Workshop - 2 System Analysis

ANT COLONY OPTIMIZATION

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Objective:

Solve the traveling sales man problem using the known swarm intelligence algorithm, in our case this is done by using Ant Colony Optimization (ACO).

Design Ideas:

- The points referring to the cities are stored in an array and each point is store as 3d point such as (x, y, z) by the use of NumPy random rand

- The distance between points is calculated by Euclidian distance formula for 3d based of the Pythagoras formula. In our code it is done by NumPy linalg norm (that gives the norm of a vector in this case a vector between our two points)

- In the case of the ACO its most important design decisions are:
    - The probability of going to a city is done by the formula: pheromone (to go to that city) * ant likeness to the pheromone + distance (between the current city and the one it could go) *

ant likeness to distances. The reason for these to probabilities to be sum together its due search the shortest distance and avoid negative probabilities.
  - Next since we strive for the next city to be choose by probability roulette, we first normalize de probabilities (each probability / the sum of all probabilities) to then run NumPy's choice function
  - Lastly, we do the route for each ant and repeat the corresponding amount of generations

- Finally, we run the ACO to solve the TSP and plot the resulting route with matplotlib

Analysis:

Parameters used:

Note: (fixed) are variables that are not changing

Cites = 50 (fixed)

Ants = [100, 150, 200]

Iterations = [100, 150]

Alpha = [1, 0.5]

Beta = [1, 0.5]

Evaporation rate = 0.5 (fixed)

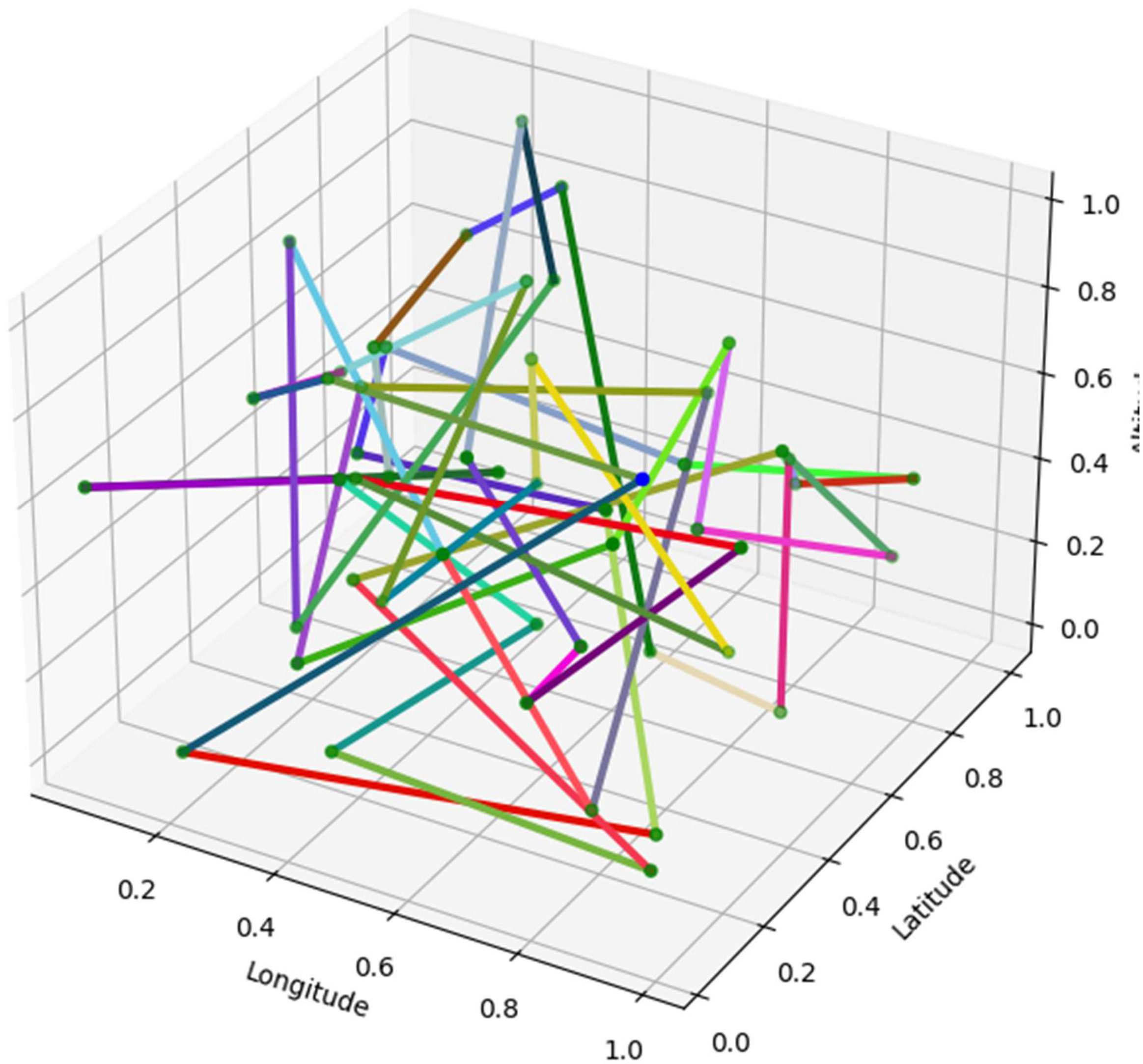
Q = 1 (fixed)

Experimental test 1:

Cites = 50	Ants = 100	Iterations = 100
Alpha = 1	Beta = 1	Evaporation rate = 0.5
Q = 1		

Best path: [31, 33, 48, 49, 43, 42, 34, 32, 41, 45, 47, 37, 39, 36, 35, 40, 38, 44, 46, 11, 21, 19, 24, 18, 23, 14, 26, 20, 30, 17, 25, 16, 12, 15, 13, 22, 28, 29, 27, 3, 7, 6, 4, 8, 10, 9, 5, 1, 2, 0]

Best path length: 26.201165988877943



Experimental test 2:

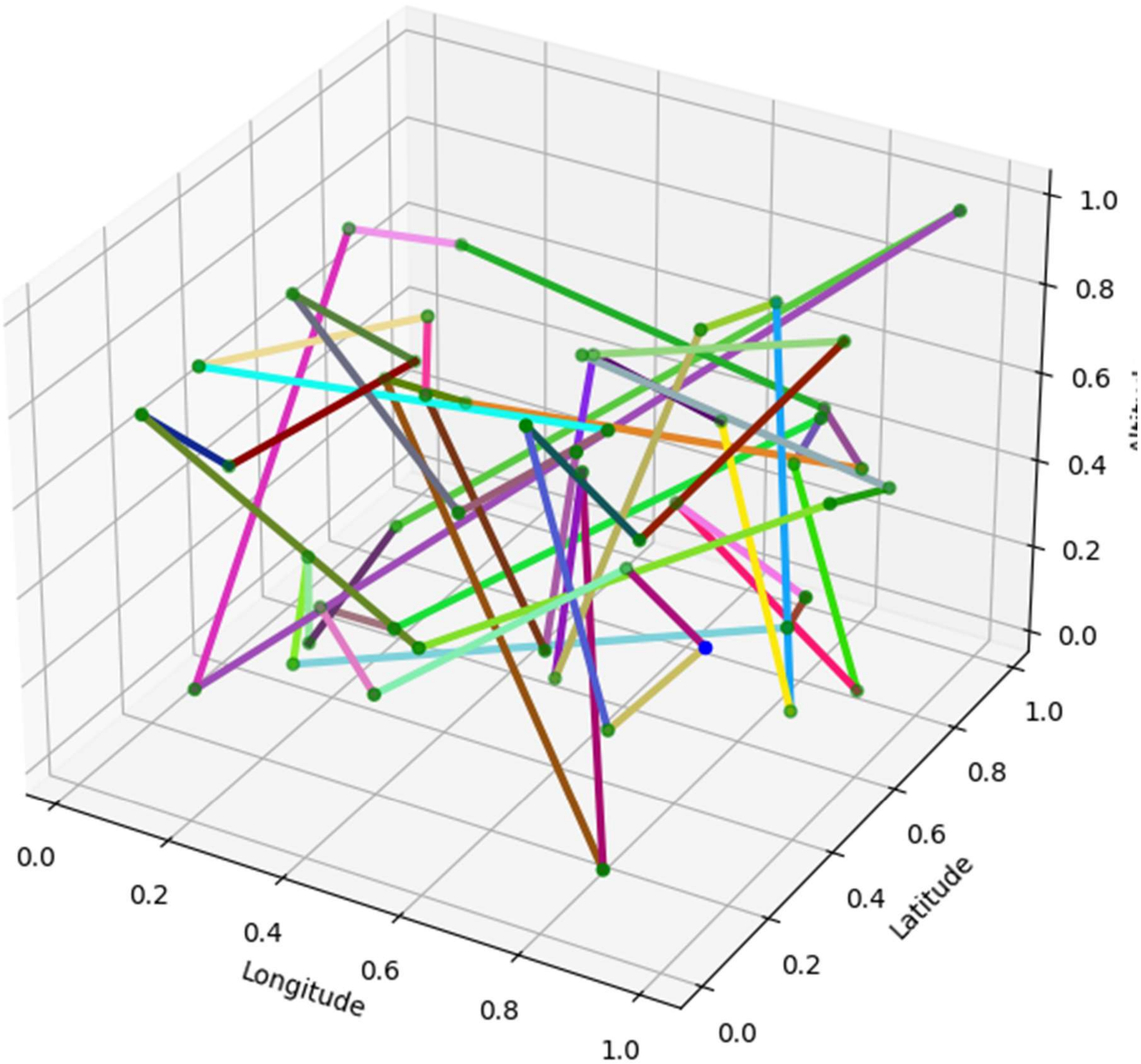
Cites = 50 Ants = 150 Iterations = 100

Alpha = 1 Beta = 1 Evaporation rate = 0.5

Q = 1

Best path: [5, 10, 33, 11, 43, 39, 15, 6, 37, 42, 8, 44, 36, 38, 48, 9, 32, 23, 19, 45, 30, 40, 31, 17, 21, 49, 27, 7, 41, 25, 13, 46, 12, 14, 20, 29, 35, 24, 22, 26, 16, 18, 28, 34, 47, 3, 4, 0, 1, 2]

Best path length: 26.984612144785988



Experimental test 3:

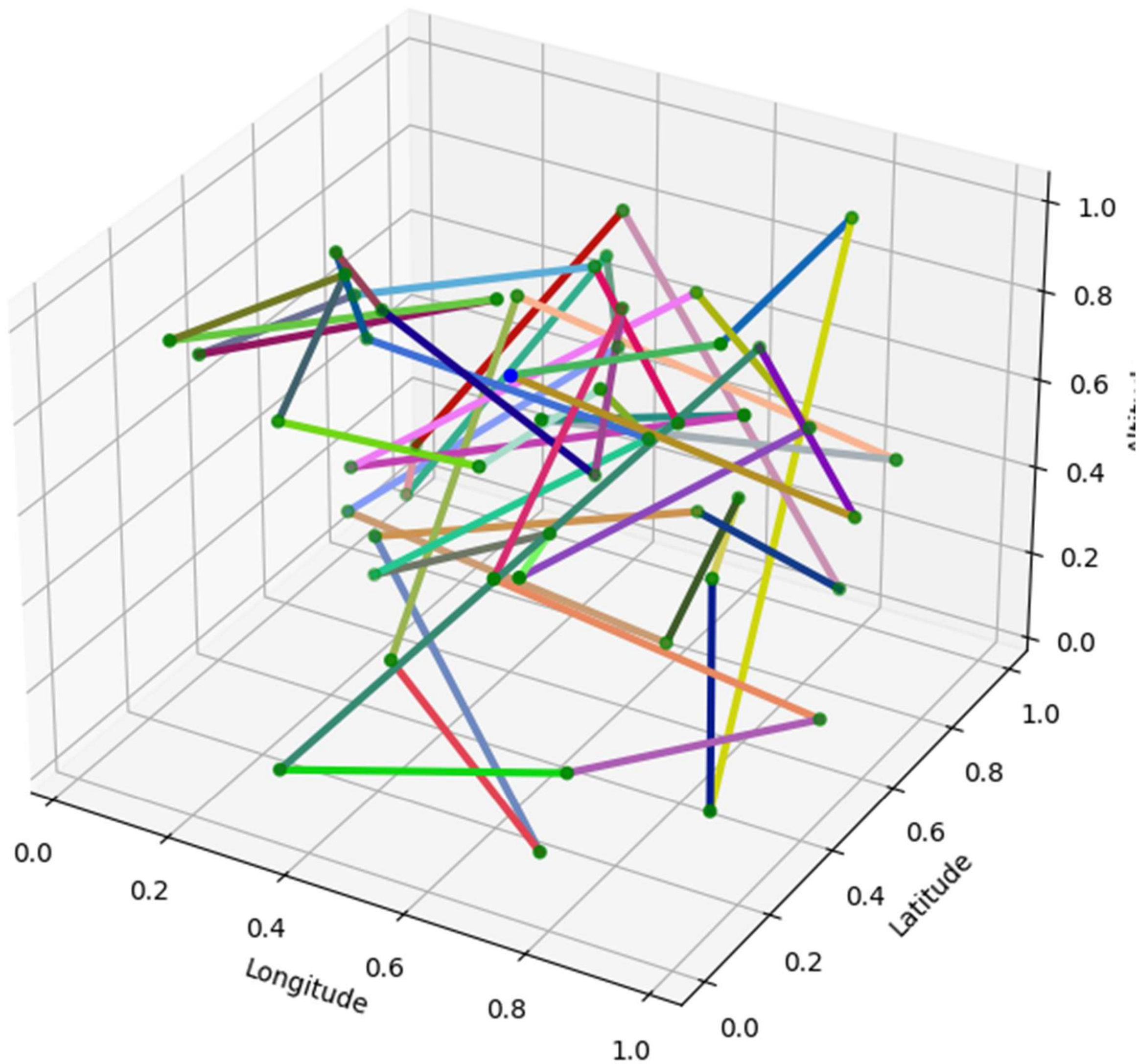
Cites = 50 Ants = 200 Iterations = 150

Alpha = 1 Beta = 1 Evaporation rate = 0.5

Q = 1

Best path: [7, 26, 29, 48, 33, 16, 14, 25, 44, 27, 17, 36, 45, 10, 15, 46, 13, 47, 21, 28, 34, 38, 8, 37, 49, 20, 35, 22, 42, 24, 40, 9, 12, 11, 19, 30, 31, 18, 23, 43, 39, 32, 41, 3, 6, 5, 4, 1, 2, 0]

Best path length: 25.84550289330271



Experimental test 4:

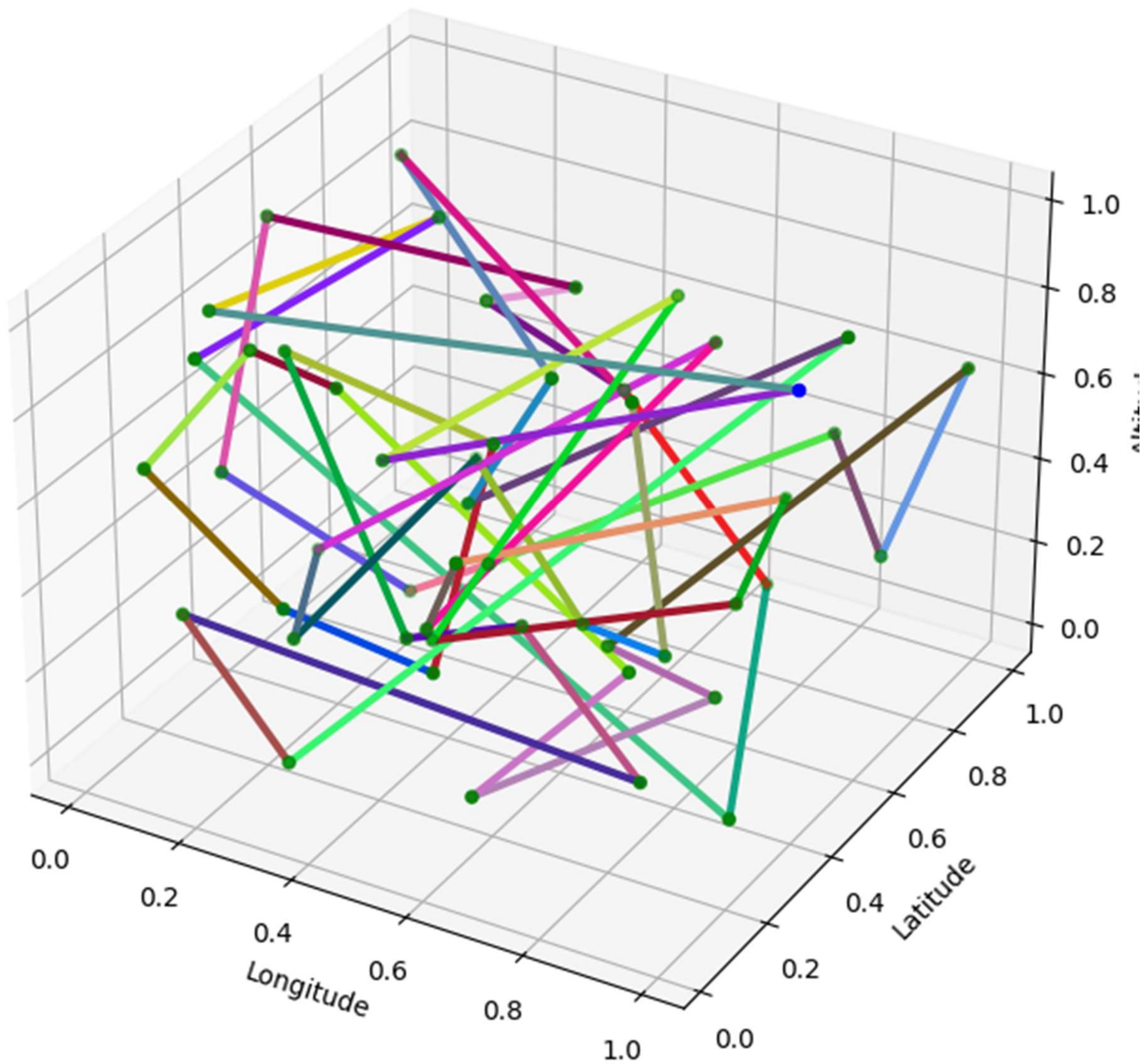
Cites = 50 Ants = 200 Iterations = 200

Alpha = 1 Beta = 0.5 Evaporation rate = 0.5

Q = 1

Best path: [25, 36, 39, 31, 41, 42, 35, 29, 30, 43, 32, 45, 47, 27, 46, 40, 33, 34, 48, 37, 44, 38, 49, 28, 26, 20, 21, 23, 24, 22, 11, 16, 12, 14, 15, 17, 13, 18, 19, 10, 1, 6, 8, 5, 9, 2, 3, 4, 7, 0]

Best path length: 27.16054240498873



Experimental test 5:

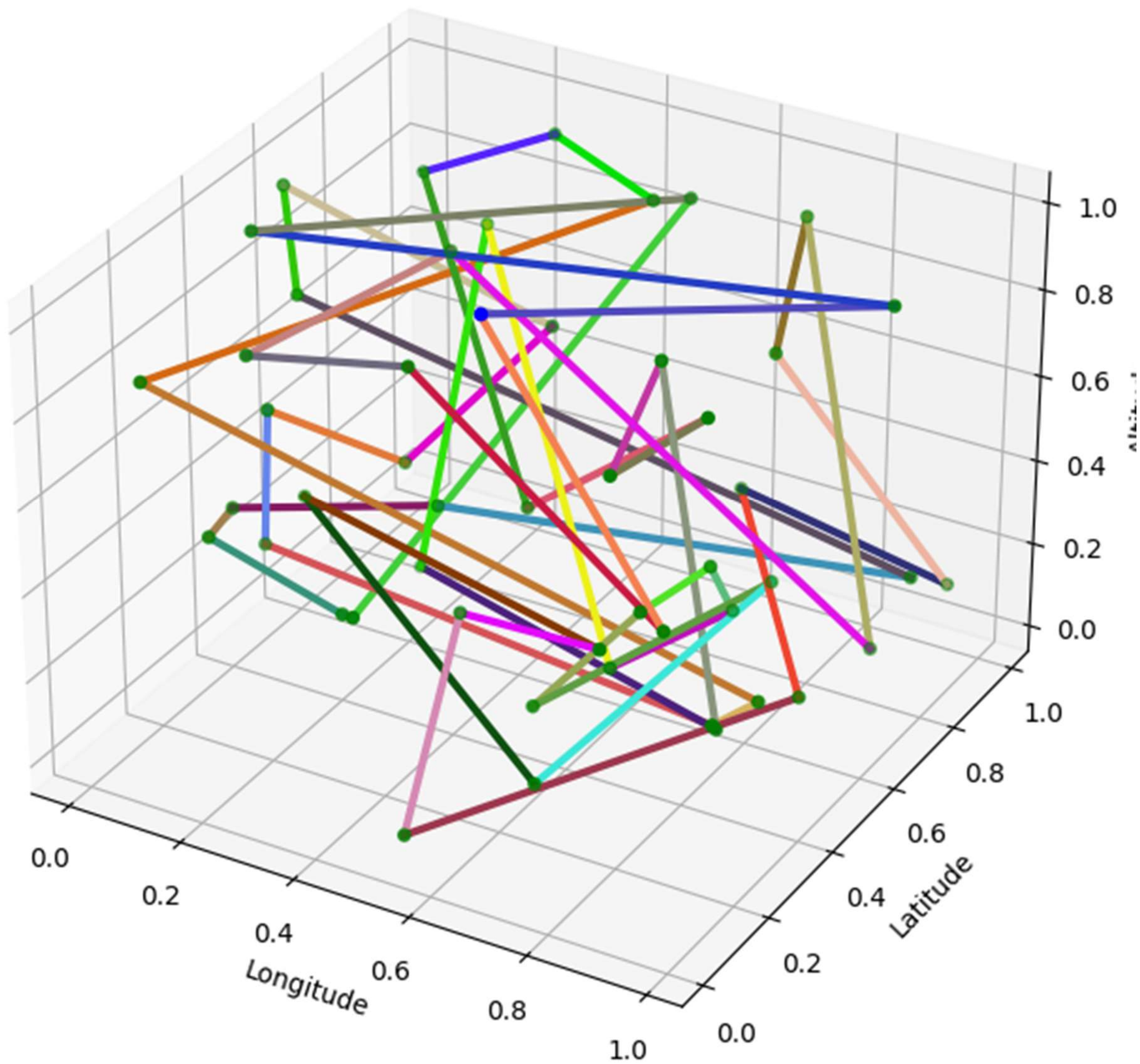
Cites = 50 Ants = 200 Iterations = 200

Alpha = 0.5 Beta = 1 Evaporation rate = 0.5

Q = 1

Best path: [49, 39, 45, 47, 42, 48, 40, 43, 44, 41, 46, 18, 26, 28, 25, 34, 29, 27, 20, 23, 21, 19, 38, 32, 33, 37, 36, 31, 24, 35, 30, 22, 9, 15, 12, 10, 14, 17, 11, 16, 13, 6, 8, 7, 5, 3, 4, 0, 2, 1]

Best path length: 28.02263999150684



Experimental test 6:

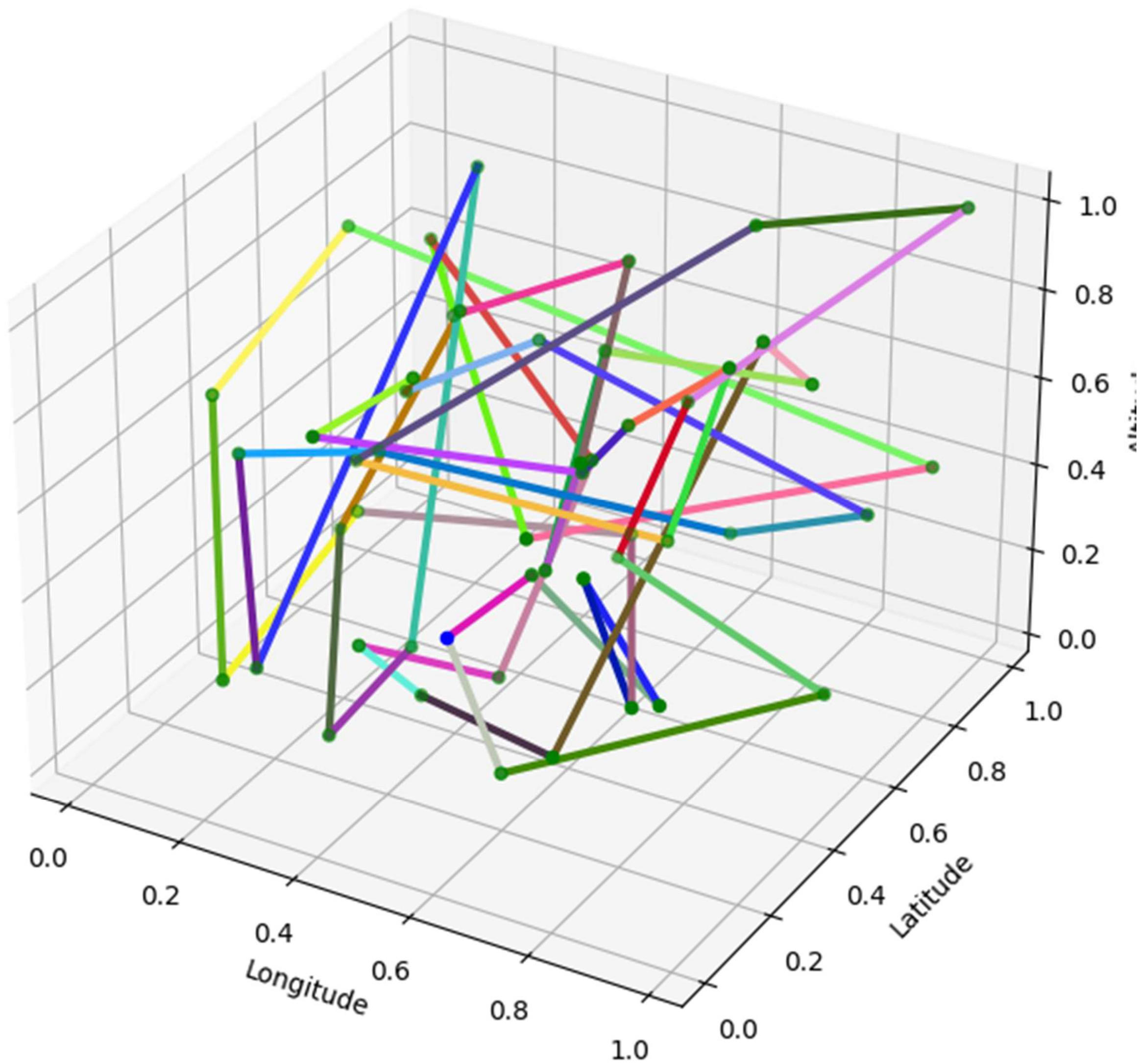
Cites = 50 Ants = 200 Iterations = 200

Alpha = 0.5 Beta = 0.5 Evaporation rate = 0.5

Q = 1

Best path: [29, 41, 30, 32, 35, 49, 40, 42, 45, 36, 39, 47, 37, 44, 34, 46, 48, 43, 38, 31, 33, 11, 21, 26, 19, 27, 23, 20, 28, 15, 24, 16, 17, 12, 14, 13, 22, 18, 25, 1, 5, 7, 8, 3, 9, 2, 4, 10, 6, 0]

Best path length: 26.470026516173764



Experimental test extra:

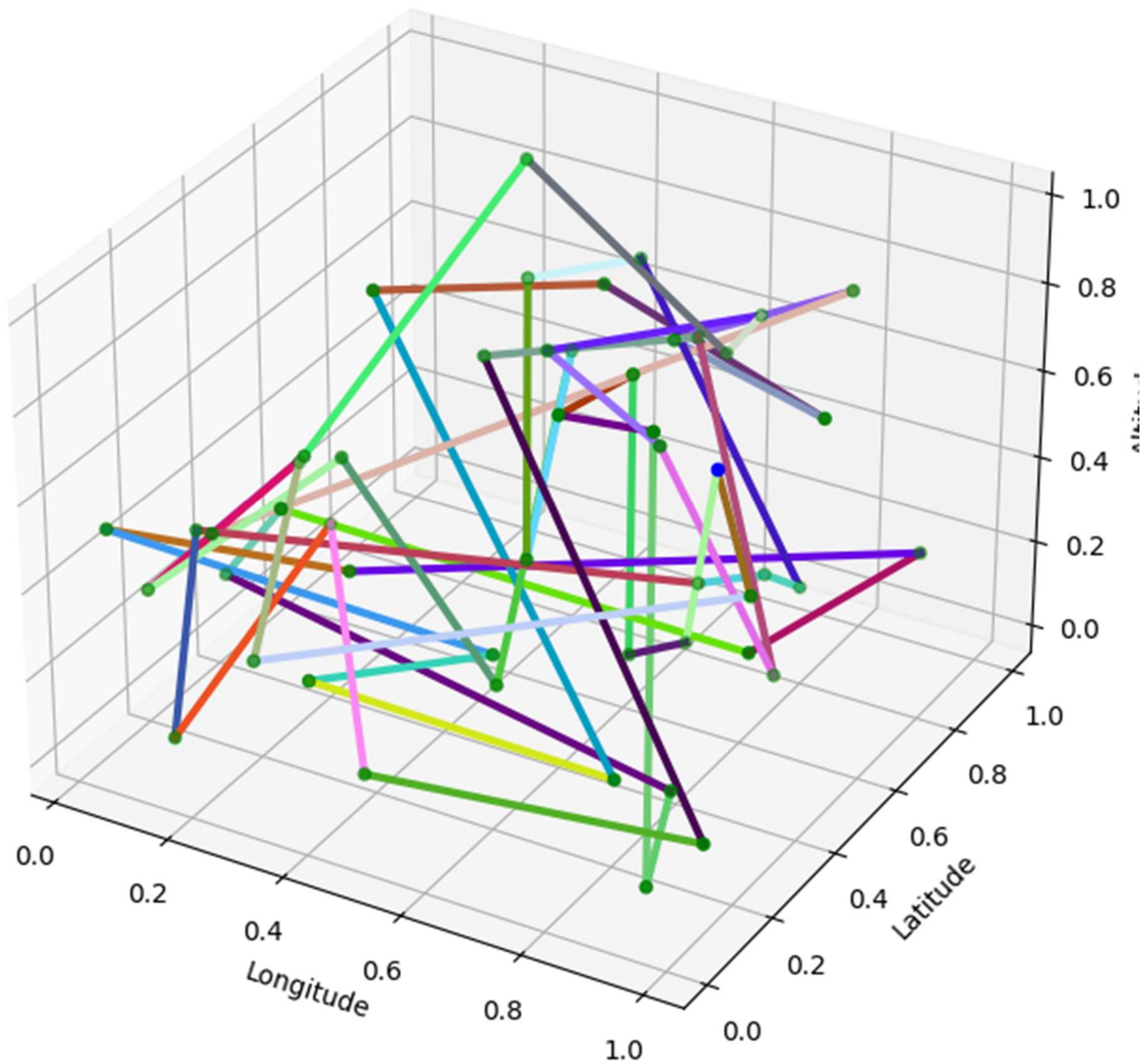
Cites = 50 Ants = 800 Iterations = 200

Alpha = 0.75 Beta = 0.2 Evaporation rate = 0.5

Q = 1

Best path: [19, 30, 40, 48, 32, 39, 29, 26, 47, 28, 44, 31, 35, 22, 38, 27, 23, 24, 49, 20, 41, 36, 46, 42, 37, 21, 33, 34, 45, 25, 43, 2, 6, 4, 3, 10, 17, 11, 12, 7, 16, 8, 13, 5, 9, 15, 18, 14, 0, 1]

Best path length: 25.726028119018977



What we notice:

1. Most of the experimental results all maintain a similar and close answers meaning that the ACO algorithm offers a good option to solve the TSP.

2. The lower that the ant’s likeness to pheromone is the more unusual paths appear making the final “best path” longer than other options, something similar happens when lowering the distance influence just that in this case is slightly lower

3. Rising the ant number and generations the ants have shows to improve the final result thought to an apparent ceiling since it seams that after a certain point the size difference of the final path becomes exponentially smaller

4. The processing struggles the machine can encounter while running the code its mainly due to the number of ants since each ant must do its own probability operations making the time spent way longer.