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| [**Genetic Algorithms for Multi-knapsack balance problem**](https://www.cs.us.es/docencia/aulavirtual/mod/page/view.php?id=2608) |
| Main practical assignment |
| Guillermo Diz Gil  Carmen Mª Muñoz Pérez |
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### **Genetic algorithm**

### **Combining individuals**

There are different ways of obtaining chromosomes by combining other individuals. In all of them there will be two randomly chosen parents from which a new chromosome will arise.

It should be noted that normally when such combinations of two individuals are made, two offspring chromosomes are usually the result. In our case, it has been decided to obtain one offspring for each of the two parents. This is due to reasons such as less complexity in the implementation and the fact that it is easier to obtain a generation with an odd number of chromosomes.

The different types of crossovers that have been implemented will be detailed below:

### **Single point crossover**

A random crossover point will be chosen and applied to both parents. Thus, each parent will be divided into two parts. The new chromosome will be formed in the following way: all the genes before the crossover point are inherited from first parent, while all the genes after the crossover point are inherited from the second parent.

It should be noted that the chromosome length must be at least two genes long.

### **Triple point crossover**

Three random crossover points will be chosen and applied to the two parents. Thus, each parent will be split into four parts. The new chromosome will be formed in the following way: the even segments of genes will be inherited from the first parent, while the odd segments of genes will be inherited from the second parent.

It should be noted that the chromosome length must be at least six genes long.

### **Uniform crossover**

This time there is no crossover point. Thus, for each position in the offspring, it will be randomly chosen which parent inherits from, i.e, each gene is chosen randomly either from the first parent or from the second one.

It should be noted that the chromosome length can be whatever.

### **Mutations in individuals**

Mutation is an operator used to maintain some diversity between the chromosomes of one generation and the next. Thus, there will be a probability of mutation, i.e., the probability that the chromosomes in the population may change. When this mutation occurs, the new chromosome that is generated is randomly selected.

### **Selection mechanisms**

When performing such algorithms, there will be occasions when certain individuals must be chosen from a population.

For this purpose, there are several selection mechanisms that normally favour those chromosomes with better fitness, although there is always a random component.

### **Roulette wheel selection**

This selection method is part of fitness-proportional selection, which consists of random selection but giving a higher probability to chromosomes with higher fitness. So, each chromosome has a probability of being selected proportional to its fitness value, which is calculated using the given fitness function. Moreover, this selection method can only be used when we have a maximization problem.

In the roulette wheel selection, first we calculate for everyone in the population, its associated cumulative sum of the values of the fitness. After that, a list of random numbers between 1 and the total sum of values is generated. Finally, for each random number the first chromosome whose cumulative sum is greater than or equal to it is returned.

Regarding our implementation, it will not be allowed to use this selection method if it is a minimisation problem. It is still possible that there is some negative fitness or 0 in maximisation so that so it is important to say that non-positive fitness value will be assumed as 1.

It should be noted that a chromosome can be selected multiple times.

### **Tournament selection**

To select an individual with this method, k chromosomes will be chosen from the population and the best one (the one with the best fitness) will be selected. This process will be carried out until the desired number of chromosomes is achieved.

This method can be used in both maximisation and minimisation problems. Moreover, the higher the k, the higher the selection pressure.

It should be noted that a chromosome can be selected multiple times.

### **Codification of the problem**

### **Genes**

Pass

### **Individual length**

Pass

### **Fitness**

Pass

### **Decode**

Pass

### **Bibliography**

First, before starting the assignment, we review unit 5 and practice 4, both of which deal with genetic algorithms:

* <https://www.cs.us.es/docencia/aulavirtual/pluginfile.php/10022/mod_resource/content/1/unit-05-2020-21.pdf> (Slides from unit 5)
* Code use as practice 4

Once we started to implement both the library for the realisation of genetic algorithm problems and for the modelling of the problem itself, the official Python documentation has been consulted on several occasions as well as other sources:

* <https://docs.python.org/3/library/random.html>
* <https://github.com/microsoft/pylance-release/blob/main/DIAGNOSTIC_SEVERITY_RULES.md#diagnostic-severity-rules>
* <https://rico-schmidt.name/pymotw-3/collections/namedtuple.html>
* <https://stackoverflow.com/questions/18296755/python-max-function-using-key-and-lambda-expression>
* <https://stackoverflow.com/questions/1260792/import-a-file-from-a-subdirectory>
* <https://stackoverflow.com/questions/4142151/how-to-import-the-class-within-the-same-directory-or-sub-directory>
* <https://stackoverflow.com/questions/22842289/generate-n-unique-random-numbers-within-a-range>
* <https://stackoverflow.com/questions/14748910/generate-a-set-of-sorted-random-numbers-from-a-specific-range>
* <https://stackoverflow.com/questions/58792963/time-complexity-for-adding-elements-to-list-vs-set-in-python>
* <https://stackoverflow.com/questions/53422887/python-how-do-i-randomly-mix-two-lists/53423019>
* <https://stackoverflow.com/questions/7529376/pythonic-way-to-mix-two-lists>
* <https://stackoverflow.com/questions/47406741/disable-auto-wrap-long-line-in-visual-studio-code>
* <https://stackoverflow.com/questions/63314452/python-autopep8-formatting-not-working-with-max-line-length-parameter>
* <https://softwareengineering.stackexchange.com/questions/308972/python-file-naming-convention>
* <https://stackoverflow.com/questions/9195455/how-to-document-a-method-with-parameters>
* <https://stackoverflow.com/questions/58622/how-to-document-python-code-using-doxygen>