# Genetic Algorithm

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# Genetic Algorithm?

- The class of evolutionary algorithms that includes genetic algorithms was largely influenced by biological evolution.

- We are all aware of the three components of biological evolution:
  - The selection of parents
  - Reproduction
  - Offspring mutation

# Genetic Algorithm?

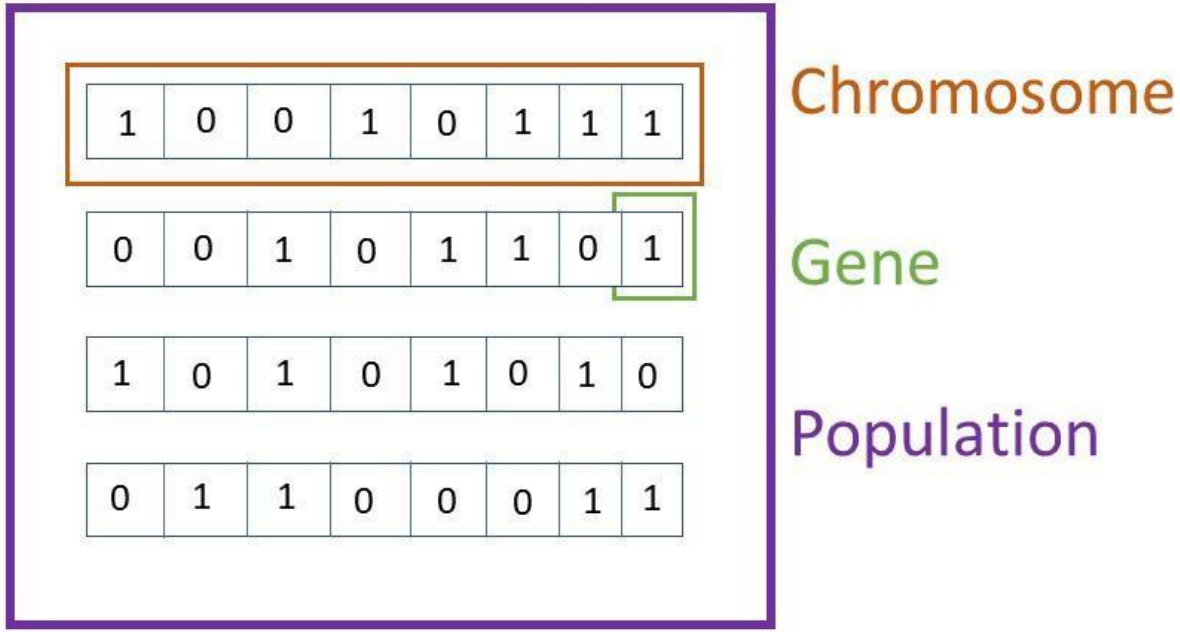
- To produce offspring that are biologically superior to their parents is the primary goal of evolution.

- A genetic algorithm attempts to imitate Darwin's Theory of Evolution by Natural Selection. It is based primarily on this theory.

# Algorithm

- Initialize population
- Select parents by evaluating their fitness
- Crossover parents to reproduce
- Mutate the offsprings
- Evaluate the offsprings (Survivor Selection)
- Merge offsprings with the main population and sort

# Chromosome, Gene and Population



# 1. Initialization

- The algorithm generally starts with the randomly generated population.
- The size of the population depends on the nature of the problem.
- We can use 0s and 1s encoding or uniformly distributed numbers.

# 2. Parent Selection

During each successive generation, a portion of the existing population is selected to breed a new generation.

- **Random selection:** Shuffle the population by performing permutation and select the first two individuals as parents for breeding.
- **Tournament selection:** Run several tournaments among a randomly selected group of individuals, select one individual from each group as the winner, and again run the tournament by grouping winners from the first iteration, repeat the process until the convergence to two winners parents for breeding.

# 2. Parent Selection

- **Roulette wheel selection:** We all know how the roulette wheel works in casinos, drop the ball, spin the wheel, and wait till the wheel stops to see which pot the ball falls in.

# 2. Parent Selection

**Casino roulette wheel:** Each pot has an equal probability of holding the ball when the wheel stops rotating.

**In our roulette wheel:** Define the probability for each pot(individual of the population). The probability of each individual is called the **fitness of the individual.**

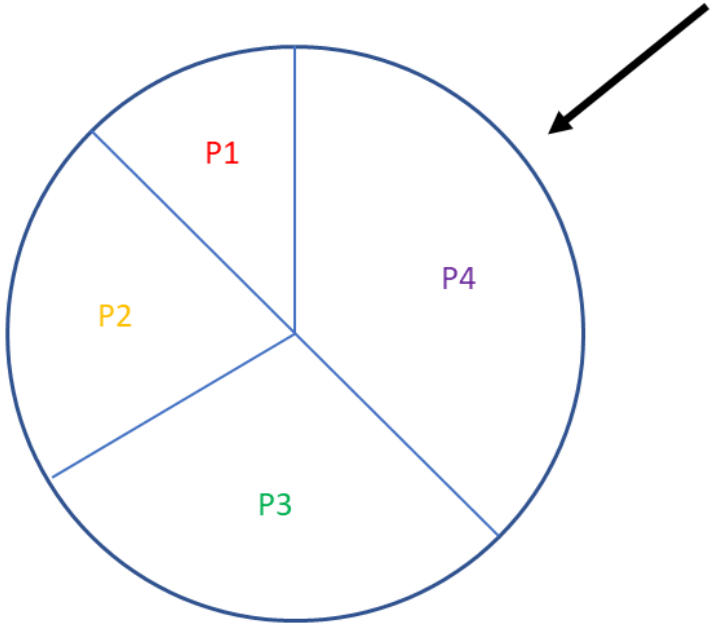
P1 = 10%

P2 = 20%

P3 = 30%

P4 = 40%

Total = 100%

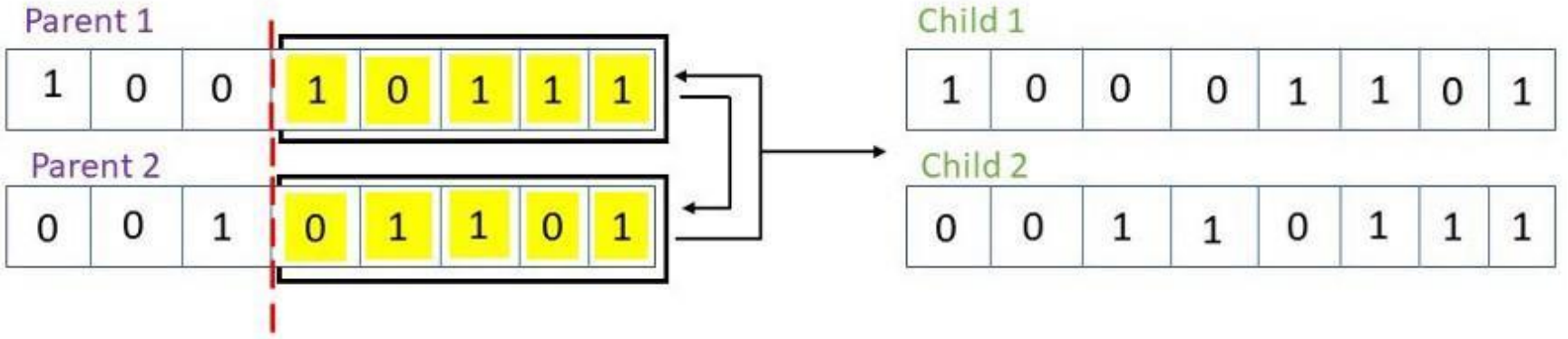


# 3. Crossover

Crossover describes the process by which some genes from both parent chromosomes are overlapped, jumbled together, or swapped to create new children. Because of the crossing of the parent chromosomes, the offspring possesses traits from both parents.

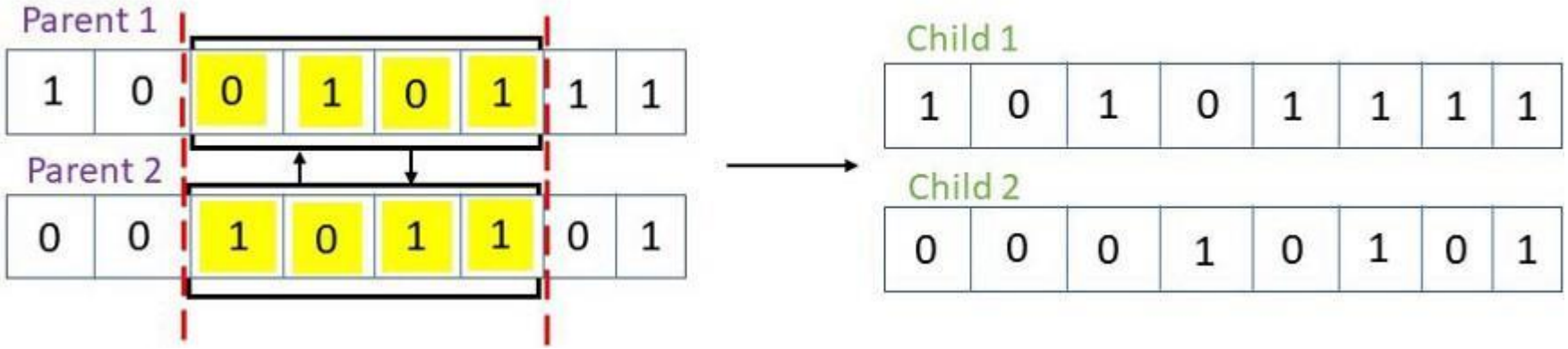
# 3. Crossover

**Single-point crossover:** In this method, both the parent chromosomes are cut at the same random point, and the leftover parts are swapped to produce two new offspring chromosomes.



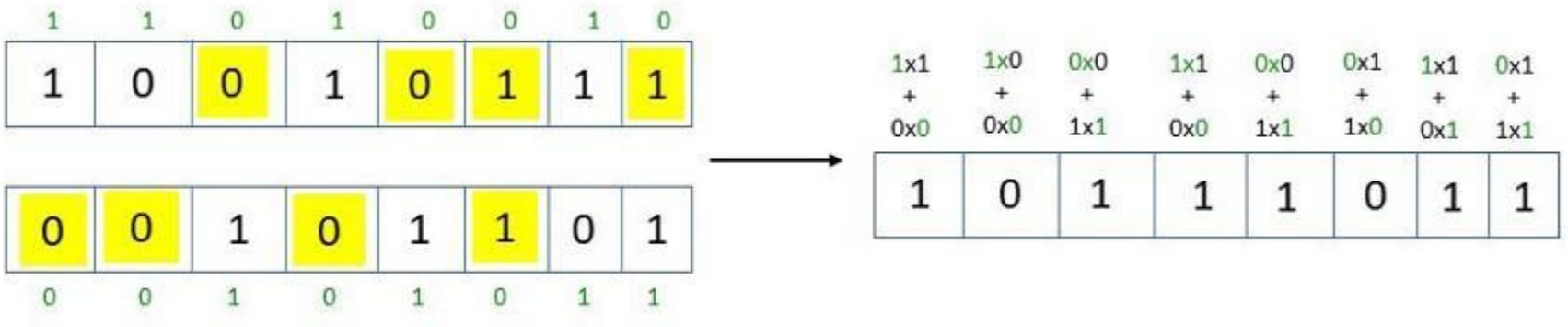
# 3. Crossover

**Two-point crossover:** A method similar to the single-point crossover, but the only difference is that the parent chromosomes are cut at two random points.



# 3. Crossover

**Uniform crossover:** Randomly choose which genes are supposed to be inherited from both the parent chromosomes. Then, model them as 0s and 1s.. The gene to be inherited is encoded as 1, and the gene that should not be inherited is encoded as 0.



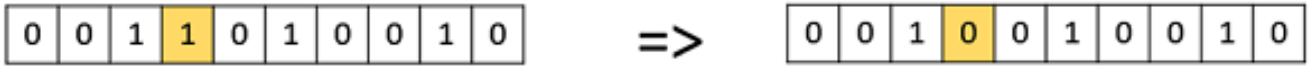
# 4. Mutation

Mutation is a natural process that occurs due to an error in replication or copying of genes. By mixing and matching the genes from both parents, we were able to reproduce the parent chromosomes during crossover. There is no guarantee that the copying of the parent gene is 100% accurate. There always occurs an error, which leads to the scope of exploration.

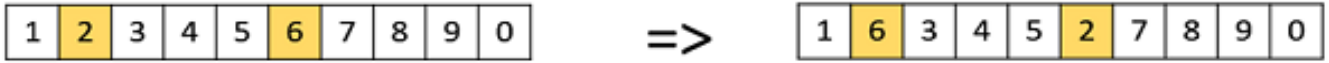
Mutating the chromosome in the genetic algorithm is necessary because it may result in revolutionary results that will help solve our problem more efficiently.

# 4. Mutation

## Bit Flip Mutation

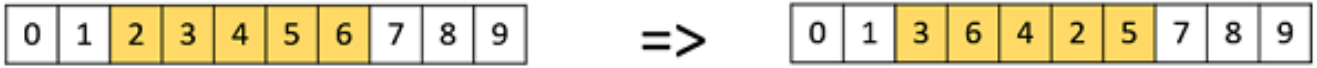



## Swap Mutation

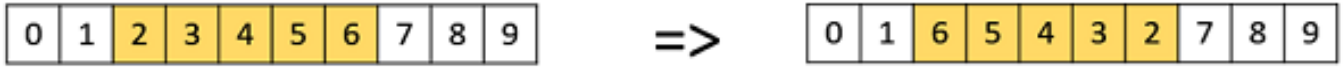


# 4. Mutation

## Scramble Mutation




## Inversion Mutation



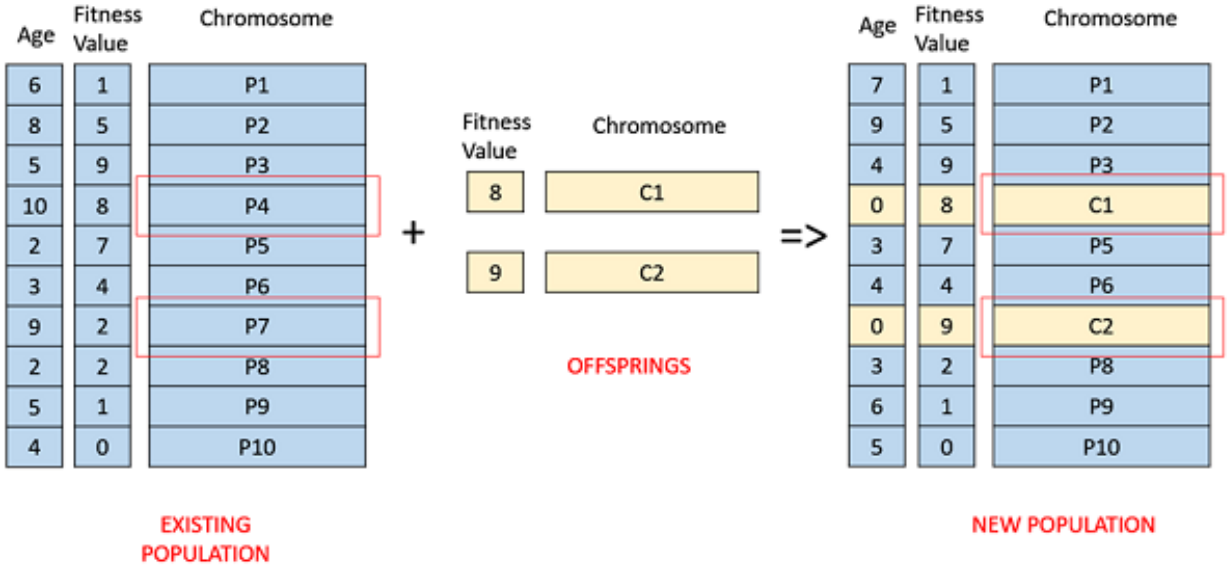
# 5. Evaluate the offsprings (Survivor Selection)

The Survivor Selection Policy determines which individuals are to be kicked out and which are to be kept in the next generation.

It is crucial as diversity should be maintained in the population.

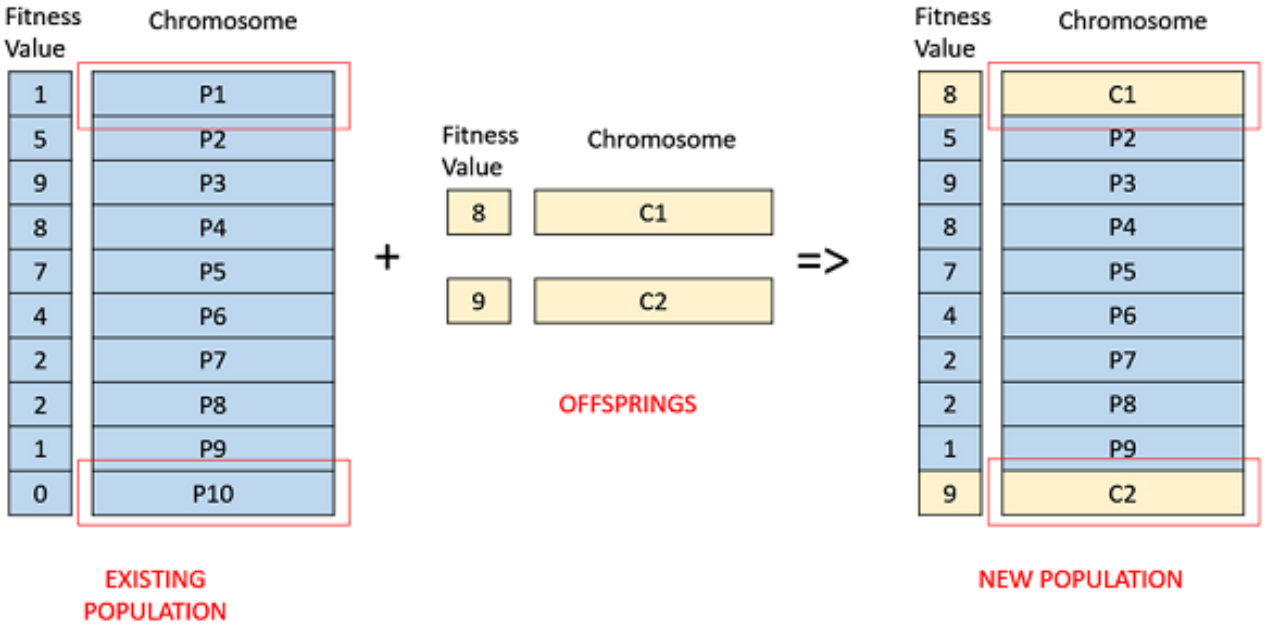
# 5. Evaluate the offsprings (Survivor Selection)

**Age-Based Selection:** It is based on the premise that each individual is allowed in the population for a finite generation where it is allowed to reproduce, after that, it is kicked out of the population no matter how good its fitness is.



# 5. Evaluate the offsprings (Survivor Selection)

**Fitness based selection**: The children tend to replace the least fit individuals in the population. (Can be achieved by sorting)



# 6. Merge Offsprings with the Main Population and Sort

Merging the offsprings is vital for them to be considered as parents to reproduce the next generation. Upon sorting the new population, better individuals are at the top.

Since the population size remains the same as the first iteration, the number of individuals at the bottom of the sorted population equal to the number of new offsprings produced in the previous iteration are eliminated from the selection process to breed new offsprings.

- **Repeat the full process**

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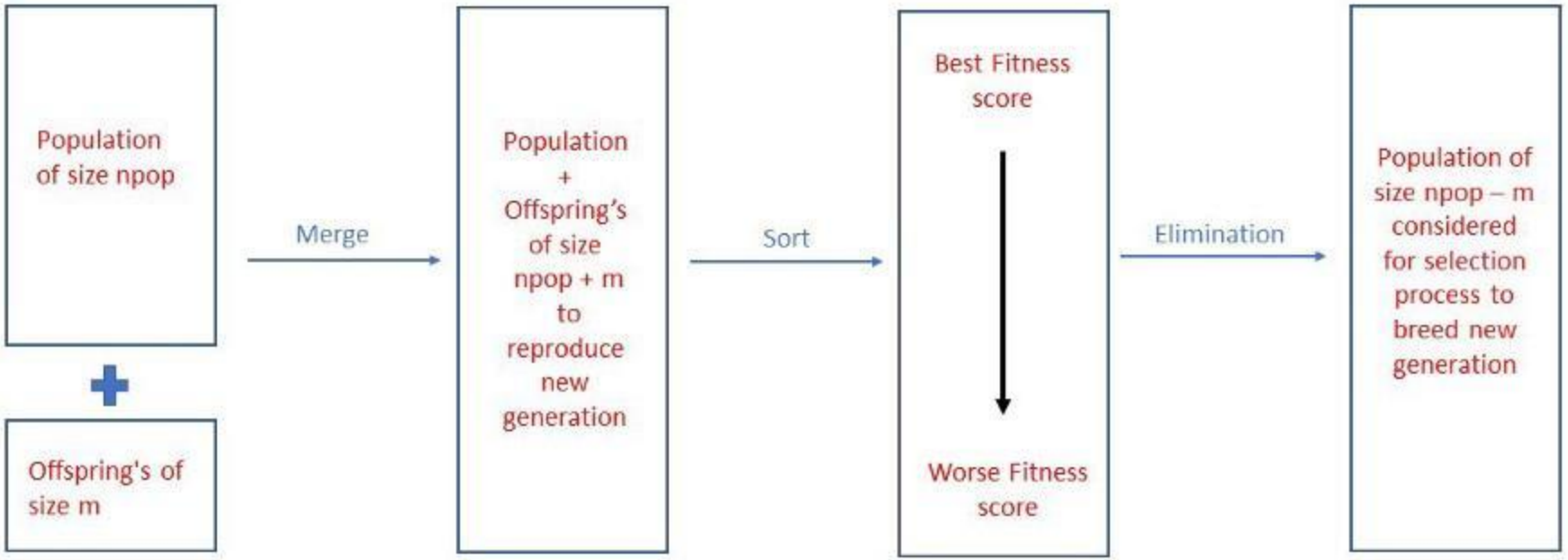

# References


1. https://pub.towardsai.net/genetic-algorithm-ga-introduction-with-example-code-e59f9bc58eaf

1. https://www.tutorialspoint.com/genetic_algorithms/genetic_algorithms_survivor_selection.htm