Genetic Algorithm

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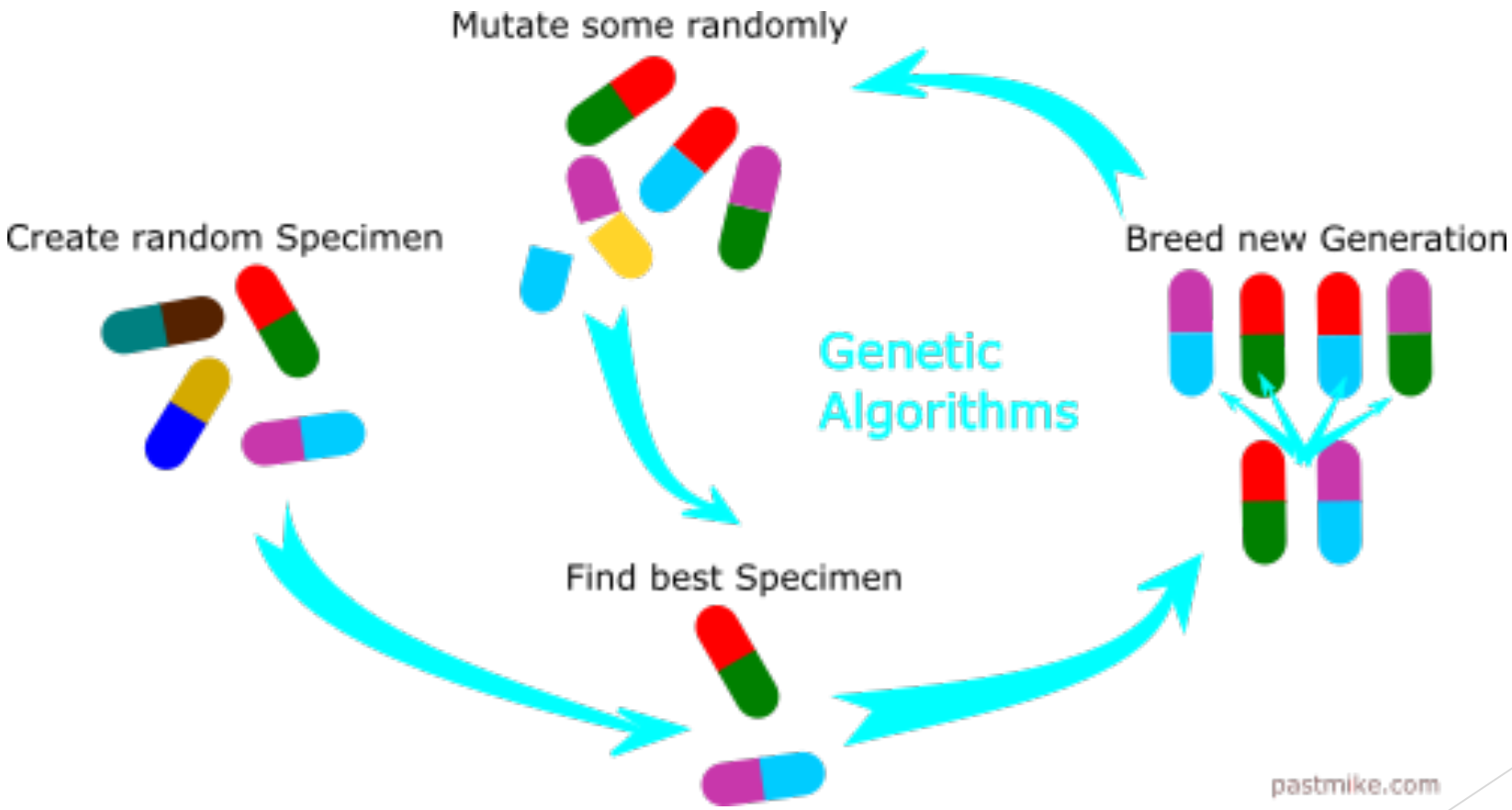
Natural Selection

- Proposed by Charles Darwin in 1859
- Variation is the result of genetic difference which can arise through mutation or genetic recombination.
- Offspring inherit traits from parents.
- Overproduction.
- Environment is challenging.
- Survival of the fittest (Advantageous traits are more likely to pass to the next generation).
- Frequency of advantageous traits increases in the population.

Connections



Travelling Salesman Problem(TSP)

- Given a list of cities and the distance between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?

- NP-hard (No efficient solution)

Terminology

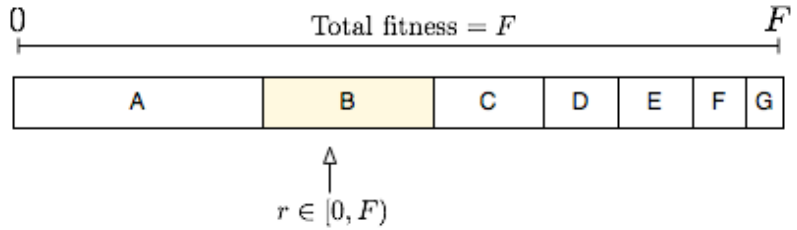
- Gene – a city (vertex)
- Individual (a.k.a. “chromosome”) - single walk satisfied the condition
- Parents - two individuals that will combine to produce new individual
- Mating Pool – collection of parents
- Fitness – a function that tells us how good the individual is
- Elitism – carry best individuals to the next generation (for quicker convergence)

Initiation

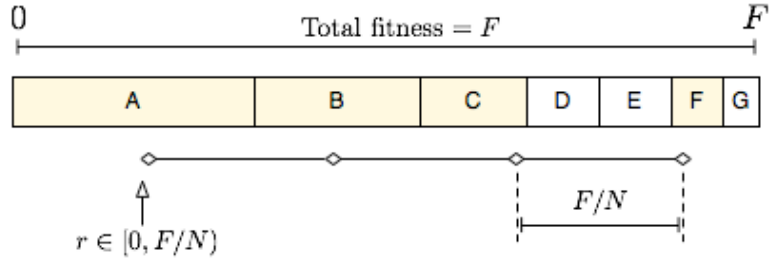
- Import data
- Randomly generate individuals
- Generate initial generation
- Determine the fitness

Selection

- Sort based on fitness
- Using selection method to select the high-fitness individual
  - Fitness proportionate selection (roulette wheel selection)



  - Stochastic universal sampling



Crossover

- Partially Mapped Crossover

$P_1 = (3\ 4\ 8 \mid 2\ 7\ 1 \mid 6\ 5),$

$P_2 = (4\ 2\ 5 \mid 1\ 6\ 8 \mid 3\ 7).$

$O_1 = (\times\ \times\ \times \mid 1\ 6\ 8 \mid \times\ \times),$

$O_2 = (\times\ \times\ \times \mid 2\ 7\ 1 \mid \times\ \times).$

$O_1 = (3\ 4\ 2 \mid 1\ 6\ 8 \mid 7\ 5).$

$O_1 = (3\ 4\ \times \mid 1\ 6\ 8 \mid \times\ 5),$

$O_2 = (4\ \times\ 5 \mid 2\ 7\ 1 \mid 3\ \times).$

$O_2 = (4\ 8\ 5 \mid 2\ 7\ 1 \mid 3\ 6).$

- Cycle Crossover

$P_1 = (1\ 2\ 3\ 4\ 5\ 6\ 7\ 8),$

$P_2 = (8\ 5\ 2\ 1\ 3\ 6\ 4\ 7).$

$O_1 = (1\ \times\ \times\ \times\ \times\ \times\ \times\ \times).$

$O_1 = (1\ \times\ \times\ \times\ \times\ \times\ \times\ 8).$

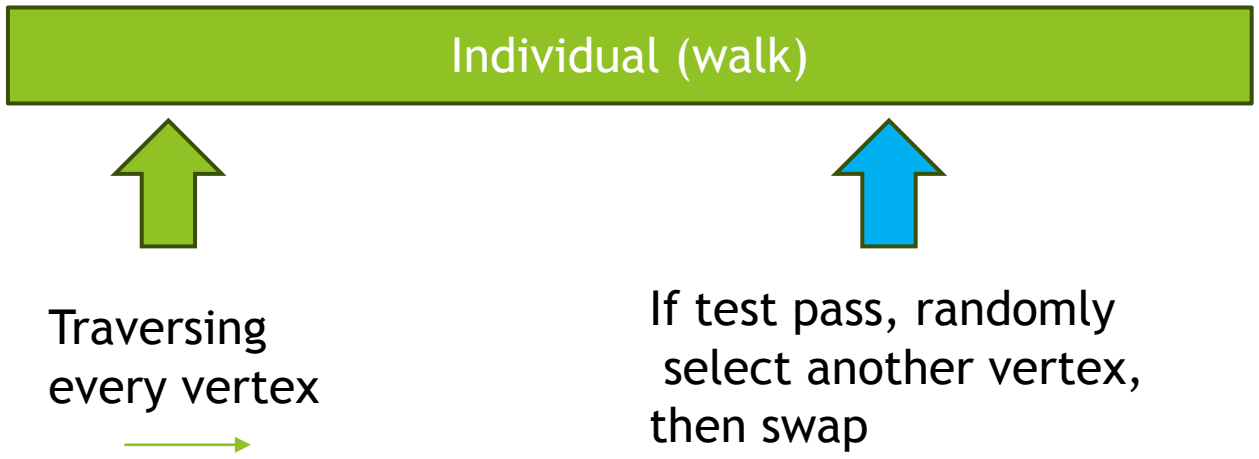
$O_1 = (1\ \times\ \times\ \times\ \times\ \times\ 7\ 8).$

$O_1 = (1\ \times\ \times\ 4\ \times\ \times\ 7\ 8).$

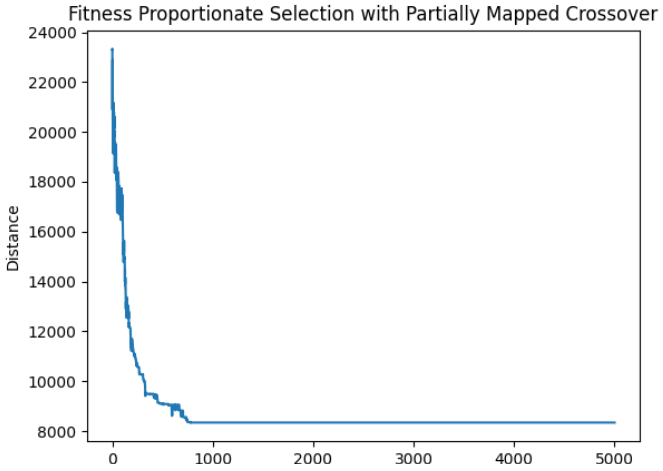
$O_1 = (1\ 5\ 2\ 4\ 3\ 6\ 7\ 8).$

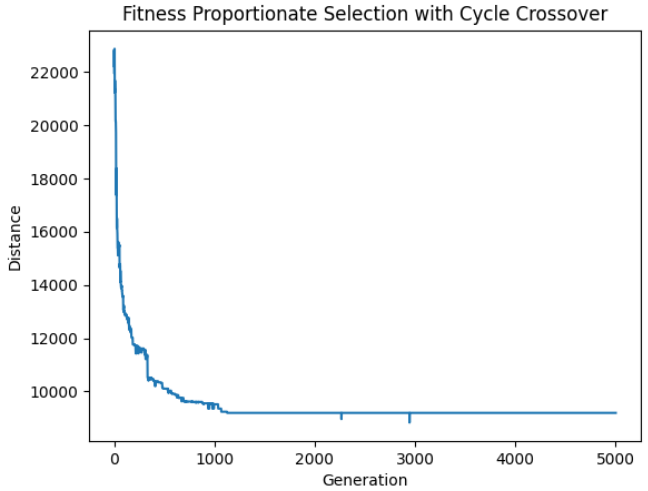
Mutation

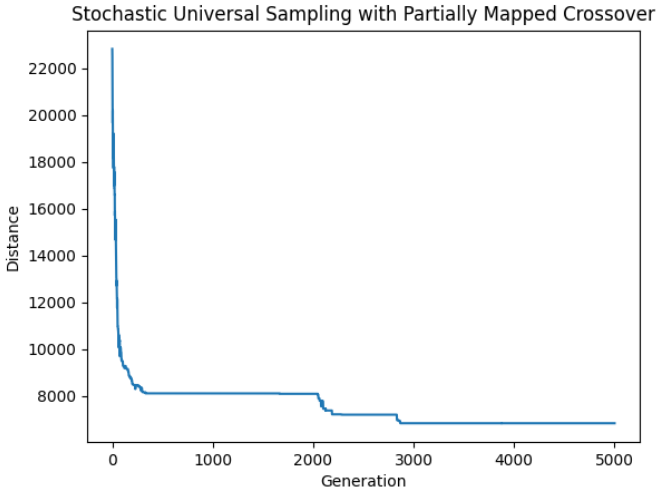
- Mutation Rate
- Test for each vertex in the walk
- If test pass, randomly select a vertex in the walk and swap

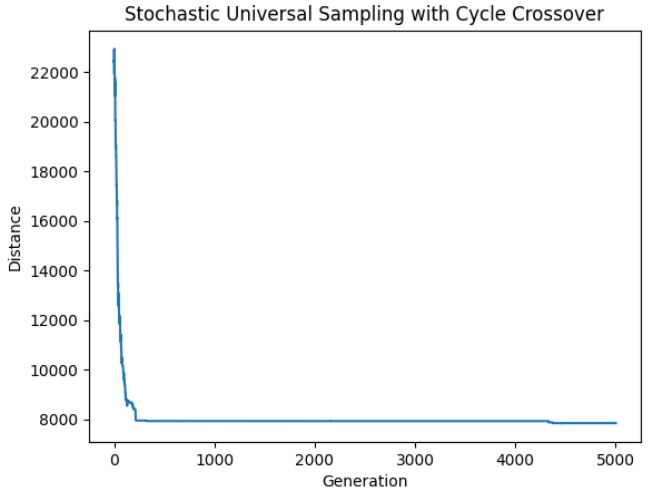


Dataset from https://www.math.uwaterloo.ca/tsp/world/countries.html
GA with population_size=100,elite_size=20,mutation_rate=0.01
number_of_generation=5000
Known that the optimal walk is of length 6656









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