Ex1 report – Allen Bronshtein 206228751 & Niv Nachum 208983239

Working Environment

1. Programming language – C++.

2. Operation system – Windows 10.

3. IDE – Visual Studio 2017

Generic Algorithm features and code design in here

8-Queen

Important note: In the Brute Force and Genetic Algorithm we found all 92 solutions

Brute Force algorithm:

We've tried a various of optimizations:

1. A naïve solution – took 17 hours to find 1 solution (1 threaded)

2. With a row optimization – We already know 2 queens can't be in the same row. By eliminating those cases ahead, it took 17 minutes to find all 92 solutions.

3. With a row and column optimization – We initiated our chromosome to be {0,1,2,3,4,5,6,7} and only tried the permutations (40,320 options). Took ~200 milliseconds to find all 92 solutions

Results:

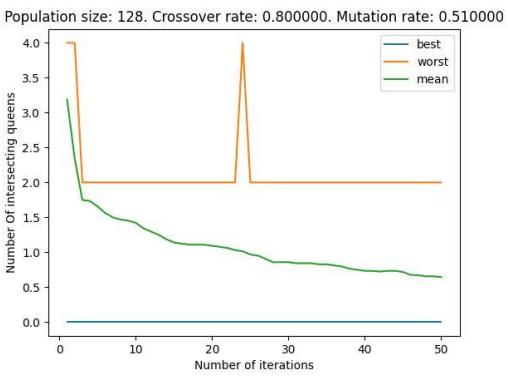
Execution time – 20 seconds for each run. ~217 milliseconds to find each solution (mean time).

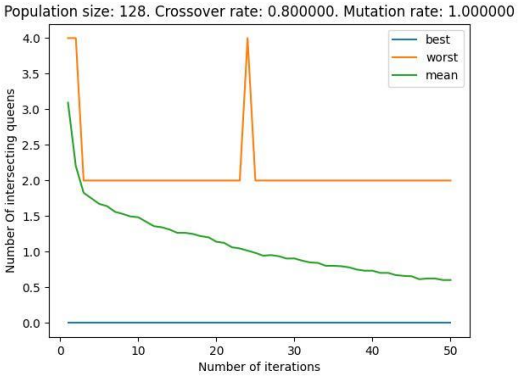
For the rates:

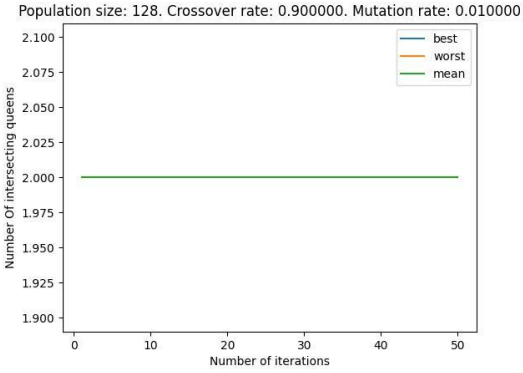
- Population Size - We see that bigger population size finishes sooner (less iterations) but the graphs figure looks the same (in terms of worst, best and mean results in each iteration).

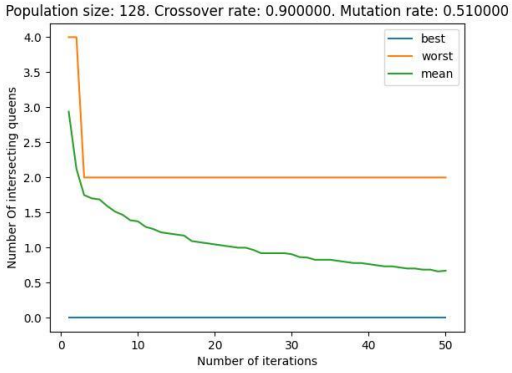
- Crossover Rate – We see that the crossover rate doesn't have a big impact over the results.

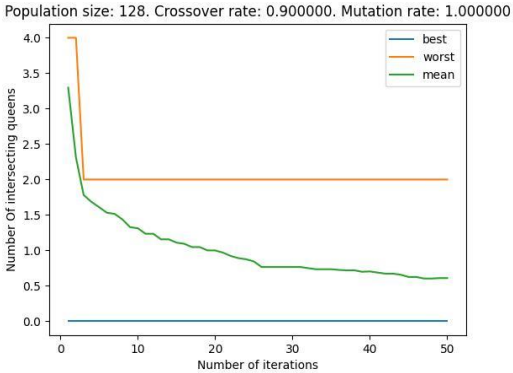
- Mutation Rate – The mutation rate in the 8-Queen problem surprised us the most. We actually see that a small mutation rate has some really bad results and we don't get any solution, while mutation rate 0.5 and even 1 find all 92 solutions pretty fast.

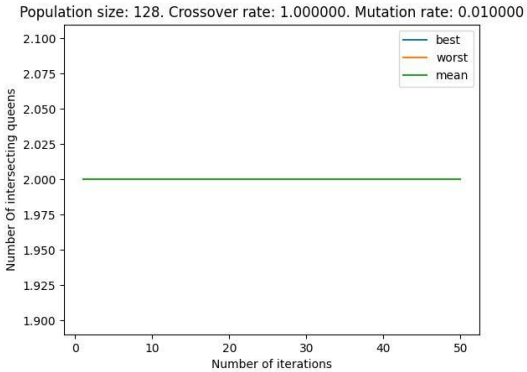












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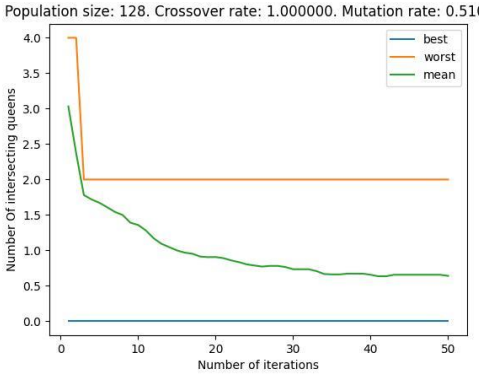

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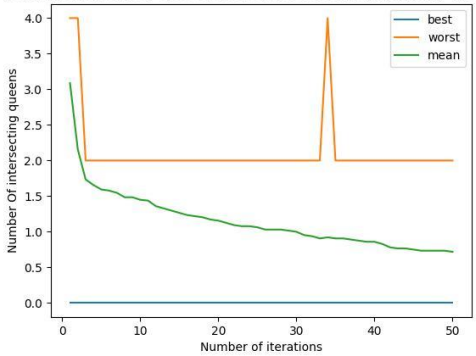
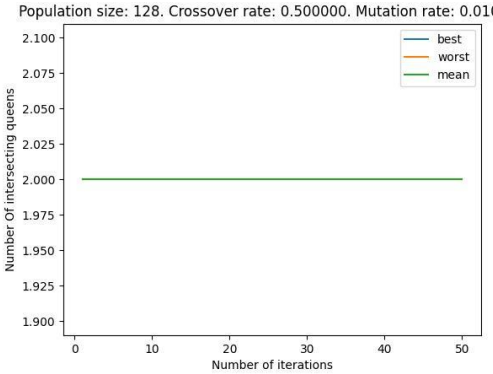


Population size: 128. Crossover rate: 0.500000. Mutation rate: 0.010000



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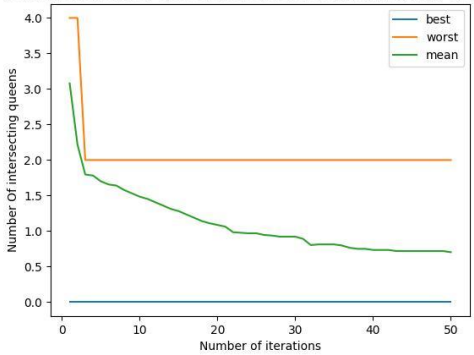

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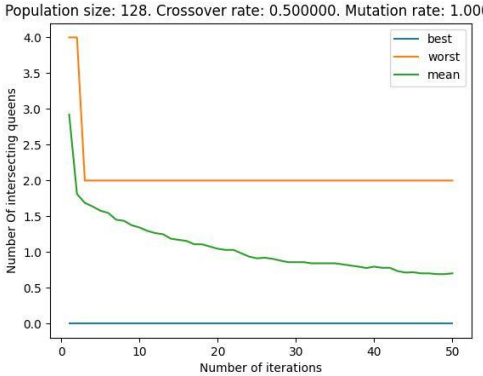
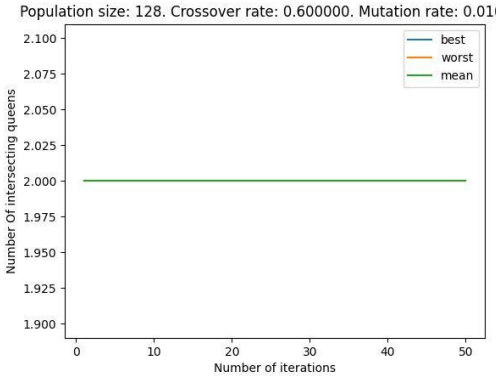


Population size: 128. Crossover rate: 0.600000. Mutation rate: 0.010000



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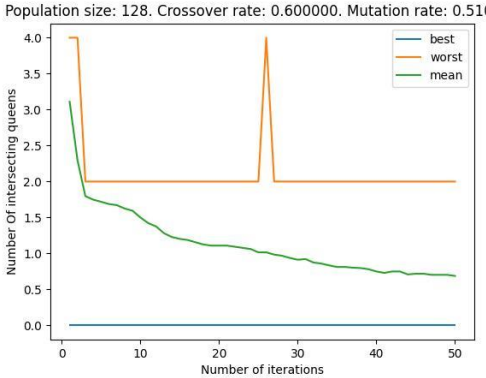

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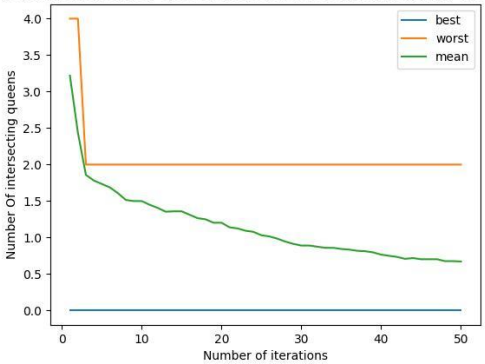

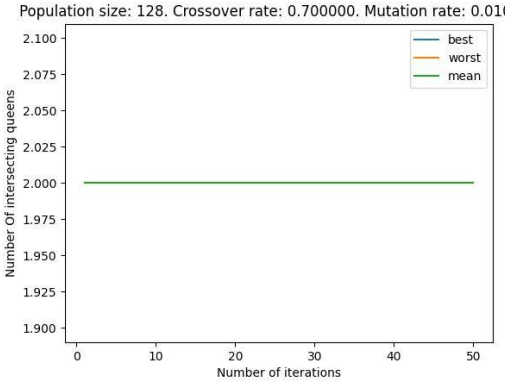
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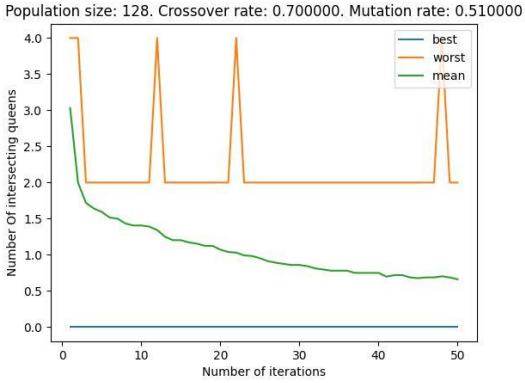
worst
mean
Number Of intersecting queens
Number of iterations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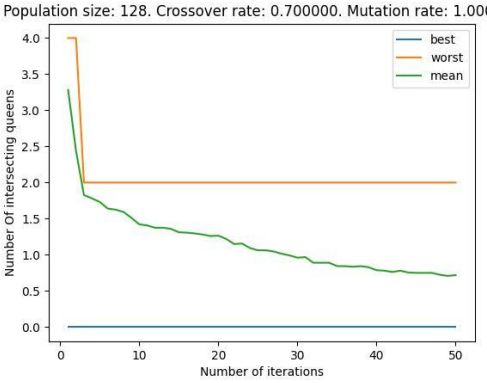
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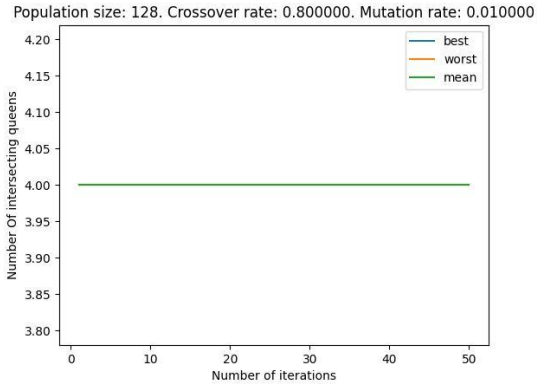
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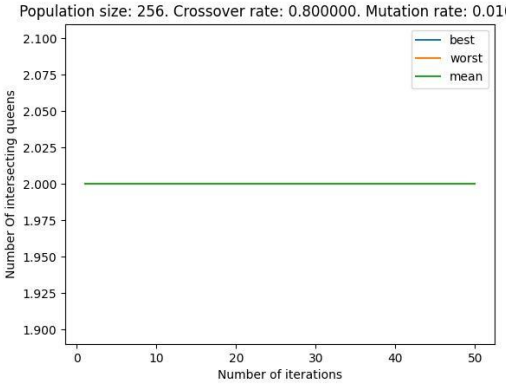
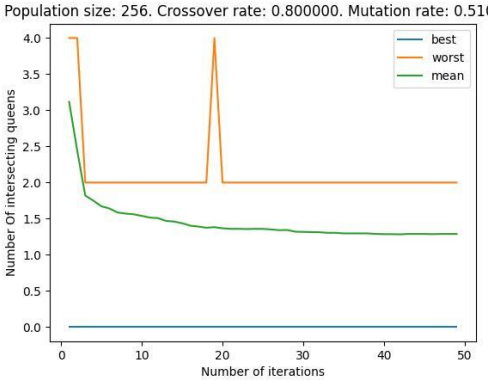
Population size: 256. Crossover rate: 0.800000. Mutation rate: 0.010000



Population size: 256. Crossover rate: 0.800000. Mutation rate: 0.510000



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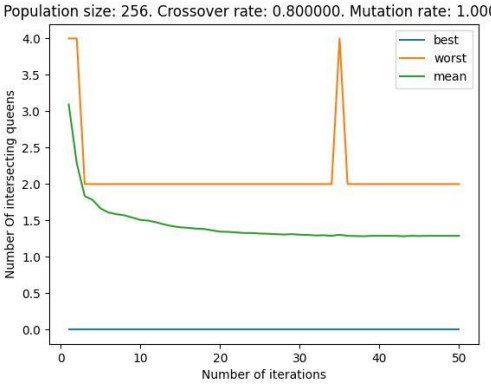

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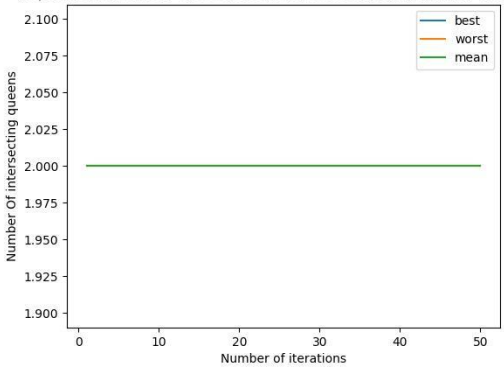

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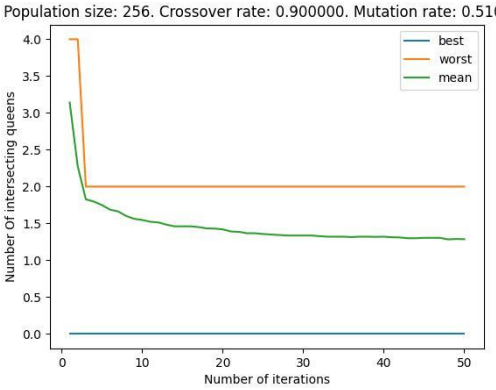

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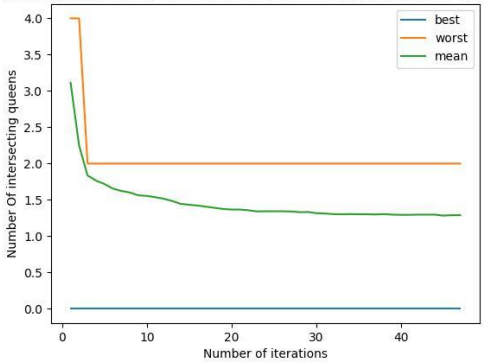

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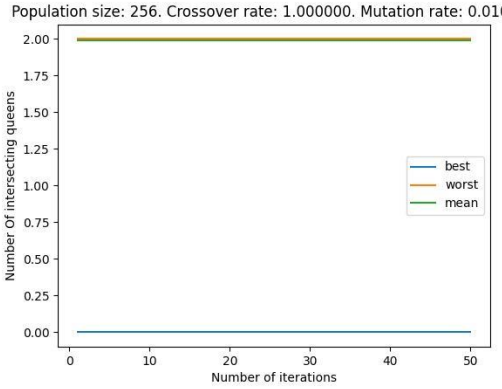

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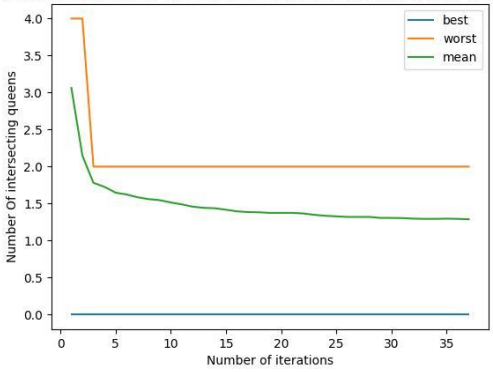

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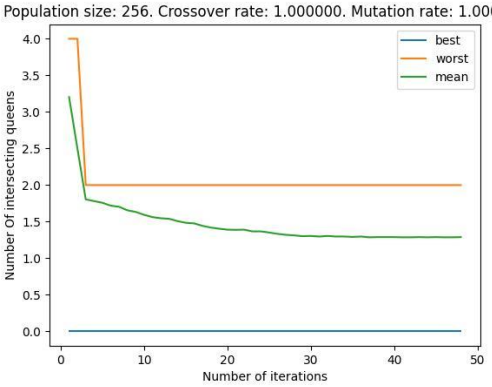
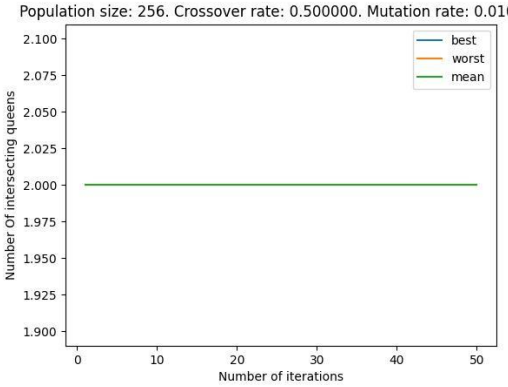


Population size: 256. Crossover rate: 0.500000. Mutation rate: 0.010000



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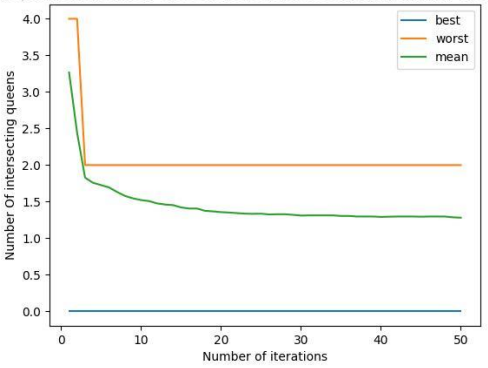

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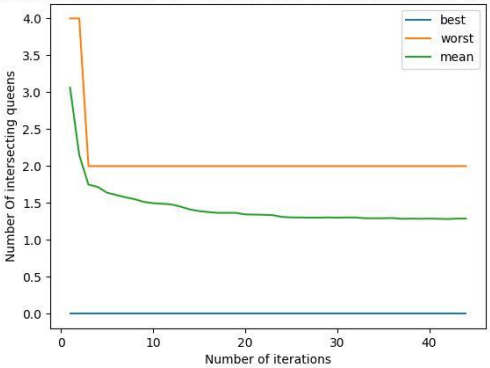

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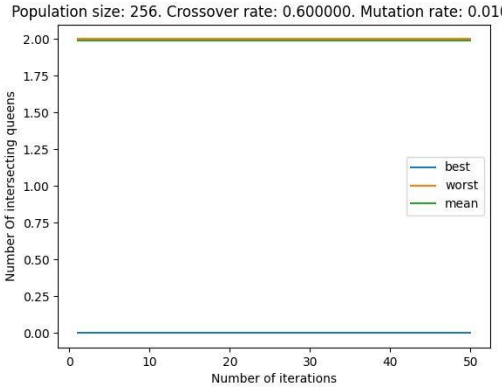
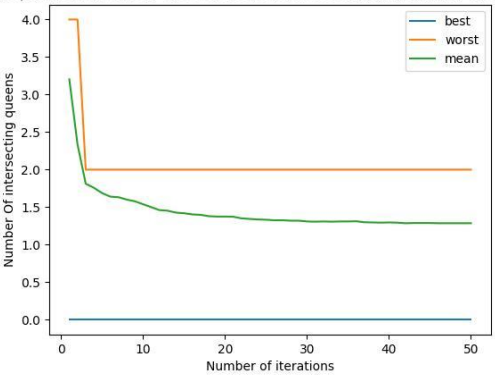
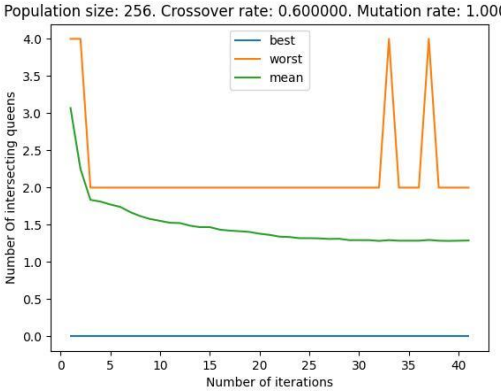


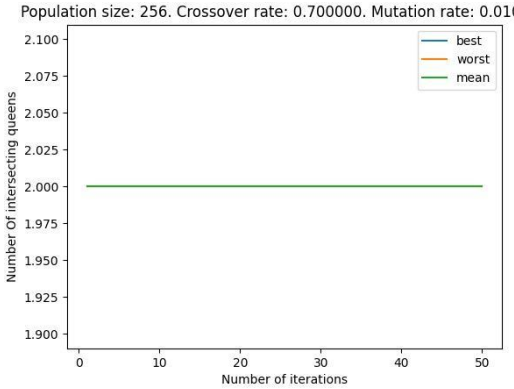
Population size: 256. Crossover rate: 0.600000. Mutation rate: 0.510000



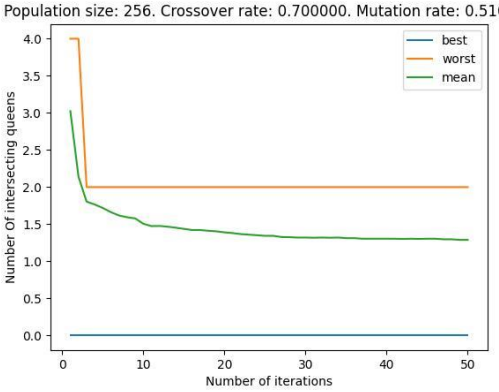
Population size: 256. Crossover rate: 0.600000. Mutation rate: 1.000000



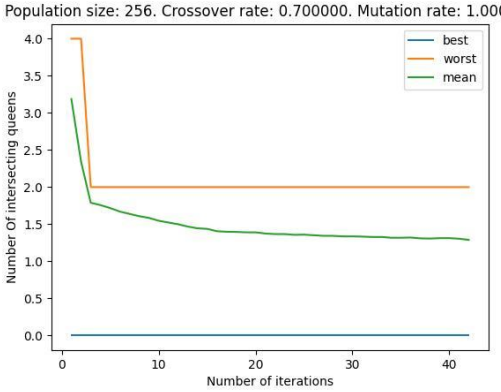
Population size: 256. Crossover rate: 0.700000. Mutation rate: 0.010000



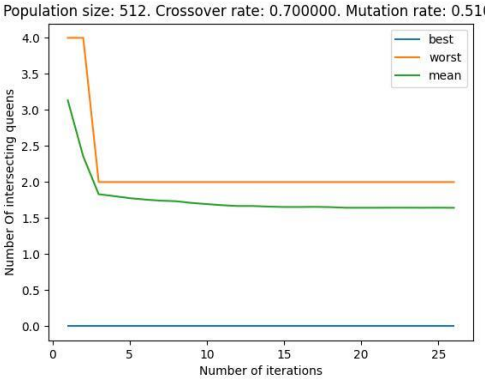
Population size: 256. Crossover rate: 0.700000. Mutation rate: 0.510000



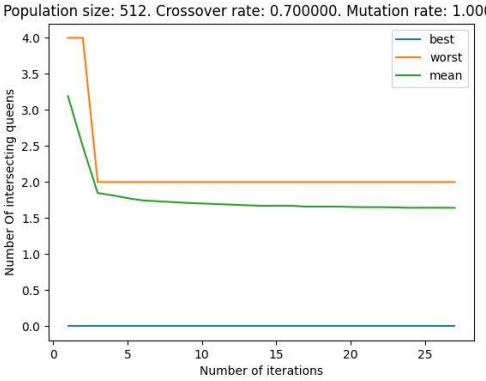
Population size: 256. Crossover rate: 0.700000. Mutation rate: 1.000000



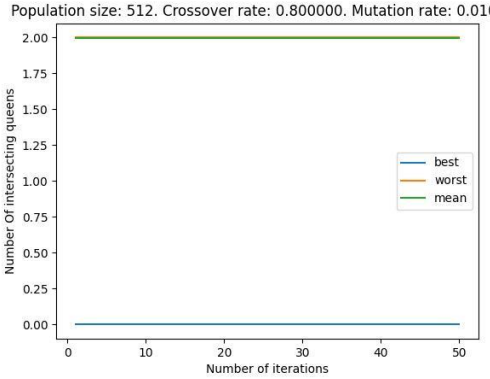
Population size: 512. Crossover rate: 0.700000. Mutation rate: 0.510000



Population size: 512. Crossover rate: 0.700000. Mutation rate: 1.000000



Population size: 512. Crossover rate: 0.800000. Mutation rate: 0.010000



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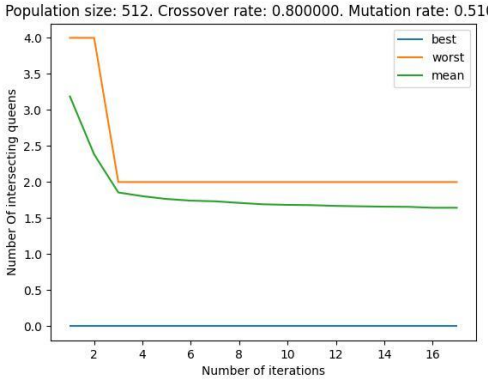

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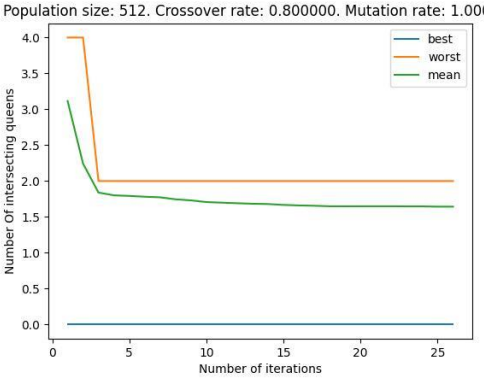
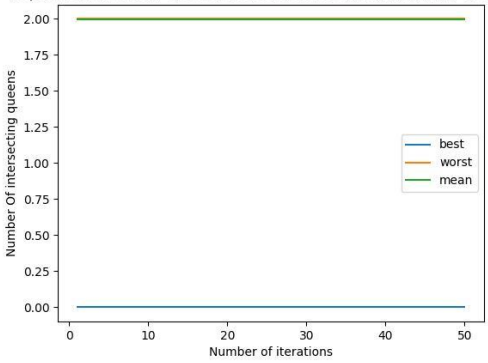
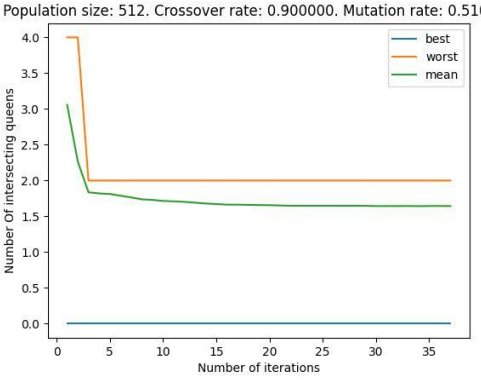


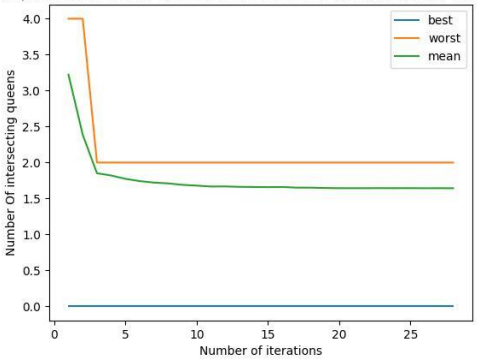
Population size: 512. Crossover rate: 0.900000. Mutation rate: 0.010000



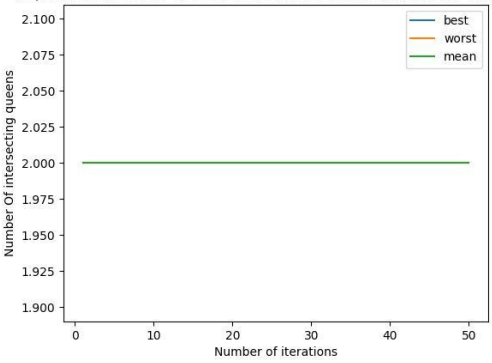
Population size: 512. Crossover rate: 0.900000. Mutation rate: 0.510000



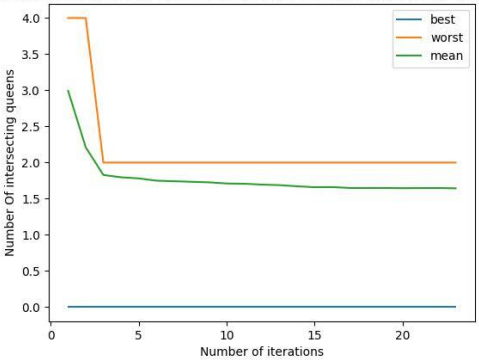
Population size: 512. Crossover rate: 0.900000. Mutation rate: 1.000000



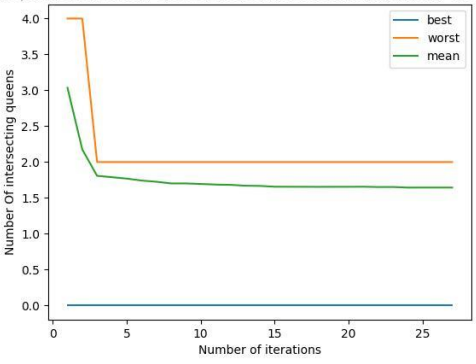
Population size: 512. Crossover rate: 1.000000. Mutation rate: 0.010000



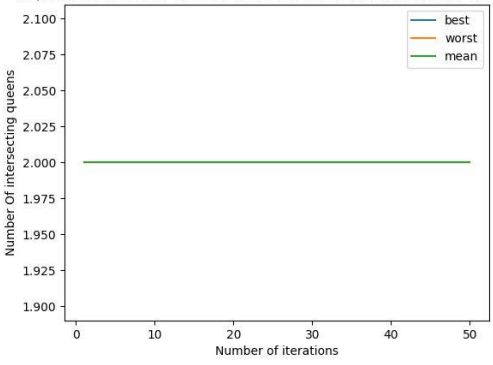
Population size: 512. Crossover rate: 1.000000. Mutation rate: 0.510000

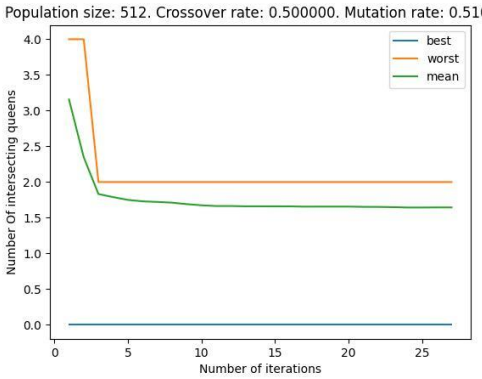


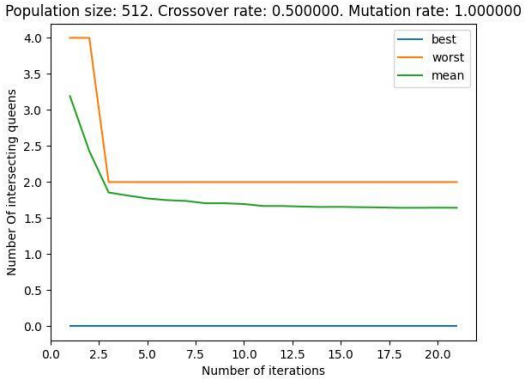
Population size: 512. Crossover rate: 1.000000. Mutation rate: 1.000000

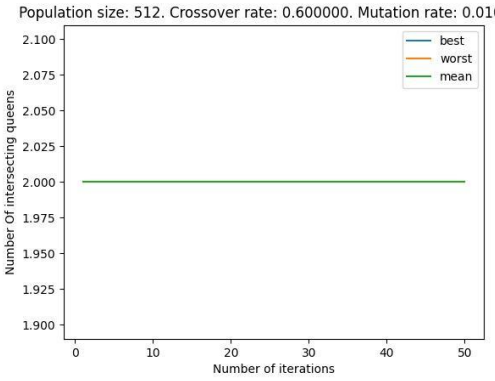


Population size: 512. Crossover rate: 0.500000. Mutation rate: 0.010000




Population size: 512. Crossover rate: 0.500000. Mutation rate: 0.510000
best
worst
mean
Number Of intersecting queens
Number of iterations


Population size: 512. Crossover rate: 0.500000. Mutation rate: 1.000000
best
worst
mean
Number Of intersecting queens
Number of iterations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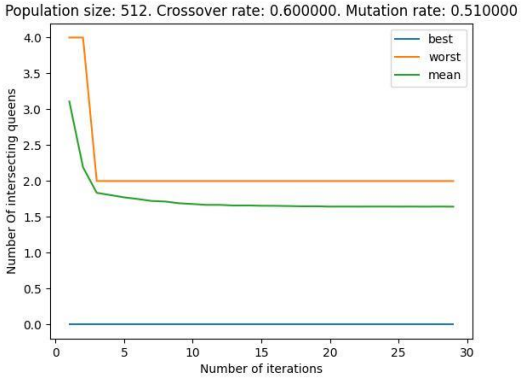
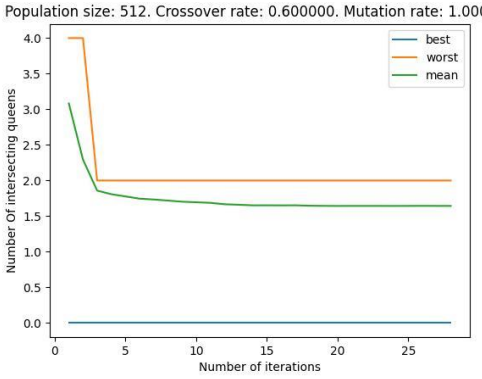
best
worst
mean
Number Of intersecting queens
Number of iterations


Population size: 512. Crossover rate: 0.600000. Mutation rate: 0.510000
best
worst
mean
Number Of intersecting queens
Number of iterations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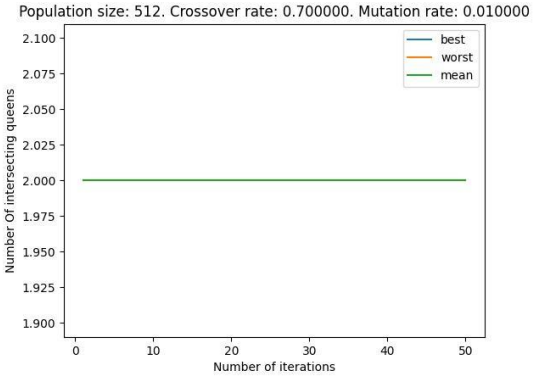
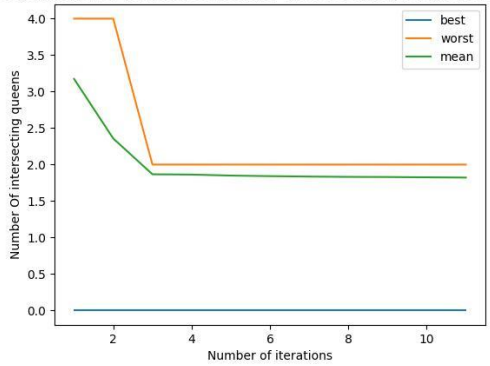
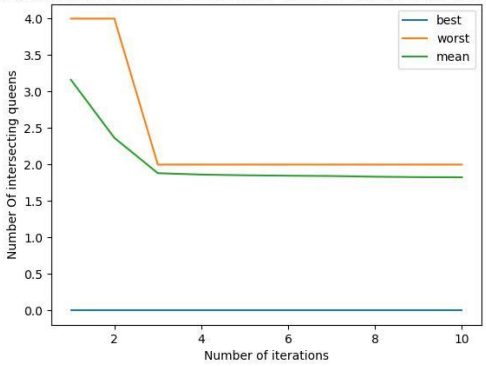
best
worst
mean
Number Of intersecting queens
Number of iterations


Population size: 512. Crossover rate: 0.700000. Mutation rate: 0.010000
best
worst
mean
Number Of intersecting queens
Number of iterations

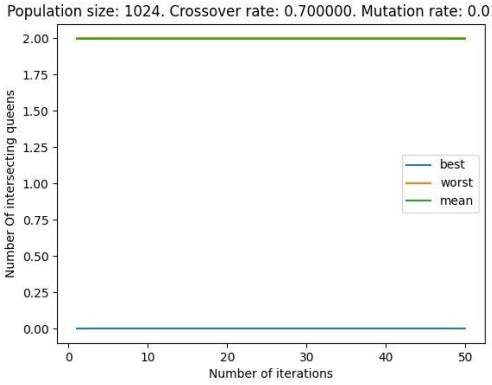
Population size: 1024. Crossover rate: 0.600000. Mutation rate: 0.510000



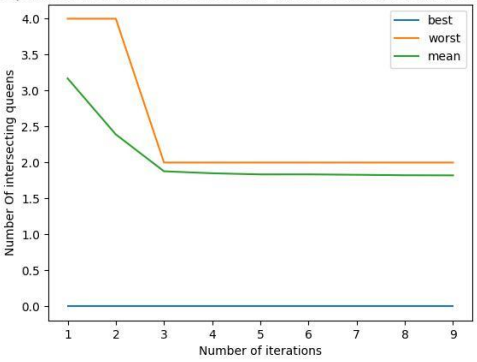
Population size: 1024. Crossover rate: 0.600000. Mutation rate: 1.000000



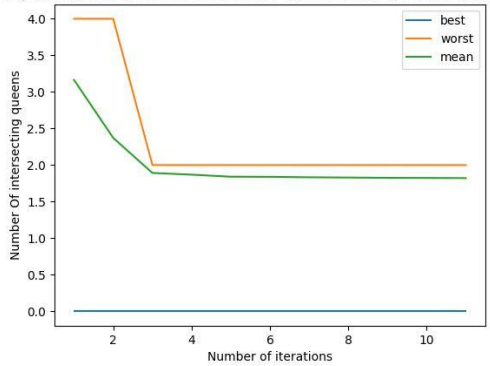
Population size: 1024. Crossover rate: 0.700000. Mutation rate: 0.010000



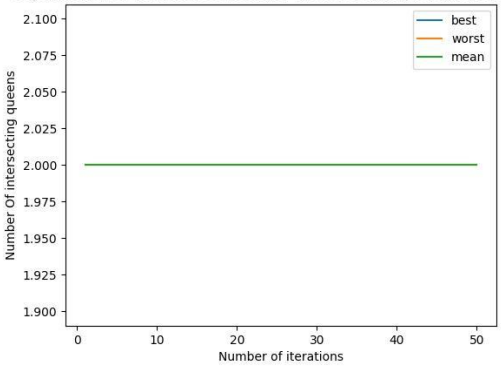
Population size: 1024. Crossover rate: 0.700000. Mutation rate: 0.510000



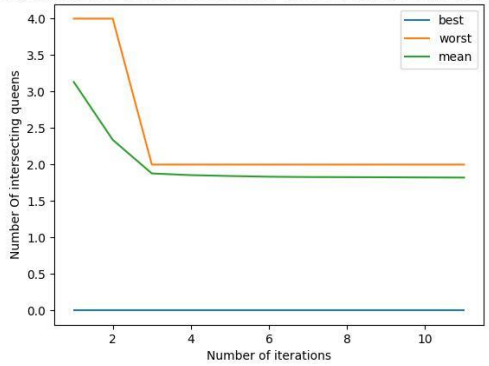
Population size: 1024. Crossover rate: 0.700000. Mutation rate: 1.000000



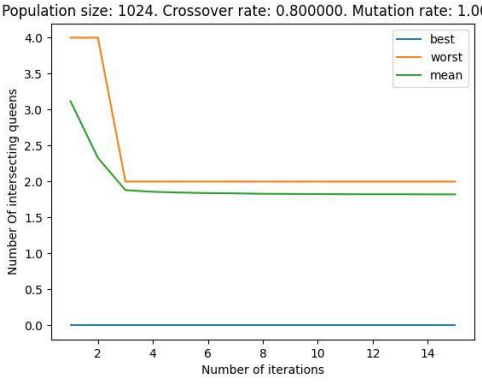
Population size: 1024. Crossover rate: 0.800000. Mutation rate: 0.010000

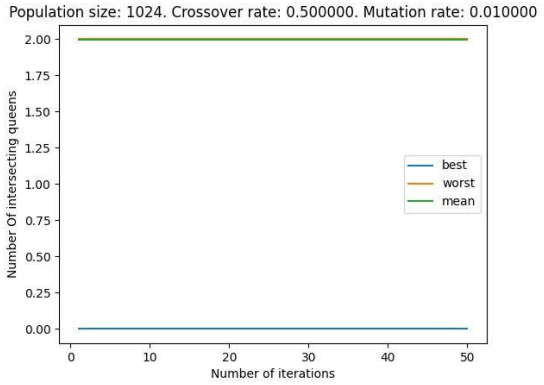


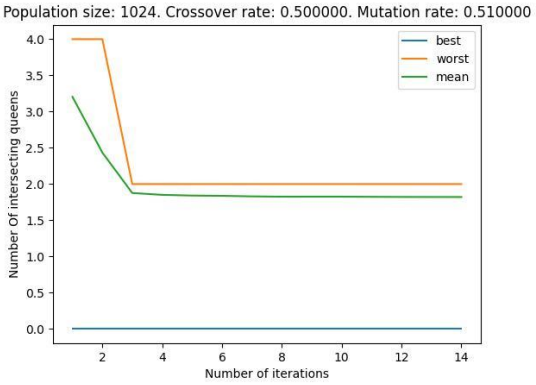
Population size: 1024. Crossover rate: 0.800000. Mutation rate: 0.510000

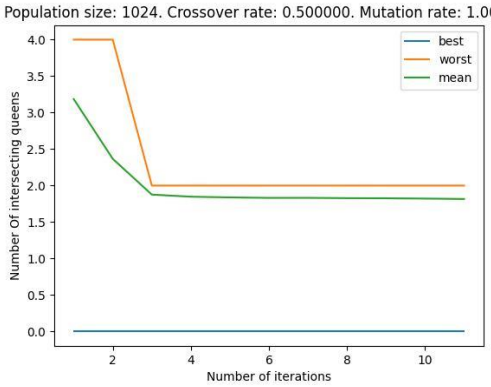


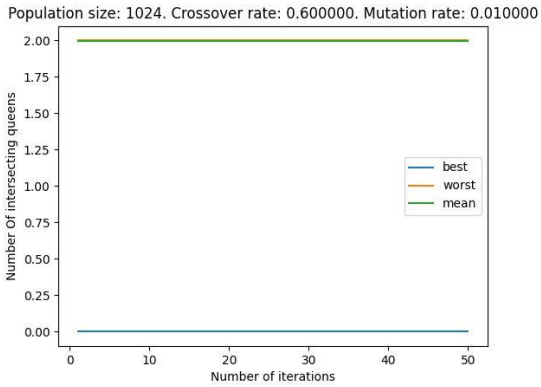
Population size: 1024. Crossover rate: 0.800000. Mutation rate: 1.000000











TSP

Greedy algorithm:

Our greedy algorithm randoms a city index and then in each iteration, proceed to the closest city. In the end, we return to the initial city.

Results:

Greedy Algorithm:

The greedy algorithm was very unstable. The route cost was around 36k – 45k. Mostly around 42k

Genetic Algorithm:

Execution time –

For 128 population size – 2 minutes for each run.

For 256 population size – 4 minutes for each run.

For 512 population size – ~8 minutes for each run (varies from 6 to 10).

For 1024 population size – We executed 1 run that was executed in 12 minutes.

As we see, we could achieve a route cost of 40k with the greedy algorithm but it was very stable.

The best run was with a population size of 1024, mutation rate of 0.01 and a crossover rate of 0.5 and it took 12 minutes. We achieved a cost of 39.7k.

Our second-best run was with a population size of 512 and it took 12 minutes (half the time). We could achieve with that run a route cost of 40k.

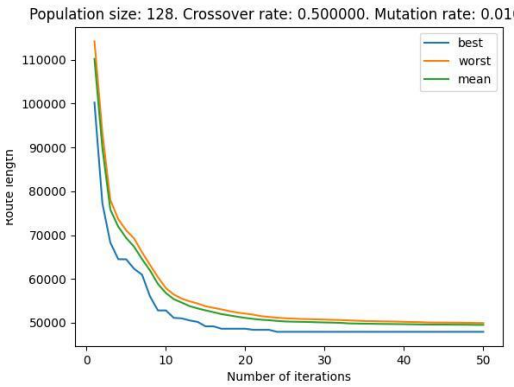
We also tried a run with a population 2048. In this run we could achieve 38k but we stopped the program in the middle because it took over an hour to run.

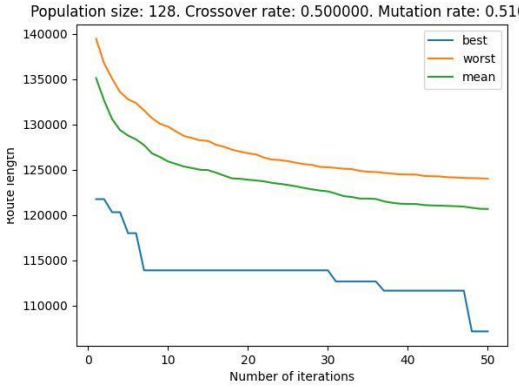
For the rates:

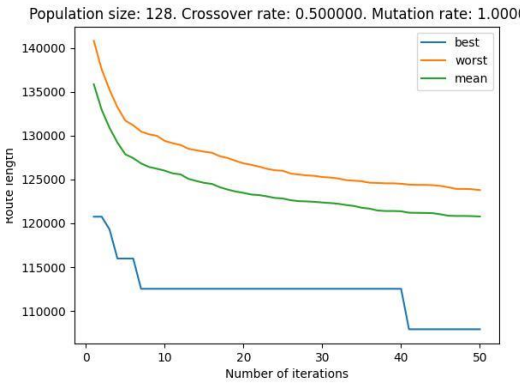
- Population Size - We see that bigger population size has better results.

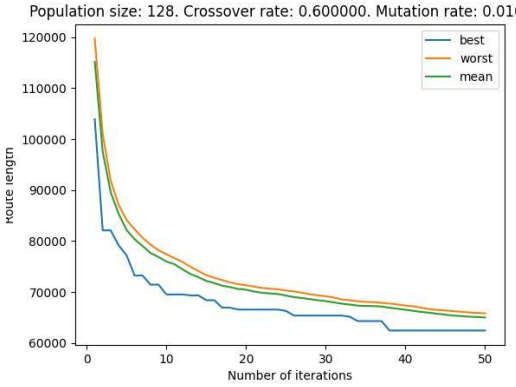
- Crossover Rate - We see that bigger crossover rate has better results.

- Mutation Rate – We that that bigger mutation rate, unlike the 8-Queen problem, has way worse results.


Population size: 128. Crossover rate: 0.500000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations


Population size: 128. Crossover rate: 0.500000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations


Population size: 128. Crossover rate: 0.500000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations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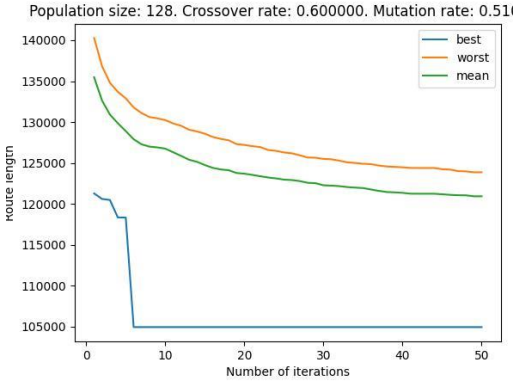
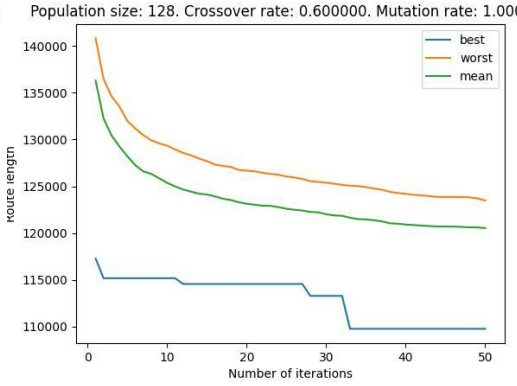
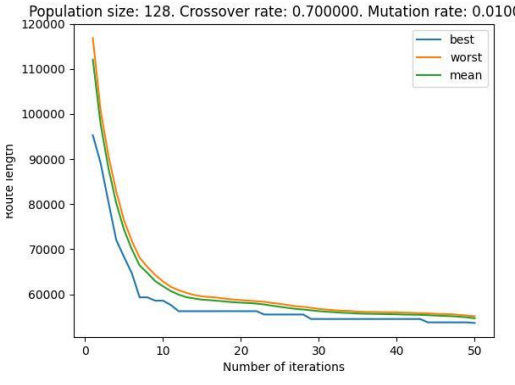
best
worst
mean
Route length
Number of iterations


Population size: 128. Crossover rate: 0.600000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations


Population size: 128. Crossover rate: 0.600000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations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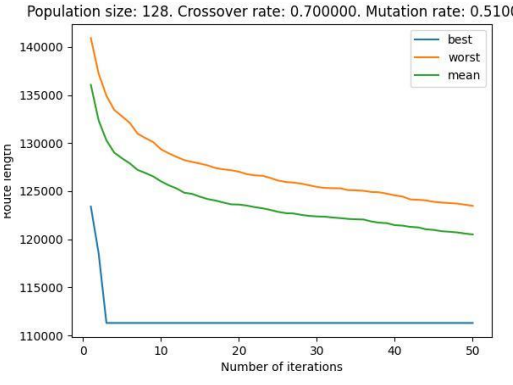
best
worst
mean
Route length
Number of iterations


Population size: 128. Crossover rate: 0.700000. Mutation rate: 0.510000
best
worst
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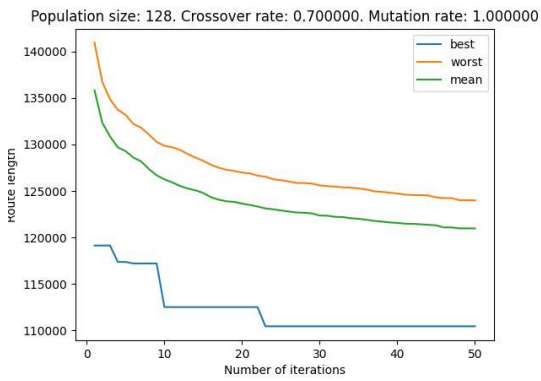
Route length
Number of iterations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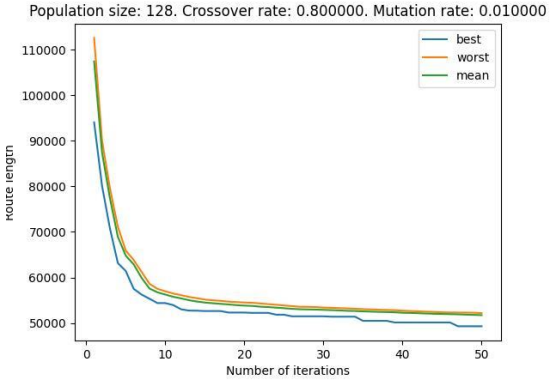
best
worst
mean
Route length
Number of iterations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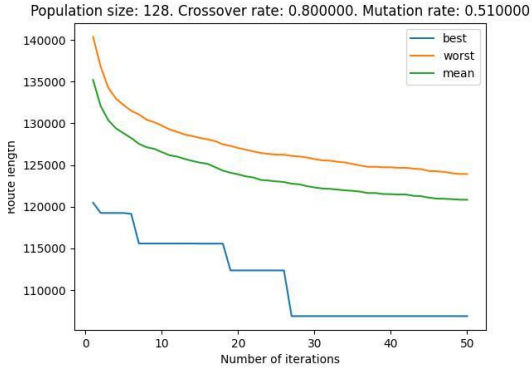
best
worst
mean
Route length
Number of iterations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best
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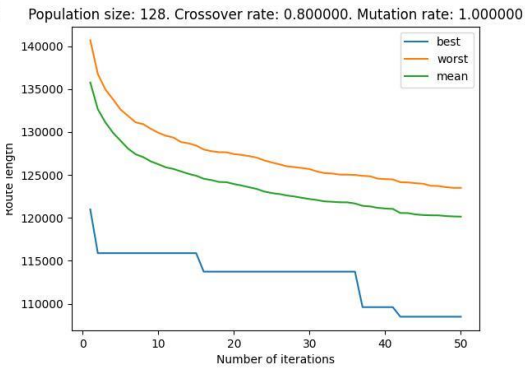
Number of iterations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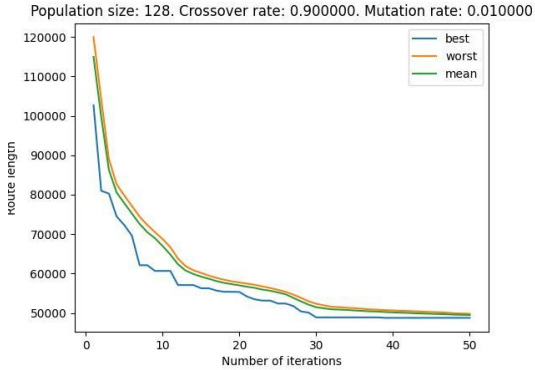
Number of iterations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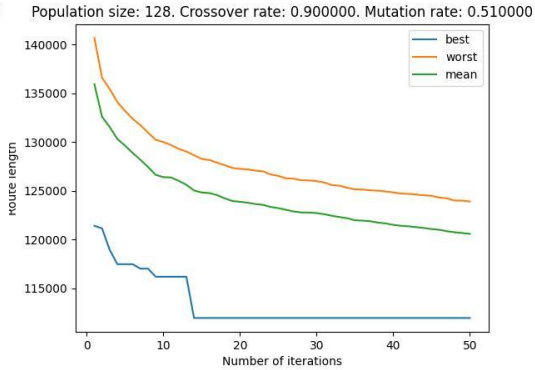
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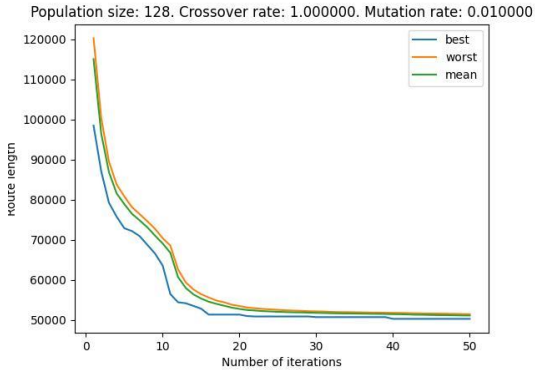
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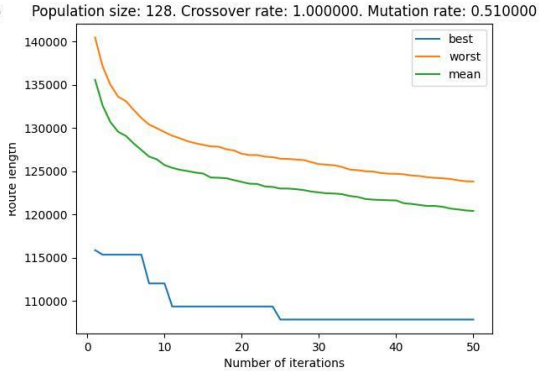
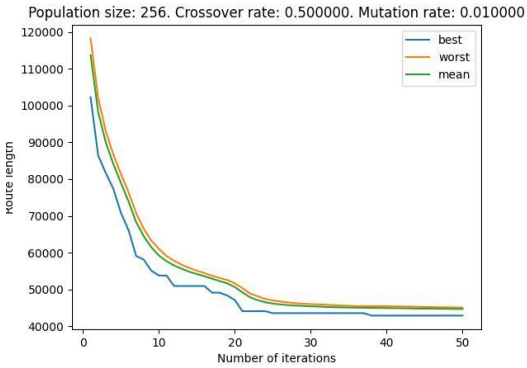
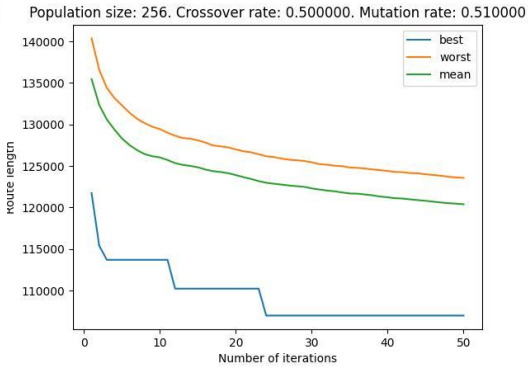
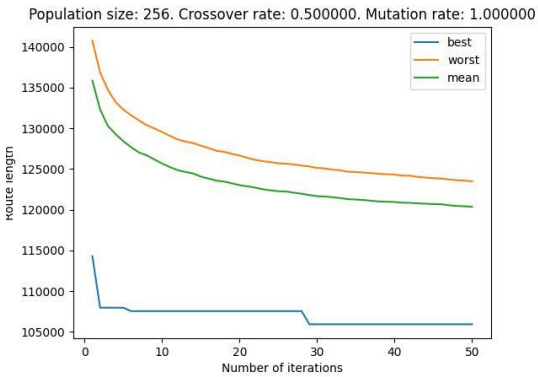
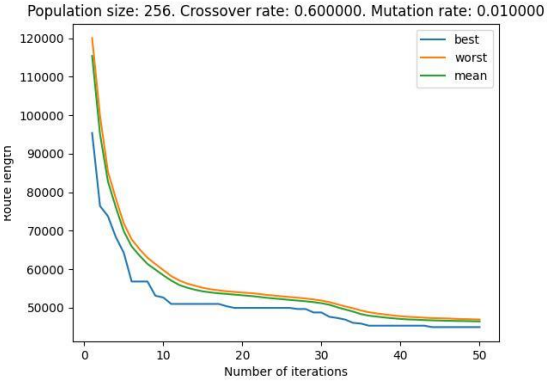
Route length
Number of iterations

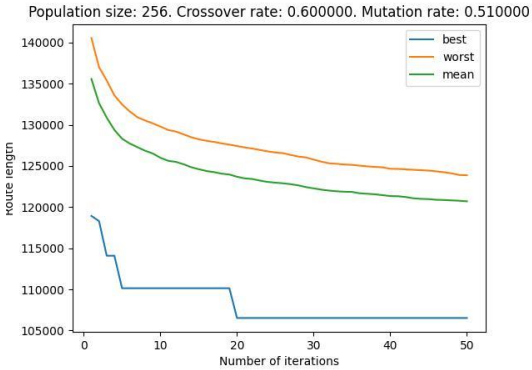

Population size: 128. Crossover rate: 1.000000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

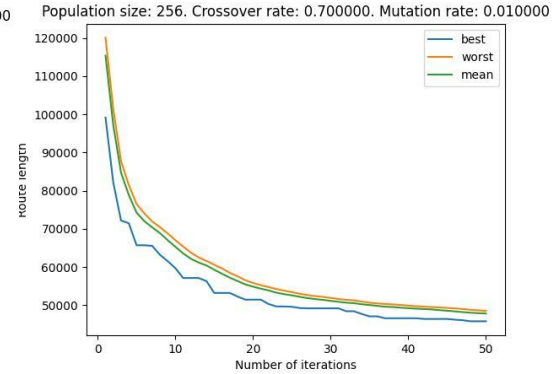

Population size: 256. Crossover rate: 0.500000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

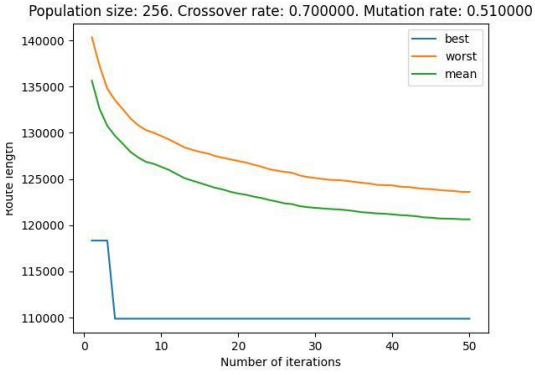

Population size: 256. Crossover rate: 0.500000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

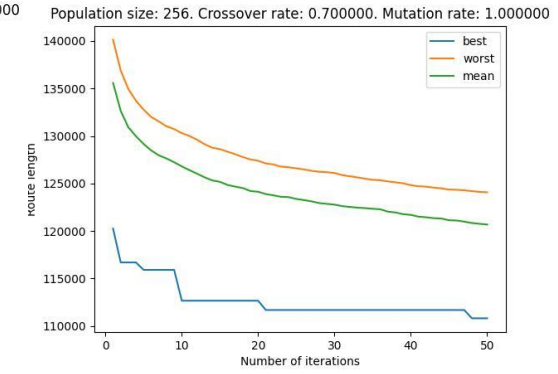

Population size: 256. Crossover rate: 0.500000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

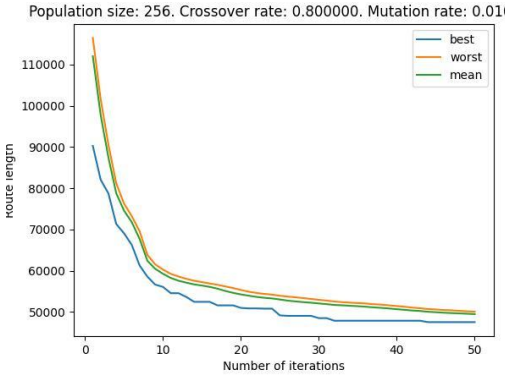

Population size: 256. Crossover rate: 0.600000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

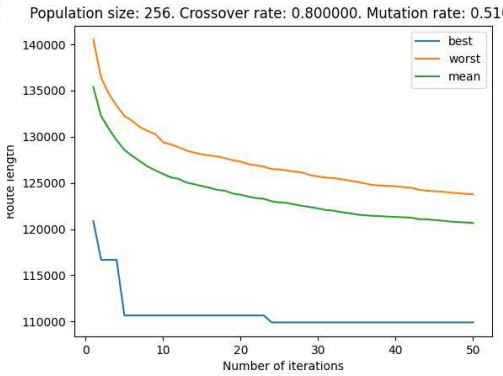

Population size: 256. Crossover rate: 0.600000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

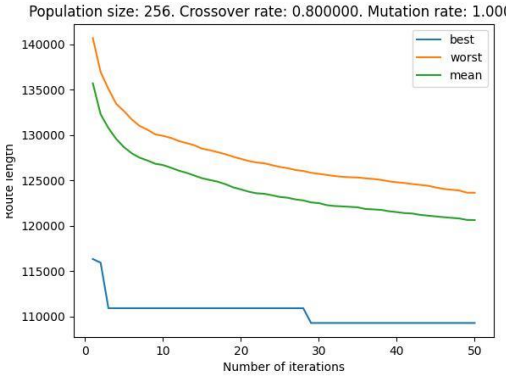

Population size: 256. Crossover rate: 0.700000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

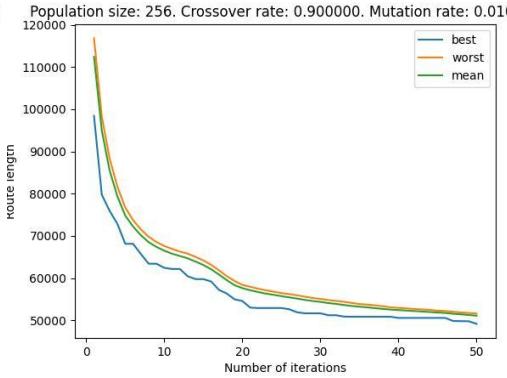

Population size: 256. Crossover rate: 0.700000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

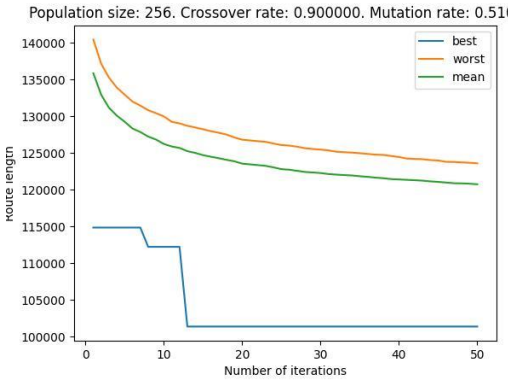

Population size: 256. Crossover rate: 0.700000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

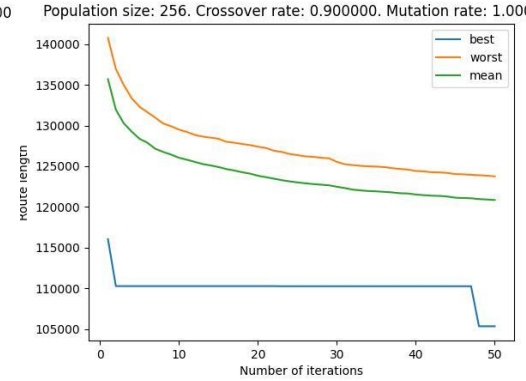

Population size: 256. Crossover rate: 0.800000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

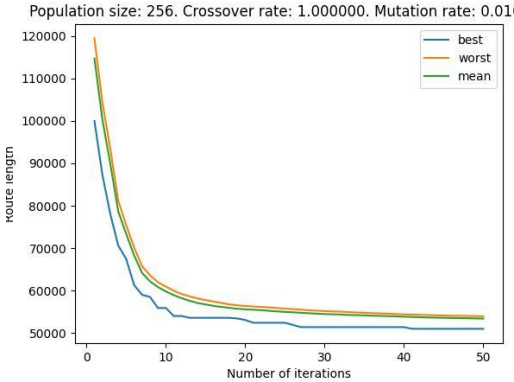

Population size: 256. Crossover rate: 0.800000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

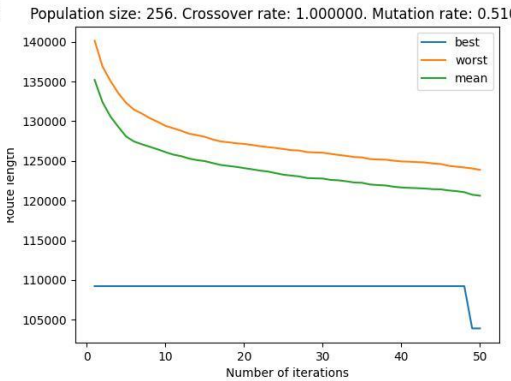

Population size: 256. Crossover rate: 0.800000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

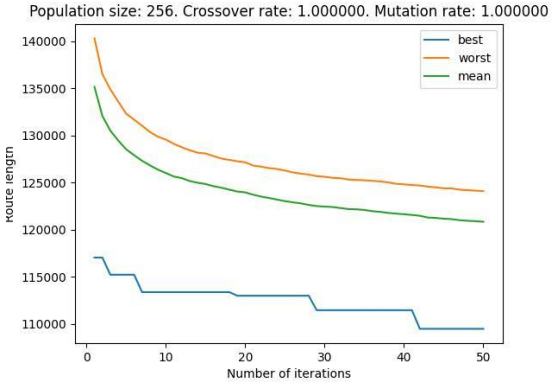

Population size: 256. Crossover rate: 0.900000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

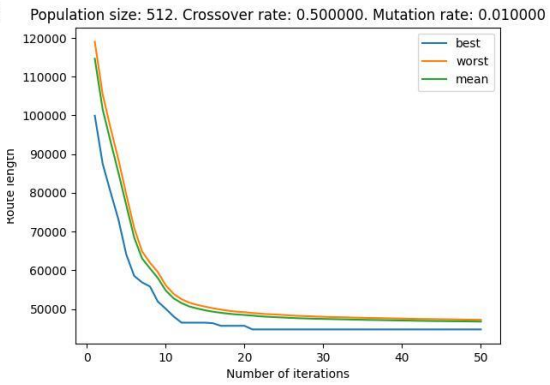

Population size: 256. Crossover rate: 0.900000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

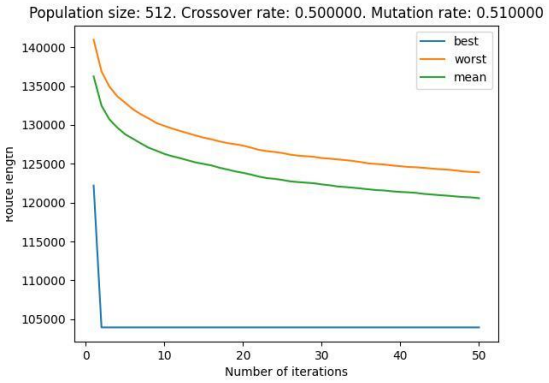

Population size: 256. Crossover rate: 0.900000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

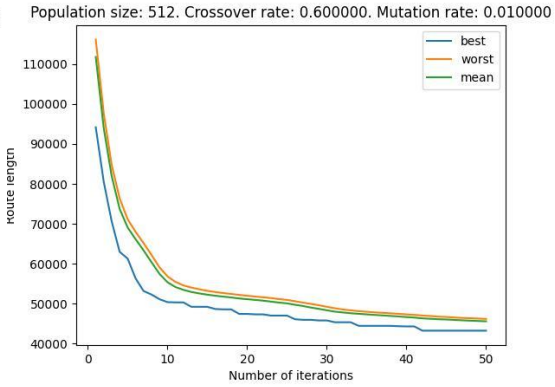

Population size: 256. Crossover rate: 1.000000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

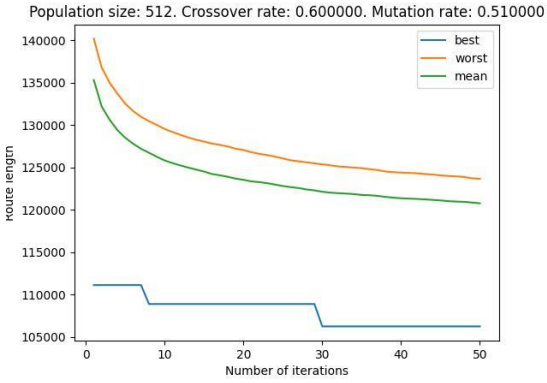

Population size: 256. Crossover rate: 1.000000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

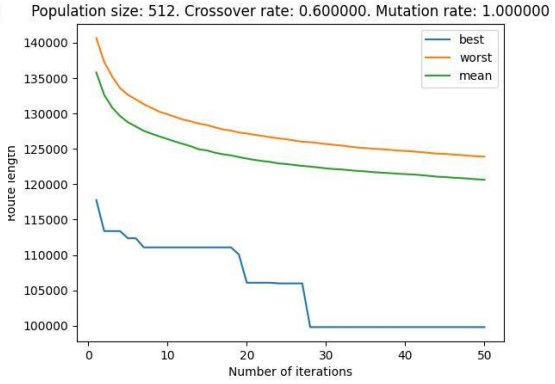

Population size: 256. Crossover rate: 1.000000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

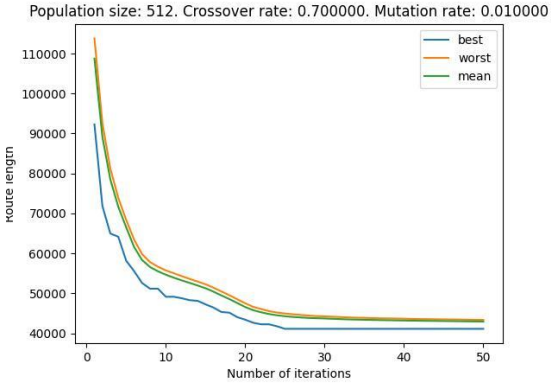

Population size: 512. Crossover rate: 0.500000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

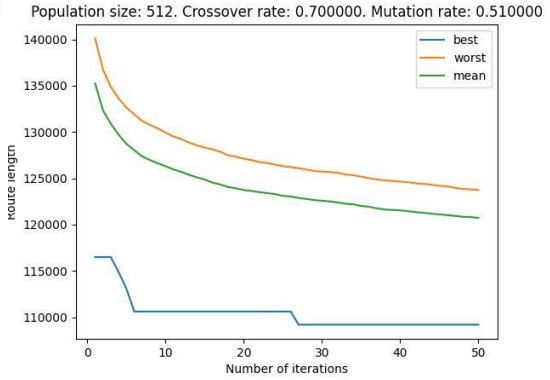

Population size: 512. Crossover rate: 0.500000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations


Population size: 512. Crossover rate: 0.600000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations

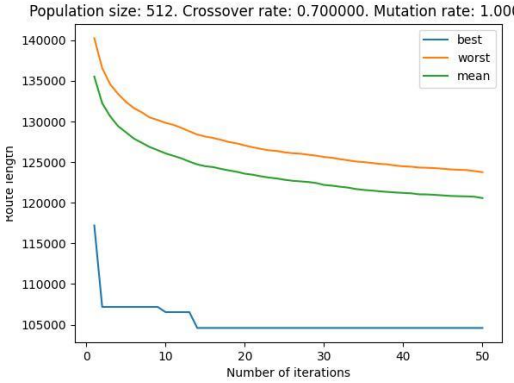

Population size: 512. Crossover rate: 0.600000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations


Population size: 512. Crossover rate: 0.600000. Mutation rate: 1.000000
best
worst
mean
Route length
Number of iterations

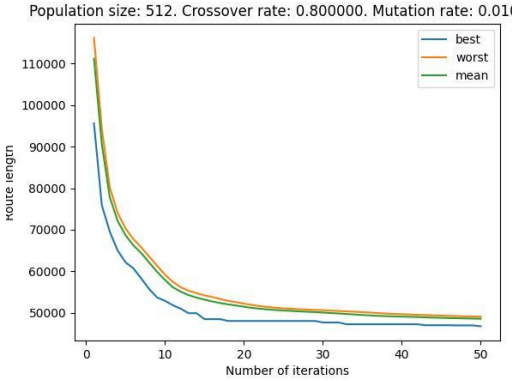

Population size: 512. Crossover rate: 0.700000. Mutation rate: 0.010000
best
worst
mean
Route length
Number of iterations


Population size: 512. Crossover rate: 0.700000. Mutation rate: 0.510000
best
worst
mean
Route length
Number of iterations

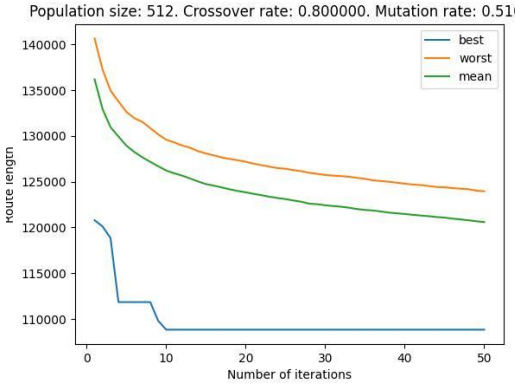
Population size: 512. Crossover rate: 0.700000. Mutation rate: 1.000000



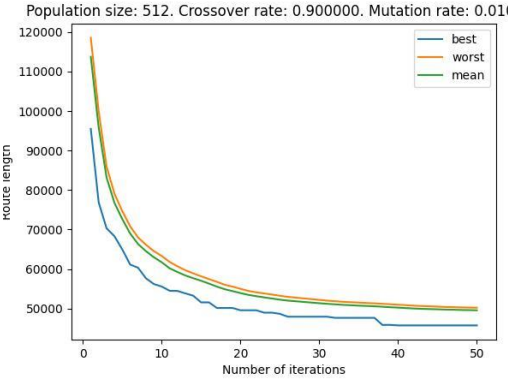
Population size: 512. Crossover rate: 0.800000. Mutation rate: 0.010000



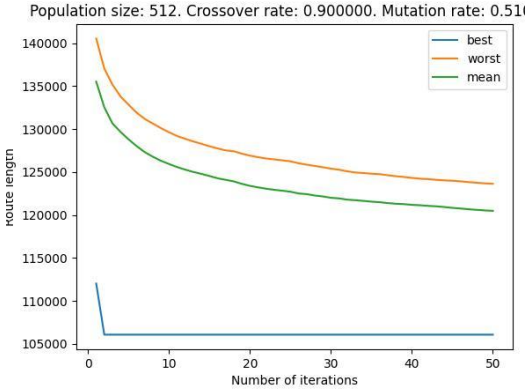
Population size: 512. Crossover rate: 0.800000. Mutation rate: 0.510000



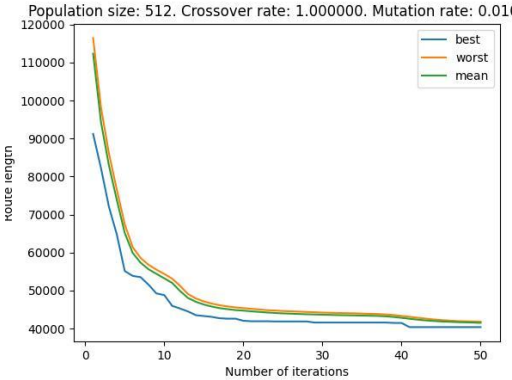
Population size: 512. Crossover rate: 0.900000. Mutation rate: 0.010000



Population size: 512. Crossover rate: 0.900000. Mutation rate: 0.510000



Population size: 512. Crossover rate: 1.000000. Mutation rate: 0.010000



Population size: 1024. Crossover rate: 0.500000. Mutation rate: 0.010000