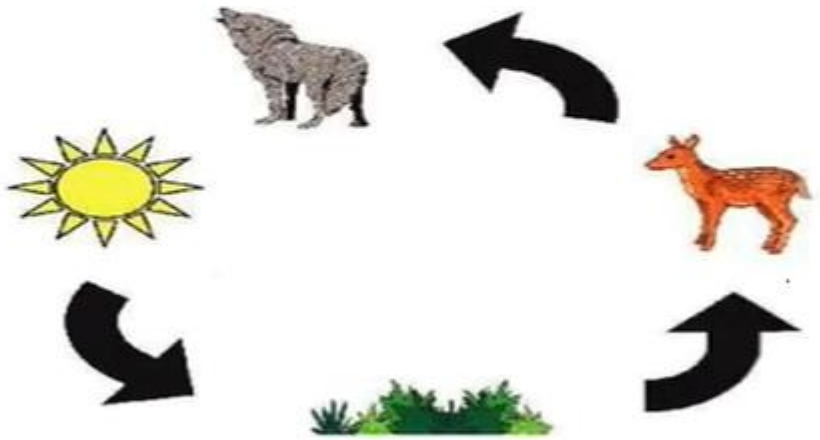
GENETIC ALGORITHM

Evaluation in Nature



Generate and test for survival of fittest

Positive or Negative influence

Competition within the population of ecosystem

Competition within the population of species

Central Theme

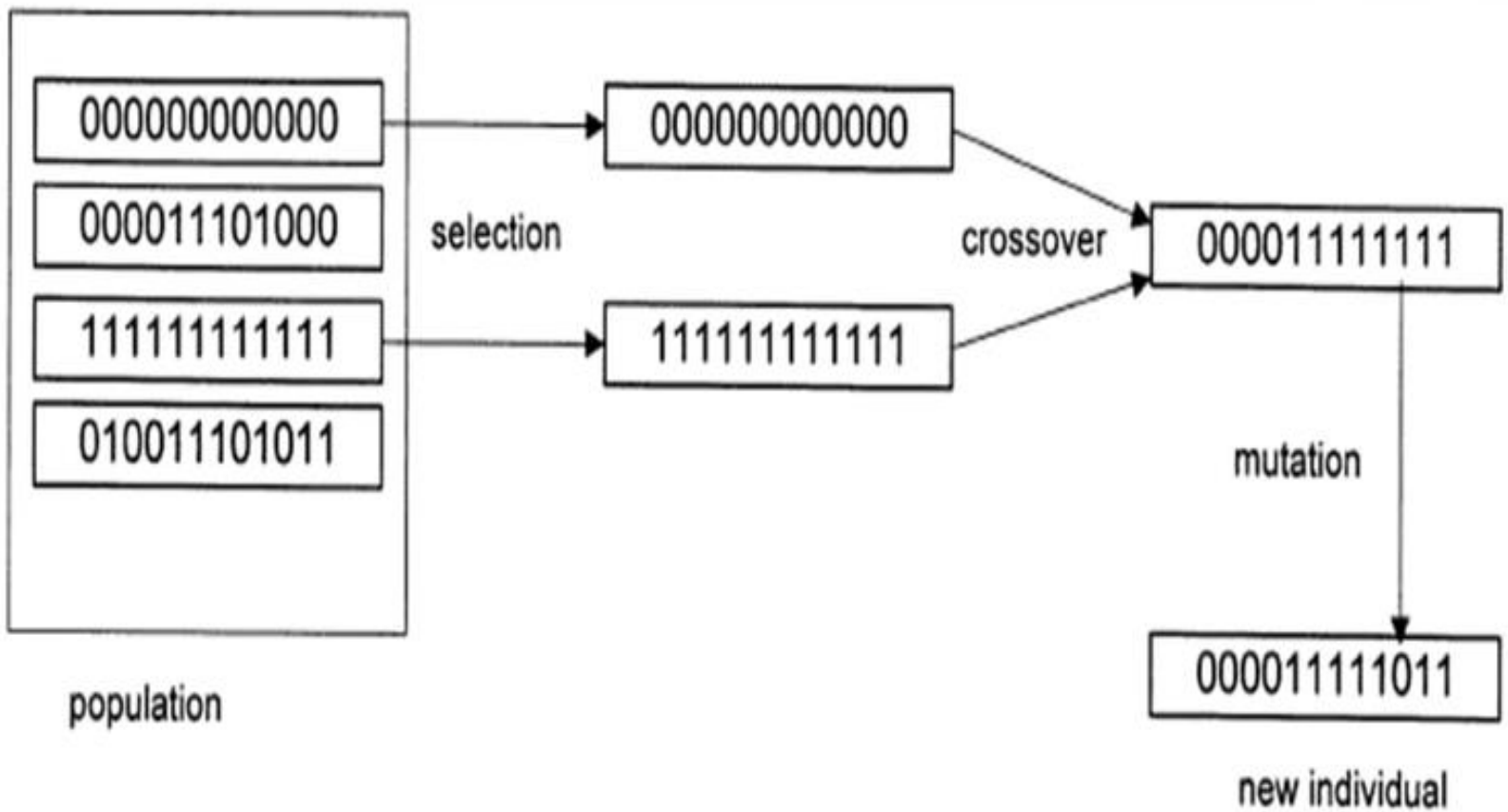
Robustness -: survival in many different Environment

What is the Idea

- Creating new complex object by adding two simple objects
- Random mixing of gens

This kind of optimization is what we call Genetic Algorithm

Genetic Algorithm Operators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population
selection
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crossover
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mutation
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new individual

Selection
Select the best Discard the rest

- Selection operators give preference to better solutions (chromosomes), allowing them to pass on their 'genes' to the next generation of the algorithm. The best solutions are determined using some form of objective function (fitness function) before being passed to the crossover operator. Different methods for choosing the best solutions exist, for example,
- Fitness proportionate selection

Fitness proportionate selection

- also known as **roulette wheel selection.**
- Selecting potentially useful solutions for recombination(which solution to reproduce).
- The fitness function assigns a fitness to possible solutions.
- This fitness level is used to associate a probability of selection with each individual chromosome.
- If f_i is the fitness of individual i in the population, its probability of being selected is

$$p_i = \frac{f_i}{\sum_{j=1}^{N} f_j},$$

dividing the fitness of a selection by the total fitness of all the selections

where N is the number of individuals in the population.

Truncation Selection

- While candidate solutions with a higher fitness will be less likely to be eliminated, there is still a chance that they may be eliminated because their probability of selection is less than 1 (or 100%).
  - In this case one can use Truncation Selection.
- In truncation selection the candidate solutions are ordered by fitness, and some proportion, p, (e.g. $p = 1/2, 1/3$, etc.), of the fittest individuals are selected and reproduced 1/p times.
  - Truncation selection is less sophisticated than many other selection methods, and is not often used in practice.

Tournament selection

- Selecting an individual from a population of individuals in a G.A.
- Involves running several "tournaments" among a few individuals or chromosomes chosen at random from the population.
- The winner of each tournament (the one with the best fitness) is selected for crossover.
- If the tournament size is larger, weak individuals have a smaller chance to be selected because if a weak individual is selected to be in a tournament, there is a higher probability that a stronger individual is also in that tournament.

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choose k (the tournament size) individuals from the population at random
choose the best individual from the tournament with probability p
choose the second best individual with probability p*(1-p)
choose the third best individual with probability p*((1-p)^2)
and so on
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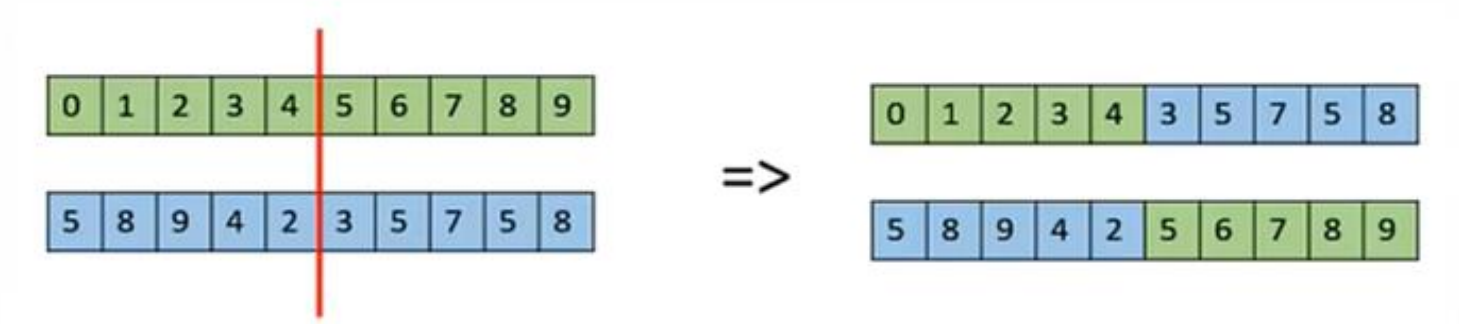
Crossover

- Crossover is a process of taking more than one parent solution and producing a child solution from them.
- Crossover Operators
  - One Point Crossover
  - Multi Point Crossover
  - Uniform Crossover

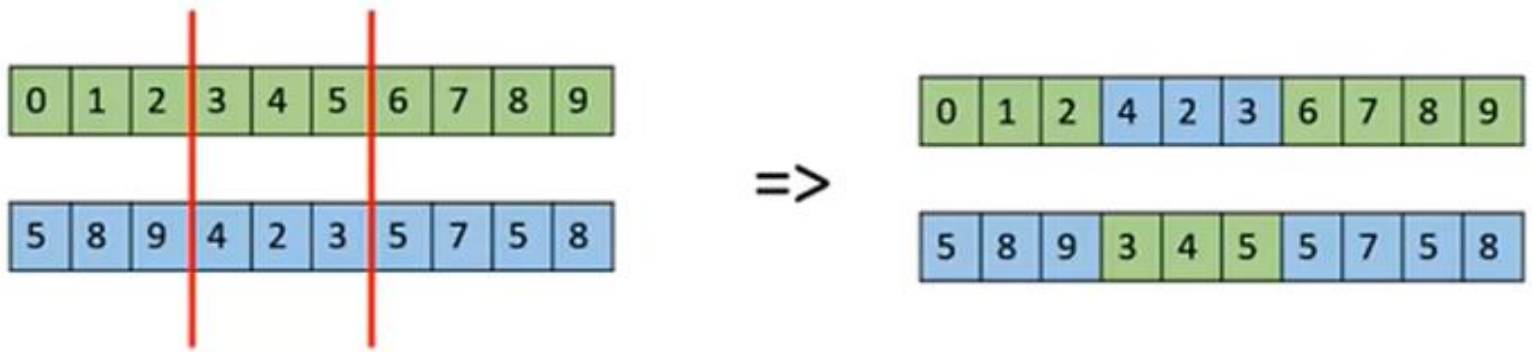
One Point Crossover

- In this one-point crossover, a random crossover point is selected and the tails of its two parents are swapped to get new off-springs.



Multi Point Crossover

- Generalization of the one-point crossover wherein alternating segments are swapped to get new off-springs.



Uniform Crossover

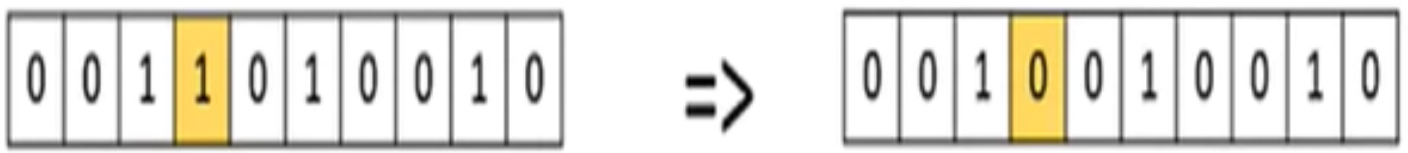
- We don't divide the chromosome into segments, rather we treat each gene separately.
- Essentially flip a coin for each chromosome to decide whether or not it'll be included in the off-spring.
- We can also bias the coin to one parent, to have more genetic material in the child from that parent.

Mutation

- A mutation is a permanent change in a gene that is passed from one generation to the next. An organism born with a mutation can look very different from its parents.
- It work in a single chromosome.

Bit Flip Mutation

- In this bit flip mutation, we select one or more random bits and flip them. This is used for binary encoded GAs.



Swap Mutation

- we select two positions on the chromosome at random, and interchange the values. This is common in permutation based encodings.

Scramble Mutation

- Scramble mutation is also popular with permutation representations.
- From the entire chromosome, a subset of genes is chosen and their values are scrambled or shuffled randomly.