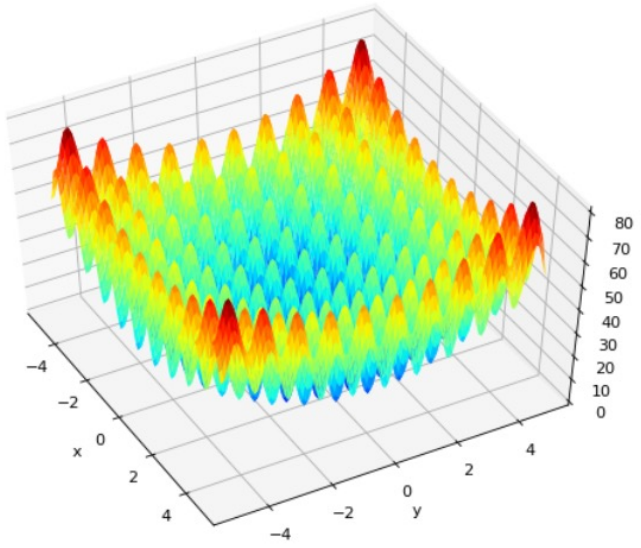
- In module function_opt presented 3 experiments:
  - Genetic algorithm
  - Particle swarm optimization
  - Together

Benchmark function – Rastrigin function.

https://www.mathworks.com/help/gads/example-rastrigins-function.html

Dimension can be modified.

Type	minimization
Range	$x_i \in [-5.12, 5.12]$
Global optima	$x_i = 0, \forall i \in \{1 \dots N\},\ f(\mathbf{x}) = 0$
Function	$f(\mathbf{x}) = 10N + \sum_{i=1}^{N} x_i^2 - 10\cos(2\pi x_i)$



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