ITMO UNIVERSITY

Saint Petersburg, Russia

Lecture 2:
Components of Evolutionary Algorithms

Michael Melnik

mihail.melnik.ifmo@gmail.com

What are Evolutionary Algorithms?

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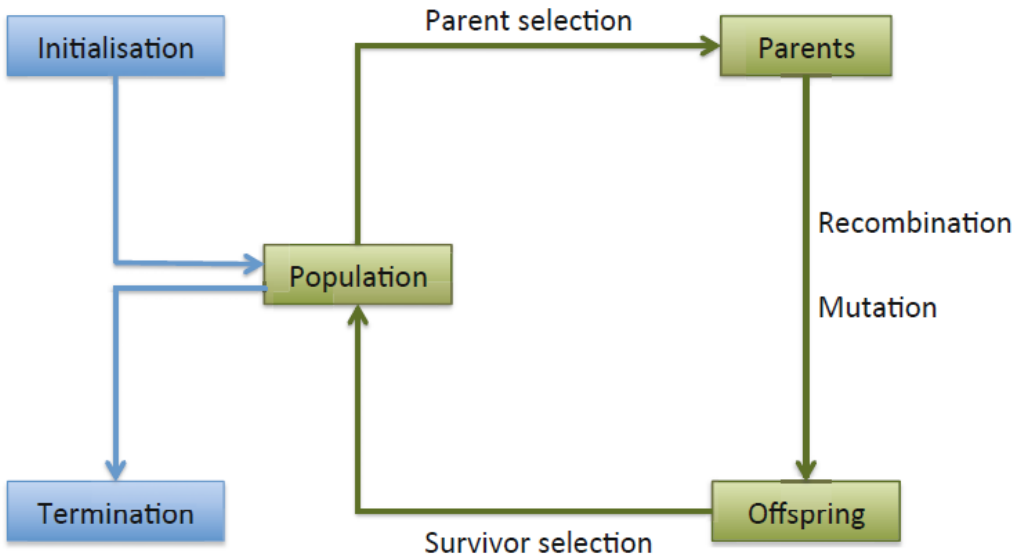
- Nature inspired stochastic optimization algorithms
- Population of individuals within problem's environment
- Evolution is based on two forces:
  - Variation (recombination, mutation)
  - Selection
- Family of generate and test methods



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Components of EAs

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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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Representation

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- Bridge between **original problem context** and **problem solving space**
- Objects forming possible solution within original problem context are referred to such terms as:
  - Phenotype
  - Candidate solution
  - Individual
- Encoded individuals within EA are called:
  - Genotype
  - Chromosome
- Elements of genotype can be called **genes**, alleles.

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Representation

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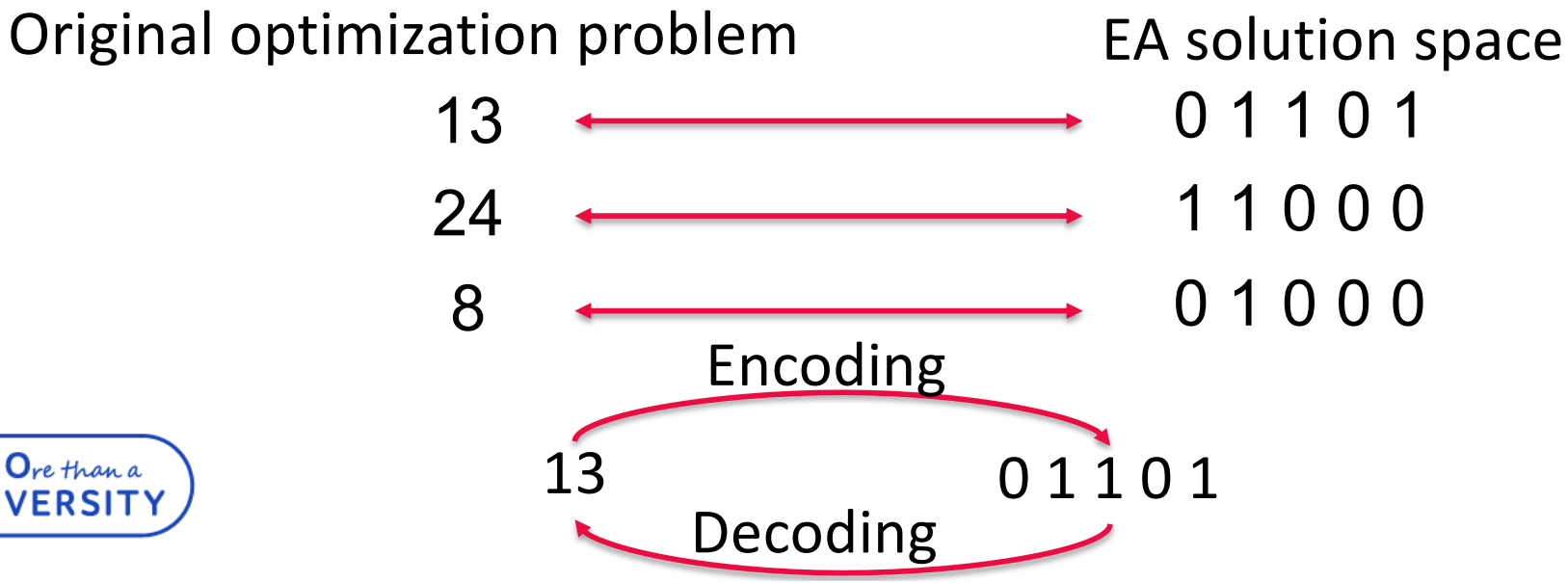
- Mapping from phenotype to genotype is **encoding**
- Mapping from genotype to phenotype is **decoding**

Example: find integer x, that optimizes x^2



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Evaluation function (fitness function)

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- Fitness function defines requirements to which population should adapt
- Fitness function is a procedure, that assigns a quality measure for solutions (genotypes)
  - For phenotypes it called **objective function**
- Naturally fitness function should be maximized
- However, there are no problems to reverse it to minimization

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Example

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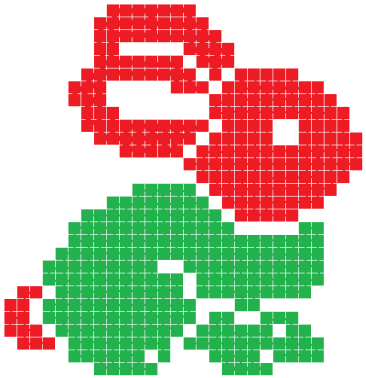
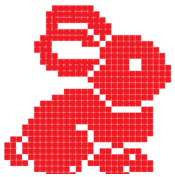
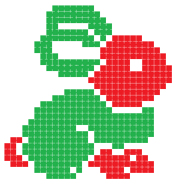
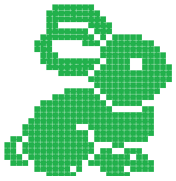
- Rabbits have 5 parts of body:
  - Ears, head, body, legs, tail
  - Each part can be green or red
  - More green rabbits are better than less green



	Phenotype	Genotype	
worst		0 0 0 0 0	0
		1 0 1 0 0	2
best		1 1 1 1 1	5

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Population

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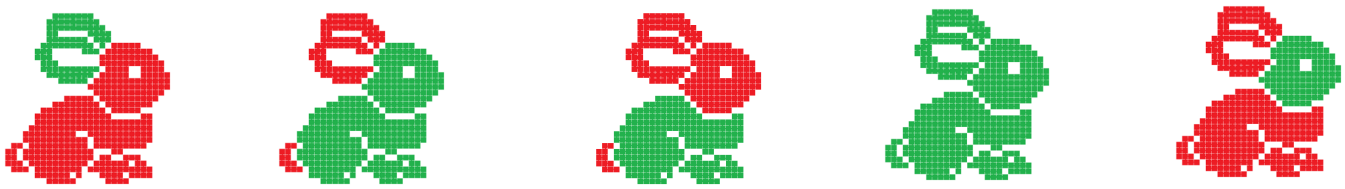
- Population holds solutions
- Population is a multiset of genotypes (copies are allowed)
- May has special structure (grid)
- Population size is constant
- Diversity of population – number of different solutions within
- Initialization: the first population is seeded by random generated individuals



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Parent selection mechanism

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- Parent selection mechanism aimed to select individuals from population, which will generate offspring (children)
- Parent selection is probabilistic
- Can be uniform
- Generally, less quality solution have less chances to be selected

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Variation operators

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- Variation creates new individuals from old and increases diversity of population
  - Variation operators a stochastic, but some problem specific rules can be used
- Mutation
  - Applied to one individual and deliver one new individual (mutant)
  - Mutation provides something new
- Recombination
  - Merges information from two (or more) individuals to create offspring

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Survivor selection mechanism

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- Mechanism, that selects, which solutions will be selected for the next generation of population
- Selection is stochastic and based on fitness estimation of individuals
- Selection saves the initial size of population

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Terminate conditions

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- Define rules and conditions, when an algorithm has to stop its evolving process
- Common terminate conditions:
  - The maximally allowed CPU time elapses.
  - The total number of fitness evaluations reaches a given limit.
  - The fitness improvement remains under a threshold value for a given period of time (i.e., for a number of generations or fitness evaluations).
  - The population diversity drops under a given threshold.

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Behavior of EAs

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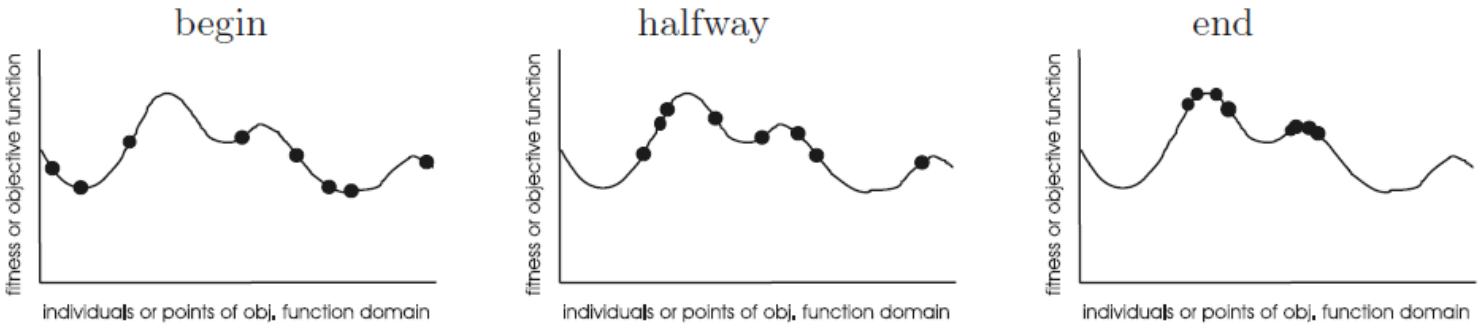
- Evolutionary process is a trade-off between **exploration** and **exploitation**
- Exploration – generation of something new, observation of untested regions of search space
- Exploitation – concentration on specific regions of good solutions, trying to improve them



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Anytime behavior

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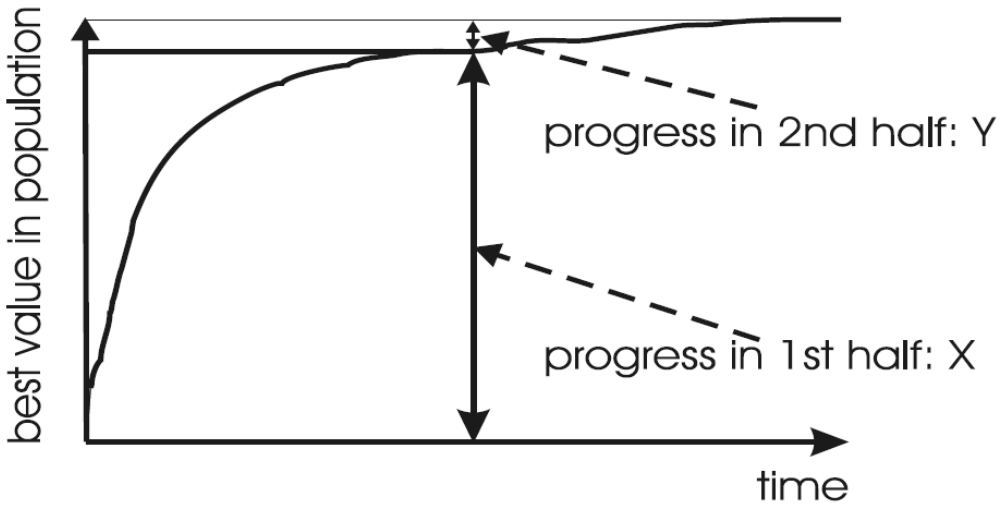
- Anytime behavior is typical for many iterations based algorithms
- This means, that algorithm can be stopped anytime, and algorithm will has a solution



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View of performance

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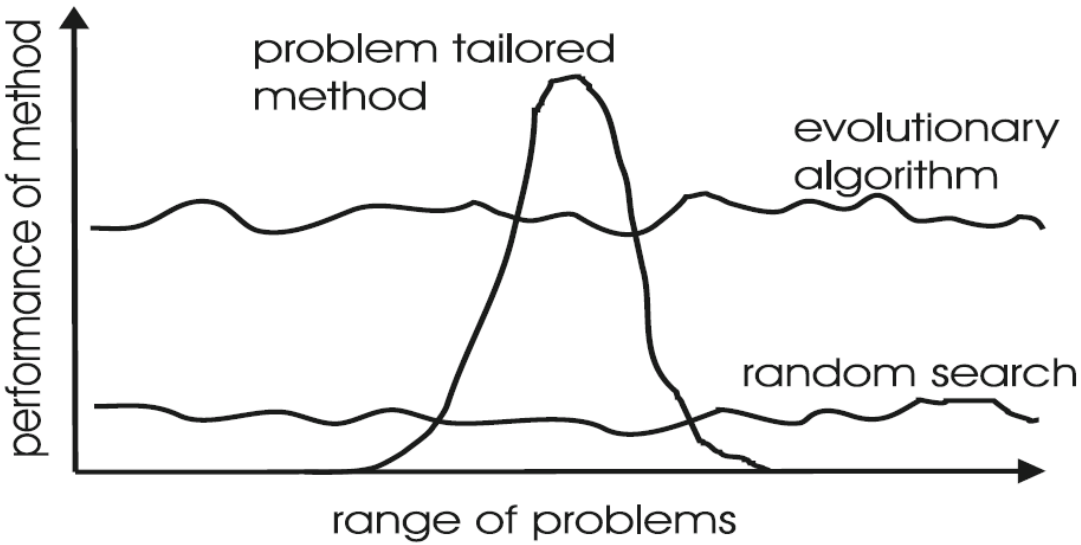
- It is assumed, that EAs are better than random search approach in average
- But it many cases, problem specific algorithms are more appropriate



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