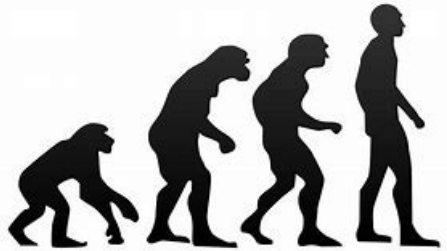


Evolution with constraints

1/ Reminder on evolutionary algorithms
May 2020, É. Vareilles

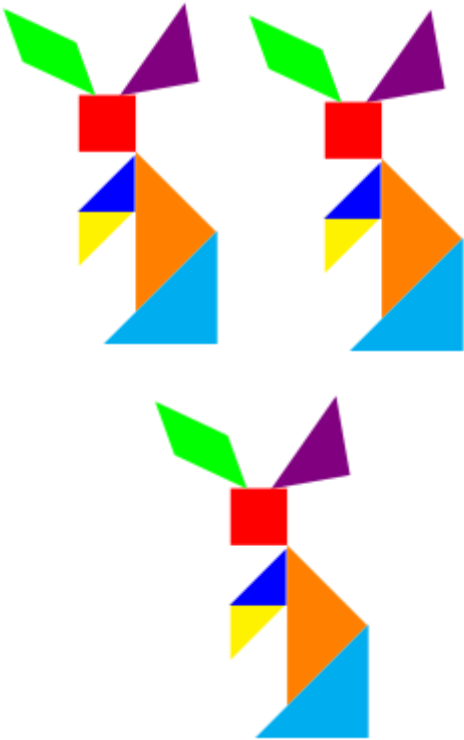
Agenda / 1. Reminder on evolutionary algorithms

- 1.1. General, definitions & concepts
- 1.2. Conventional & stochastic operators
- 1.3. SPEA-2 algorithm



- Inspired from evolution theory (Darwin)
- To make the individuals of a population evolve by means of stochastic operators in order to favor by selection the emergence of individuals whose evaluation / adaptation is better.
- Widely used and recognized to solve difficult, combinatorial and multi-objective optimization problems.
- A wide family :
 - Genetic algorithms [Holland 1975]
 - Genetic programming [Smith 1980]
 - Evolution strategies [Rechenberg & Schwefel, 1965],
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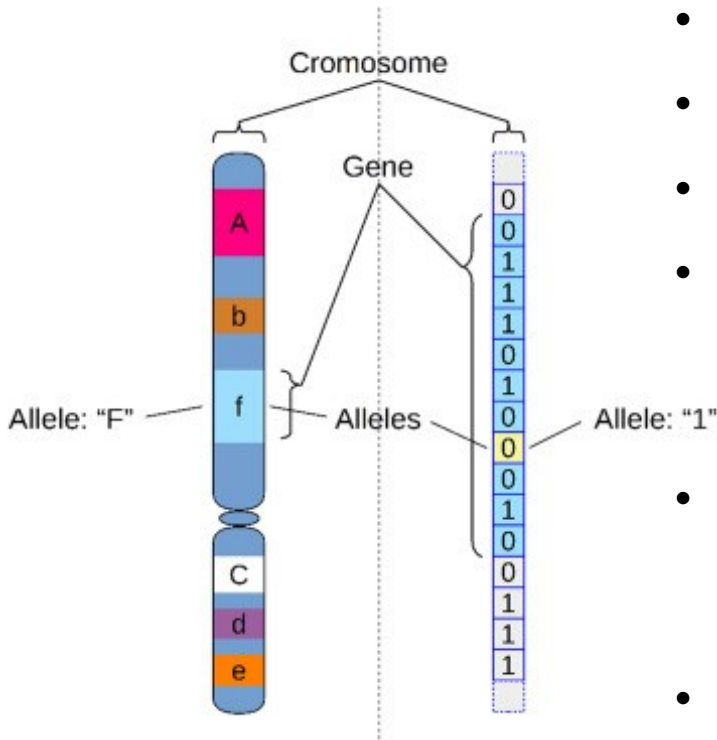
Glossary of terms



- Individual: carrier of the genetic information. It is characterized by its state in the search space, its fitness, and, where applicable, a set of strategy parameters. The individual is the unit of selection.
- Population : pool of individuals exhibiting equal or similar genome structures, which allows the application of genetic operators
- Generation: (natural) time unit of the EA, an iteration step of the EA, a complete cycle comprising the procreation and evaluation (fitness determination and selection) of one or more individuals.
- Fitness function: evaluation of an individual with respect to its reproduction capability. The term ``fitness function" is often used as a synonym for objective function.

1.1. General, definitions & concepts

Glossary of terms :



- Chromosome: set of genes of an individual
- Gene : subunit of a chromosome, which represents each decision variable.
- Allele : different possible states of a gene
- Locus : specific, fixed position on a chromosome where a particular gene or genetic marker is located.
- Selection : necessary operator in EA, which, depending on the fitness or the objective function values, respectively, decides on the reproduction of the individuals. Selection gives a direction to evolution, it guides the search
- Crossover : special form of recombination in GA where two parents, generally, produce two offspring by gene exchange.
- Mutation : variation operator, which changes the information contained in the genome of a parent according to a given probability distribution.

Agenda / 1. Reminder on evolutionary algorithms

1.1. General, definitions & concepts

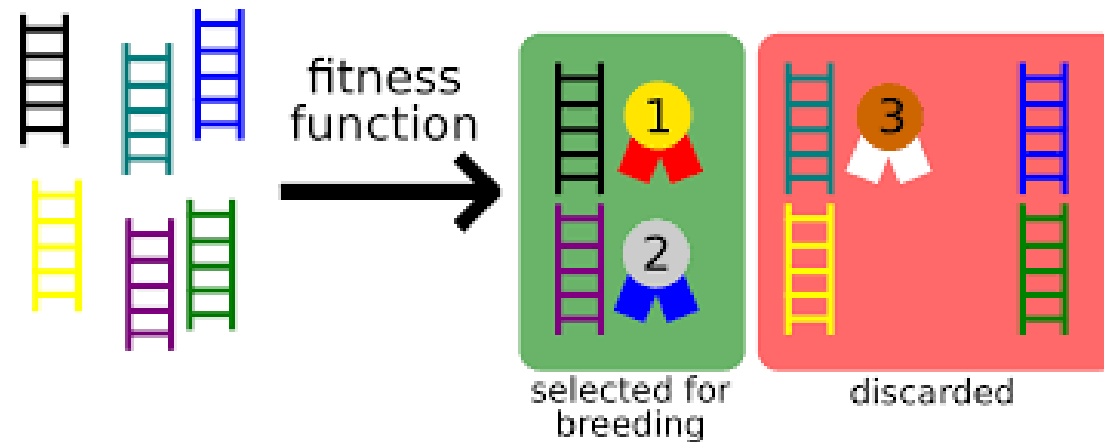
1.2. Conventional or stochastic operators

1.3. SPEA-2 algorithm

1.2. Conventional/stochastic operators

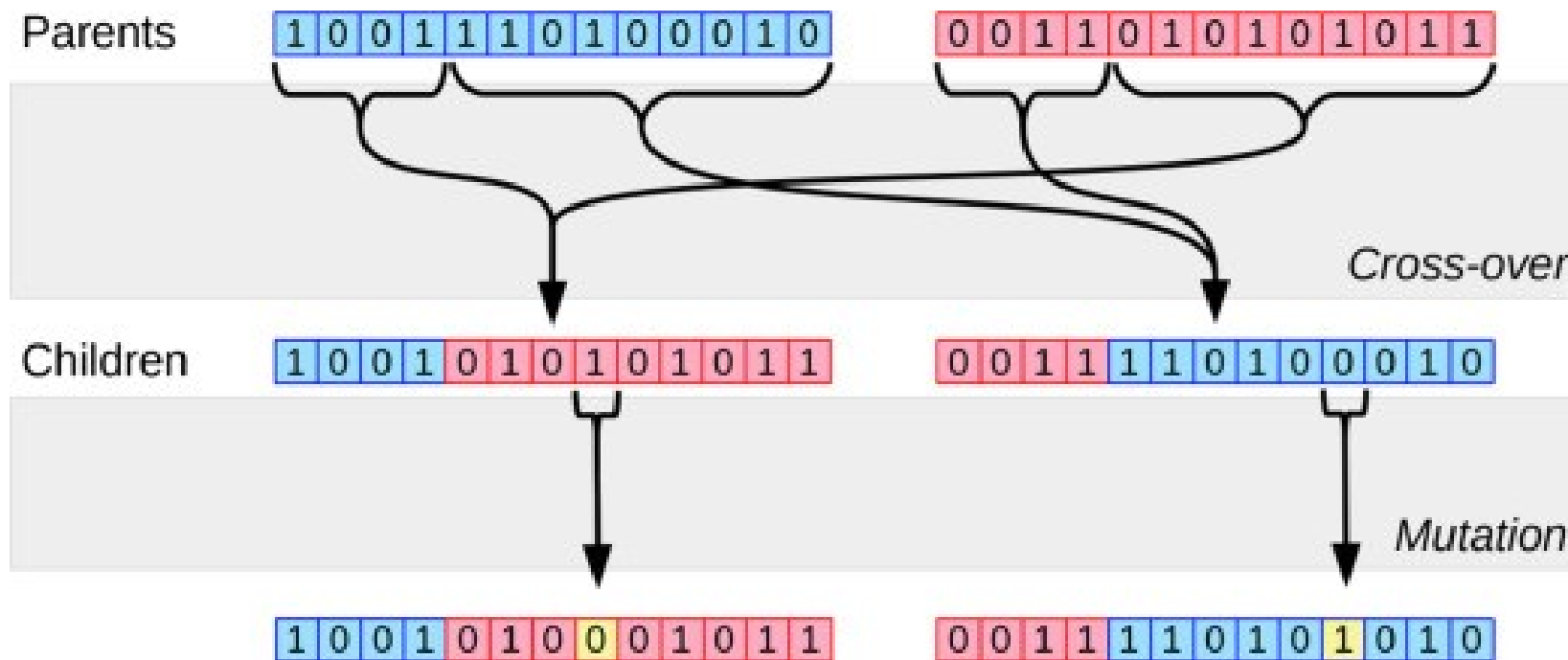
Selection Operator: necessary operator in EA, which, depending on the fitness or the objective function values, respectively, decides on the reproduction of the individuals. Selection gives a direction to evolution, it guides the search.

Fitness-proportionate selection : stochastic selection method where the selection probability of an individual is proportional to its fitness. Therefore, fitness must be non-negative (scaling function). Only fitness maximization is a possible evolution goal.



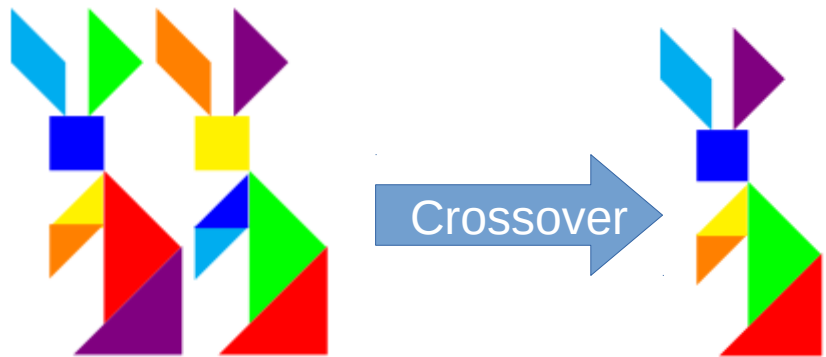
1.2. Conventional/stochastic operators

Crossover Operator : special form of recombination in GA where two parents, generally, produce two offspring by gene exchange.



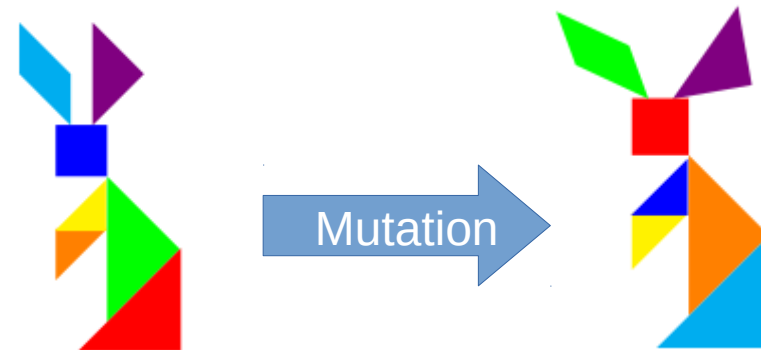
Mutation Operator : variation operator, which changes the information contained in the genome of a parent according to a given probability distribution.

1.2. Conventional/stochastic operators



Crossover to intensify individuals in regions of interest in order to discover optimums with the required precision

Mutation to discover regions of interest, which potentially contain the global optimum



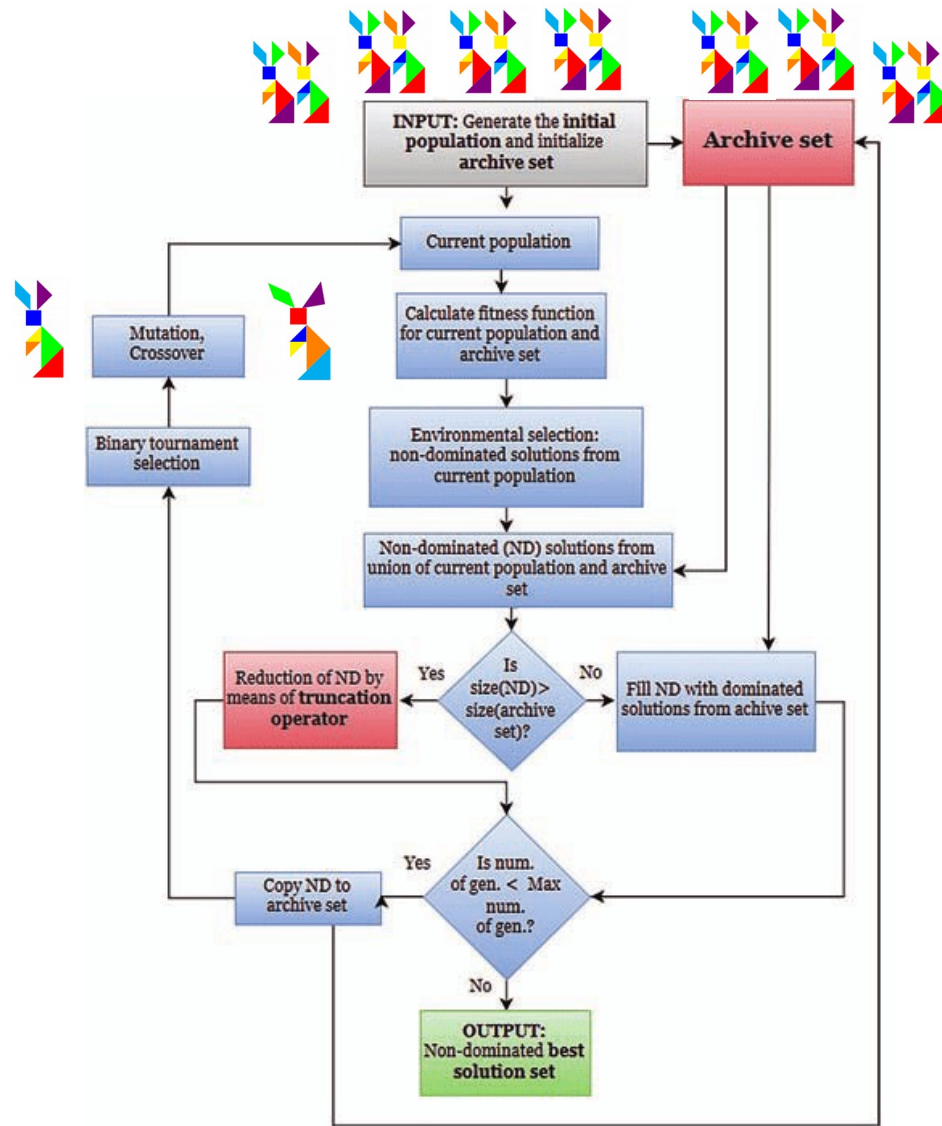
Agenda / 1. Reminder on evolutionary algorithms

1.1. General, definitions & concepts

1.2. Conventional or stochastic operators

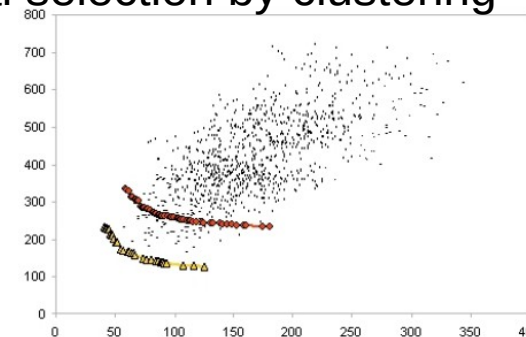
1.3. SPEA-2 algorithm

1.3. SPEA-2 algorithm

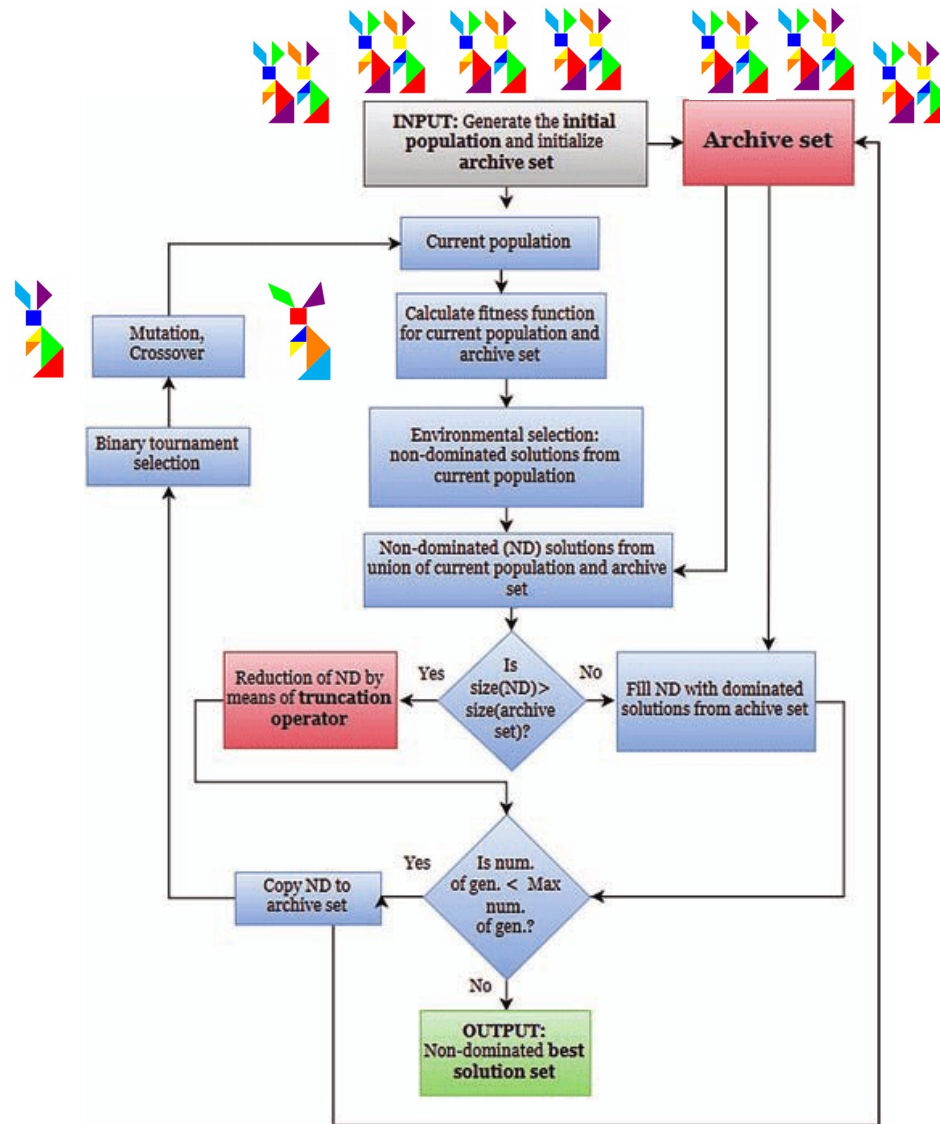


SPEA2 specificities [Zitzler et al. 2002] :

- Fitness of individuals depends on their raw performance but also on the density of solutions in the vicinity of the individual :
 - Raw performance : number of dominated individuals
 - Individual vicinity : Nearest neighbor search (NNS), as a form of proximity search, is the optimization problem of finding the point in a given set that is closest (or most similar) to a given point.
- Environmental selection by clustering



1.3. SPEA-2 algorithm



SPEA2 parameters [Zitzler et al. 2002] :

- Population size : how many rabbits ?
- Archive size : how many good rabbits to archive?
- Crossover rate : What is the right crossover rate?
- Mutation rate : What is the right mutation rate?

SPEA2 drawbacks :

- Long computing time
- Multiple generations
- Optimal solution approached, without the guarantee of having reached it.

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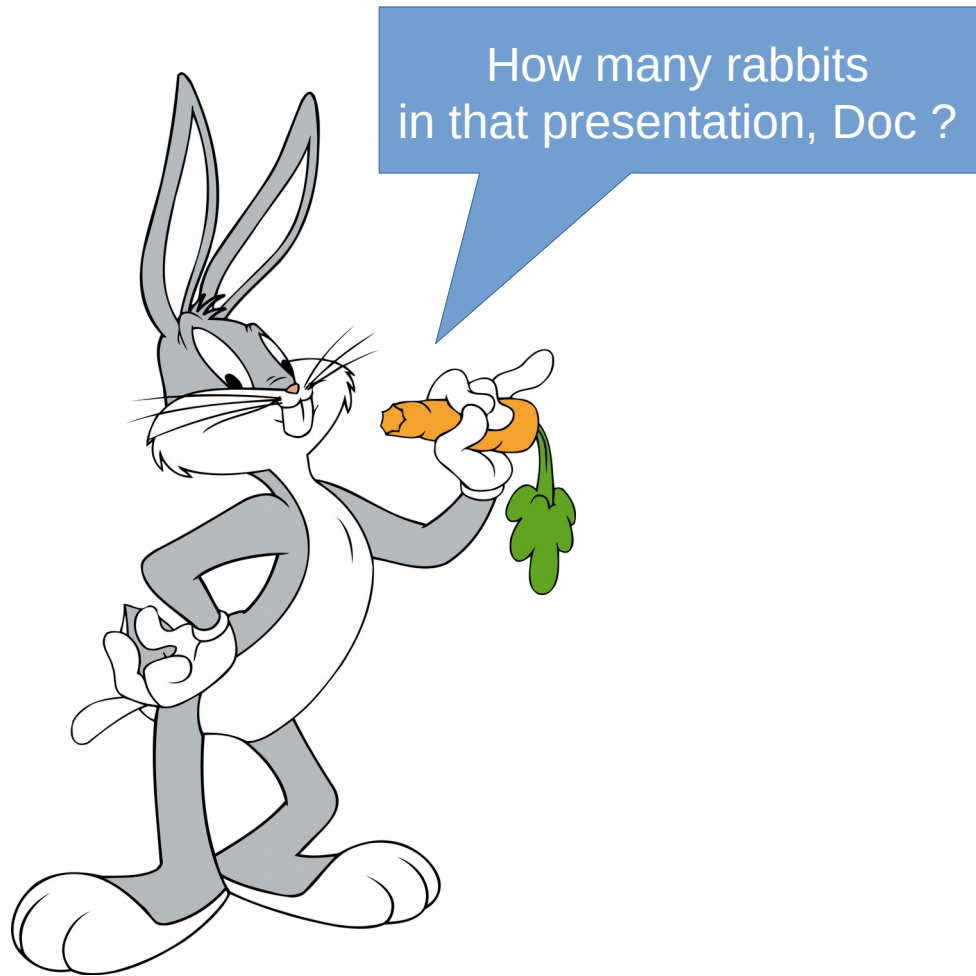
1.3. SPEA-2 algorithm

To go further with videos:

- Right Here, Right Now by Fatboy Slim, <https://www.youtube.com/watch?v=ub747pprmJ8>
- Cours de Dennis Wilson, ISAE SUPAERO
- Cours de Thomas Le Roux, http://igm.univ-mlv.fr/~dr/XPOSE2013/tleroux_genetic_algorithm/index.html
- <https://www.youtube.com/watch?v=kRIbBCOJljs> + <https://theorisons.github.io/algorithmeGenetique/>
- <https://www.youtube.com/watch?v=TNo4sGgS-t4>

To read on SPEA2 algorithm :

- SPEA2: Improving the strength pareto evolutionary algorithm, Zitzler, Eckart; Laumanns, Marco; Thiele, Lothar, 2001,
<https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/145755/eth-24689-01.pdf>



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