Assignment 2-5

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# Task 1

## Summary

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The Genetic Algorithm (GA) showed different results in solving the Traveling Salesman Problem (TSP) based on population sizes and mutation rates. The best distance recorded was 455.85 with a population size of 100 and a mutation rate of 0.3.

## Analysis

The graph above indicates that larger population sizes tended to perform better, likely due to increased diversity. Conversely, really high or low mutation rates often resulted in worse distances because they disrupted promising solutions. Moderate mutation rates (0.3 and 0.6) appeared to balance exploration and exploitation, leading to better outcomes.

## Discussion

The data emphasizes the importance of parameter selection in optimizing the Genetic Algorithm for the Traveling Salesman Problem. Larger population sizes (50 and 100) consistently provided better and more reliable results. Moderate mutation rates (0.3 and 0.6) led to optimal distances, while very high or low rates often resulted in worse outcomes.

# Task 2

## Fitness function

The fitness function is defined as follows:



To evaluate this function, I split the equation into five parts, calculated each component separately, and then combined them in the return statement. There is a possibility for the overall fitness value to become negative, which did occur during calculations. However, the task instructions did not say how to handle negative values, so this was ignored in the implementation.

## Results

| **Population Size** | **Mutation Rate** | **Best Distance** | **Tour** |
| --- | --- | --- | --- |
| 10 | 0.1 | 590.73 | ['Kyiv', 'Barcelona', 'Moscow', 'Prague', 'Minsk', 'Warsaw', 'London', 'Berlin', 'Amsterdam', 'Sofia', 'Rome', 'Bucharest', 'Budapest', 'Paris', 'Vienna', 'Brussels', 'Munich', 'Milan', 'Birmingham', 'Istanbul'] |
| 10 | 0.3 | 506.97 | ['Munich', 'Milan', 'Brussels', 'Istanbul', 'Prague', 'Rome', 'Paris', 'Amsterdam', 'Vienna', 'Kyiv', 'Berlin', 'Moscow', 'Birmingham', 'Barcelona', 'Budapest', 'Bucharest', 'Minsk', 'Sofia', 'London', 'Warsaw'] |
| 10 | 0.6 | 660.52 | ['Brussels', 'Warsaw', 'Amsterdam', 'Berlin', 'Istanbul', 'Rome', 'Budapest', 'Bucharest', 'Minsk', 'Birmingham', 'London', 'Kyiv', 'Sofia', 'Munich', 'Milan', 'Prague', 'Vienna', 'Paris', 'Moscow', 'Barcelona'] |
| 10 | 0.9 | 606.8 | ['Warsaw', 'Paris', 'Kyiv', 'Rome', 'Prague', 'Minsk', 'Moscow', 'London', 'Birmingham', 'Berlin', 'Bucharest', 'Munich', 'Amsterdam', 'Brussels', 'Istanbul', 'Sofia', 'Vienna', 'Milan', 'Budapest', 'Barcelona'] |
| 20 | 0.1 | 537.17 | ['Sofia', 'Prague', 'Berlin', 'Bucharest', 'Kyiv', 'Paris', 'Istanbul', 'Brussels', 'Munich', 'Barcelona', 'Moscow', 'Milan', 'Birmingham', 'Amsterdam', 'Minsk', 'Rome', 'Warsaw', 'London', 'Vienna', 'Budapest'] |
| 20 | 0.3 | 572.19 | ['Munich', 'Vienna', 'Barcelona', 'Rome', 'Bucharest', 'Berlin', 'Moscow', 'Birmingham', 'Amsterdam', 'Minsk', 'Warsaw', 'Sofia', 'Budapest', 'Prague', 'Kyiv', 'Istanbul', 'Milan', 'Brussels', 'London', 'Paris'] |
| 20 | 0.6 | 634.58 | ['Berlin', 'London', 'Barcelona', 'Bucharest', 'Brussels', 'Prague', 'Paris', 'Milan', 'Budapest', 'Amsterdam', 'Rome', 'Istanbul', 'Munich', 'Birmingham', 'Moscow', 'Kyiv', 'Vienna', 'Warsaw', 'Minsk', 'Sofia'] |
| 20 | 0.9 | 571.7 | ['Kyiv', 'Berlin', 'Bucharest', 'Warsaw', 'Prague', 'Amsterdam', 'Barcelona', 'Munich', 'Paris', 'Minsk', 'Birmingham', 'Brussels', 'Budapest', 'Rome', 'Milan', 'Vienna', 'Moscow', 'Sofia', 'Istanbul', 'London'] |
| 50 | 0.1 | 532.63 | ['Milan', 'Rome', 'Brussels', 'Vienna', 'Minsk', 'Amsterdam', 'Istanbul', 'Kyiv', 'Munich', 'Sofia', 'Budapest', 'Birmingham', 'Warsaw', 'London', 'Barcelona', 'Paris', 'Bucharest', 'Berlin', 'Moscow', 'Prague'] |
| 50 | 0.3 | 535.81 | ['Birmingham', 'Budapest', 'Bucharest', 'Istanbul', 'Berlin', 'Munich', 'Warsaw', 'Amsterdam', 'Kyiv', 'Barcelona', 'Prague', 'Minsk', 'Rome', 'Moscow', 'Sofia', 'Milan', 'Brussels', 'London', 'Paris', 'Vienna'] |
| 50 | 0.6 | 541.75 | ['Munich', 'Moscow', 'Brussels', 'Milan', 'Berlin', 'Minsk', 'Budapest', 'Rome', 'Istanbul', 'Amsterdam', 'Kyiv', 'Birmingham', 'Bucharest', 'Warsaw', 'Barcelona', 'Paris', 'London', 'Vienna', 'Sofia', 'Prague'] |
| 50 | 0.9 | 495.11 | ['Rome', 'Amsterdam', 'Munich', 'Budapest', 'Minsk', 'Brussels', 'Moscow', 'Kyiv', 'Barcelona', 'Bucharest', 'Sofia', 'Berlin', 'Vienna', 'Prague', 'Warsaw', 'Birmingham', 'Paris', 'Milan', 'Istanbul', 'London'] |
| 100 | 0.1 | 596.5 | ['Milan', 'Barcelona', 'Istanbul', 'Birmingham', 'Berlin', 'Prague', 'Bucharest', 'Vienna', 'Rome', 'Kyiv', 'Munich', 'Budapest', 'Minsk', 'London', 'Sofia', 'Brussels', 'Paris', 'Moscow', 'Amsterdam', 'Warsaw'] |
| 100 | 0.3 | 455.85 | ['Istanbul', 'Warsaw', 'Minsk', 'Kyiv', 'Sofia', 'Brussels', 'Moscow', 'Munich', 'Prague', 'Vienna', 'Berlin', 'London', 'Rome', 'Amsterdam', 'Bucharest', 'Birmingham', 'Barcelona', 'Paris', 'Milan', 'Budapest'] |
| 100 | 0.6 | 514.29 | ['Rome', 'Barcelona', 'Warsaw', 'Sofia', 'Budapest', 'Berlin', 'Kyiv', 'Amsterdam', 'Paris', 'London', 'Istanbul', 'Milan', 'Vienna', 'Munich', 'Prague', 'Moscow', 'Minsk', 'Birmingham', 'Brussels', 'Bucharest'] |
| 100 | 0.9 | 549.45 | ['Warsaw', 'Vienna', 'Brussels', 'Munich', 'Sofia', 'Berlin', 'Milan', 'London', 'Minsk', 'Birmingham', 'Prague', 'Istanbul', 'Bucharest', 'Paris', 'Moscow', 'Kyiv', 'Budapest', 'Barcelona', 'Amsterdam', 'Rome'] |