summarize,

analyze,

results

imported needed packages,

parameter

random coordinate representation for presenting the random location for each city

function computes city distance for each couple of city.

first generation: repeating for population time :random sequence of the city as a a new solution (individual ).

Output: an array in population size where every element is a solution.

Fitness:input city dictionary (city name, coordination), city list

Computes the Distance between sewuential cities of individual

Get all fitness: dictionary input is a population set (the array of indivituals)

runs fitness for each individual in population array

selection: normalizing the fitness, random choice of two indivitaul from population

**def mate\_progenitors: one-point crossover** for mating two progenitors (prog\_a and prog\_b) in a genetic algorithm, but your code is only taking a fixed slice of the first progenitor (prog\_a[0:5]) and then filling in the remaining cities from prog\_b if they aren't already in the offspring

mutation: two cities (or elements) in the offspring are randomly swapped to introduce variation.

Here's a breakdown of the logic in your mutate\_offspring function:

* **Mutation Loop**: The loop runs a number of times based on the product of the number of cities (n\_cities) and the mutation rate (mutation\_rate).
* **Random Swapping**: Two random indices a and b are chosen, and their corresponding elements in offspring are swapped.
* **Mutation Rate**: The higher the mutation rate, the more swaps are performed.

Best solution in every population is selected and printed.

It replaces with the first element of the array

|  |  |  |
| --- | --- | --- |
| Mutation rate | Population size | Best result  iteration or generation number, fitness value,path |
| 0.9 | 100 | [3697,  557.8461606238724,  array([['Amsterdam', 'Barcelona', 'Bucharest', 'Vienna', 'Berlin',  'Sofia', 'Paris', 'Moscow', 'London', 'Budapest', 'Milan',  'Brussels', 'Rome', 'Munich', 'Istanbul', 'Prague', 'Minsk',  'Birmingham', 'Kyiv', 'Warsaw']], dtype='<U10')] |
| 0.6 | 100 | [2524,  604.5359905053764,  array([['Barcelona', 'Berlin', 'Brussels', 'Birmingham', 'Istanbul',  'Amsterdam', 'Milan', 'Moscow', 'London', 'Munich', 'Budapest',  'Bucharest', 'Prague', 'Rome', 'Minsk', 'Warsaw', 'Kyiv',  'Paris', 'Vienna', 'Sofia']], dtype='<U10')] |
| 0.3 | 100 | [7496,  482.004457999315,  array([['Sofia', 'Prague', 'Kyiv', 'Warsaw', 'Vienna', 'Istanbul',  'Munich', 'Rome', 'Barcelona', 'Amsterdam', 'London', 'Budapest',  'Bucharest', 'Brussels', 'Minsk', 'Berlin', 'Birmingham',  'Milan', 'Paris', 'Moscow']], dtype='<U10')] |
| 0.1 | 100 | 5609,  550.7144636450676,  array([['Barcelona', 'Moscow', 'Vienna', 'Budapest', 'Rome', 'Minsk',  'Brussels', 'Kyiv', 'Milan', 'Istanbul', 'London', 'Birmingham',  'Munich', 'Sofia', 'Warsaw', 'Paris', 'Amsterdam', 'Prague',  'Bucharest', 'Berlin']], dtype='<U10')] |
| 0.1 | 50 | [8387,  606.5497866245164,  array([['Kyiv', 'Bucharest', 'Milan', 'Amsterdam', 'Barcelona', 'Prague',  'Budapest', 'Istanbul', 'Vienna', 'London', 'Moscow', 'Rome',  'Berlin', 'Minsk', 'Birmingham', 'Paris', 'Munich', 'Warsaw',  'Brussels', 'Sofia']], dtype='<U10')] |
| 0.3 | 50 | [7241,  657.4131143935194,  array([['Munich', 'Minsk', 'Sofia', 'Kyiv', 'Amsterdam', 'Birmingham',  'Berlin', 'Bucharest', 'Istanbul', 'Rome', 'Brussels',  'Barcelona', 'Milan', 'Vienna', 'Warsaw', 'Paris', 'Budapest',  'Moscow', 'Prague', 'London']], dtype='<U10')] |
| 0.6 | 50 | [8113,  573.0091428365286,  array([['Barcelona', 'Amsterdam', 'Milan', 'Moscow', 'Sofia', 'Budapest',  'Brussels', 'Istanbul', 'Berlin', 'Munich', 'Bucharest',  'London', 'Vienna', 'Rome', 'Warsaw', 'Minsk', 'Birmingham',  'Kyiv', 'Paris', 'Prague']], dtype='<U10')] |
| 0.9 | 50 | [394,  545.3760963115338,  array([['Sofia', 'Munich', 'Birmingham', 'Vienna', 'Minsk', 'Prague',  'Istanbul', 'Berlin', 'Kyiv', 'Amsterdam', 'Bucharest',  'Barcelona', 'Brussels', 'Moscow', 'Paris', 'London', 'Budapest',  'Rome', 'Warsaw', 'Milan']], dtype='<U10')] |
| 0.9 | 20 | [6443,  566.0443978649489,  array([['Munich', 'Brussels', 'Berlin', 'Prague', 'London', 'Bucharest',  'Paris', 'Amsterdam', 'Moscow', 'Milan', 'Vienna', 'Barcelona',  'Rome', 'Sofia', 'Istanbul', 'Budapest', 'Minsk', 'Birmingham',  'Kyiv', 'Warsaw']], dtype='<U10')] |
| 0.6 | 20 | [7767,  570.904056917633,  array([['Paris', 'Vienna', 'Budapest', 'Amsterdam', 'London', 'Sofia',  'Minsk', 'Munich', 'Berlin', 'Barcelona', 'Prague', 'Warsaw',  'Rome', 'Moscow', 'Milan', 'Kyiv', 'Brussels', 'Bucharest',  'Istanbul', 'Birmingham']], dtype='<U10')] |
| 0.3 | 20 | 3613,  536.8090671213663,  array([['Vienna', 'Berlin', 'Bucharest', 'Budapest', 'London',  'Istanbul', 'Moscow', 'Brussels', 'Munich', 'Minsk', 'Paris',  'Milan', 'Warsaw', 'Kyiv', 'Amsterdam', 'Sofia', 'Rome',  'Prague', 'Barcelona', 'Birmingham']], dtype='<U10')] |
| 0.1 | 20 | [2277,  614.2218944197805,  array([['Vienna', 'Bucharest', 'Barcelona', 'Paris', 'Istanbul',  'Prague', 'Minsk', 'Milan', 'Munich', 'London', 'Budapest',  'Berlin', 'Rome', 'Warsaw', 'Sofia', 'Amsterdam', 'Moscow',  'Birmingham', 'Kyiv', 'Brussels']], dtype='<U10')] |
| 0.1 | 10 | [3780,  640.0872723566481,  array([['Budapest', 'Vienna', 'Munich', 'Istanbul', 'London', 'Berlin',  'Bucharest', 'Kyiv', 'Milan', 'Birmingham', 'Rome', 'Minsk',  'Barcelona', 'Moscow', 'Warsaw', 'Sofia', 'Brussels', 'Paris',  'Prague', 'Amsterdam']], dtype='<U10')] |
| 0.3 | 10 | [83,  527.558670566981,  array([['Milan', 'London', 'Sofia', 'Vienna', 'Kyiv', 'Barcelona',  'Munich', 'Birmingham', 'Warsaw', 'Paris', 'Bucharest',  'Istanbul', 'Berlin', 'Brussels', 'Prague', 'Budapest',  'Amsterdam', 'Minsk', 'Moscow', 'Rome']], dtype='<U10')] |
| 0.6 | 10 | [6271,  580.1201997328003,  array([['Barcelona', 'Prague', 'Amsterdam', 'Birmingham', 'Milan',  'Berlin', 'Budapest', 'Munich', 'Rome', 'Warsaw', 'Moscow',  'Brussels', 'London', 'Paris', 'Sofia', 'Kyiv', 'Minsk',  'Istanbul', 'Bucharest', 'Vienna']], dtype='<U10')] |
| 0.9 | 10 | [9115,  539.49809894372,  array([['Berlin', 'Warsaw', 'Barcelona', 'Birmingham', 'Rome',  'Amsterdam', 'Minsk', 'Milan', 'Bucharest', 'Budapest', 'Prague',  'Kyiv', 'Moscow', 'Paris', 'London', 'Brussels', 'Munich',  'Sofia', 'Istanbul', 'Vienna']], dtype='<U10')] |