Comparison of Euclidean and Manhattan Distance for Travelling Salesman Problem Using Genetic Algorithm

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I. Introduction

Traveling salesman problem (TSP) is the problem to find the shortest possible route that visit each city in a list of given cities, exactly once and returns to the origin city. The goal of this problem is to find the route with minimum cost, i.e. shortest route or fastest route between nodes, i.e. cities. For this project, the Shopee delivery truck was chosen to represent the salesman while Shopee express hub as the nodes. For the sake of simplicity, each express hub is considered connected to other hubs.

II. Nodes Representation

20 Shopee express hub in Selangor and Kuala Lumpur was selected to represent the node for the TSP. Table I list the the names of the express hub and its location in x and y coordinate.

TABLE I
List of Shopee Express Hub

Name	X coordinate	Y coordinate
Cheras	82	66
Cyberjaya	91	03
Ecohill	12	85
Hentian Kajang	92	94
Kajang 1	63	68
Kajang 2	09	76
Klang 1	28	75
Klang 2	55	39
Klang Selatan	96	66
Klang Utara	97	17
Kota Kemuning	15	71
Lakefield	98	03
OUG	96	27
Petaling Jaya	49	04
Puchong	89	09
Serdang	14	83
Sungai Chua	42	70
USJ 21	92	32
Wangsa Maju	80	95

III. Distance Metric

Two distance metrics was chosen to calculate the distance between the hubs, namely Euclidean distance and Manhattan distance. Equation 1 describe Euclidean distance while equation 2 describe Manhattan distance.

$$d(x, y) = \sqrt{(y_1 - x_1)^2 + (y_2 - x_2)^2} \tag{1}$$

$$d(x, y) = |x_2 - x_1| + |y_2 - y_1| \tag{2}$$

where d is the distance between x and y coordinate in spatial space.

IV. Ordered Crossover

Ordered crossover transfer information about the relative order form the second parent to the offspring. Given two permutations, P_0 and P_1 of the same set.

$$P_0 = (A, B, C, D, E, F, G, H, I, J)$$

$$P_1 = (B, D, A, H, J, C, E, G, F, I)$$

Add a random selection of gene segments in P_0. Here from gene position 1 and 2, which is A, B and 6 to 8, which is F, G, H.

$$P_0 = (\boldsymbol{A}, \boldsymbol{B}, C, D, E, \boldsymbol{F}, \boldsymbol{G}, \boldsymbol{H}, I, J)$$

Create a child permutation that contains the selected gene segments of P_0 in the same position.

$$P_{child} = (A, B, ?, ?, ?, F, G, H, ?, ?)$$

The remaining missing genes are now also transferred, but in the order in which they appear in P_1.

$$P_{child} = (A, B, \boldsymbol{D}, \boldsymbol{J}, \boldsymbol{C}, F, G, H, \boldsymbol{E}, \boldsymbol{I})$$

V. Tournament Selection

Tournament selection involves running several ‘tournaments’ among few individuals (or chromosomes) chosen at random form the population The winner of each tournaments is selected for crossover. *Selection pressure*, a probabilistic measure of a chromosome’s likelihood of participation in the tournament based on the participant selection pool size, is easily adjusted by changing the tournament size. If the tournament size is larger, weak individuals have a smaller chance to be selected, because if a weak individual is selected to be in a tournament, there is a higher probability that a stronger individual is also in that tournament.

VI. Mutation

Mutation is a genetic operator used to maintain genetic diversity of the population’s chromosomes. Random mutation based on probabilistic was chosen. Given n number of cities and the same number of paths between cities, P, chose two paths, P_1 and P_2 from P. Swap P_1 with P_2.

VII. Experimental Results

Table II show the minimum distance after 200 generations and 30 runs for Euclidean and Manhattan distance. Figure 1 and 2 show the optimal path for Euclidean and Manhattan Distance respectively. Figure 3 and 4 show the minimum distance length over generation for Euclidean and Manhattan Distance respectively.

TABLE II
Minimum Distance

Distance Metric	Average Minimum Distance
Euclidean Distance	346.20
Manhattan Distance	1862.00

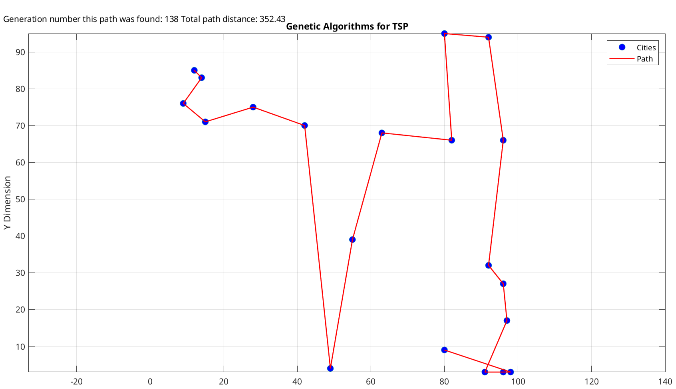

Fig. 1. Best Path using Euclidean Distance

As shown in Figure 1 and 2, both Euclidean and Manhattan distance have different optimal route. Also, from Figure 4, Manhattan distance achieve optimal solution far earlier compared to Euclidean distance in Figure 3.

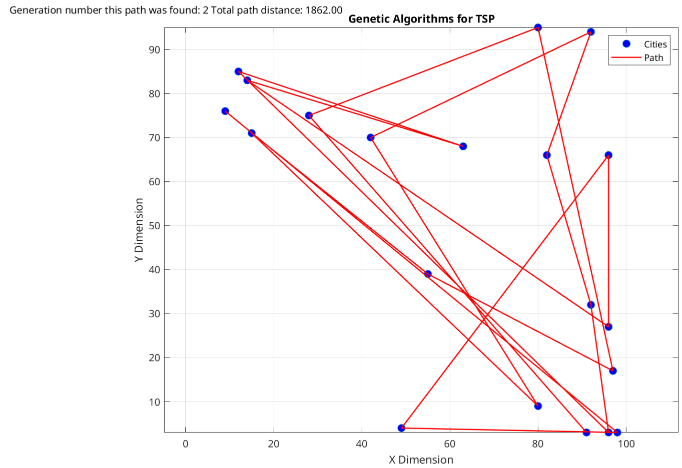

Fig. 2. Best Path using Manhattan Distance

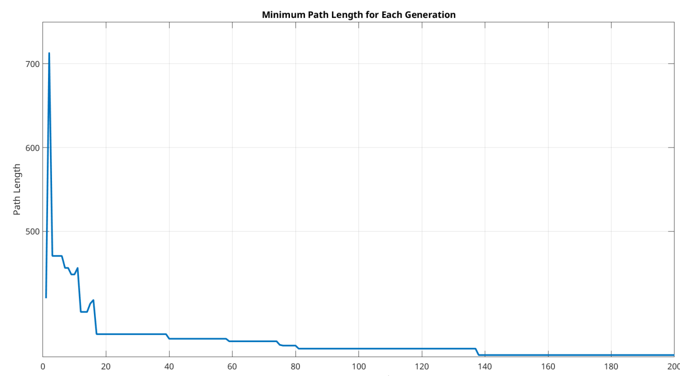

Fig. 3. Minimum Route Over Time Euclidean

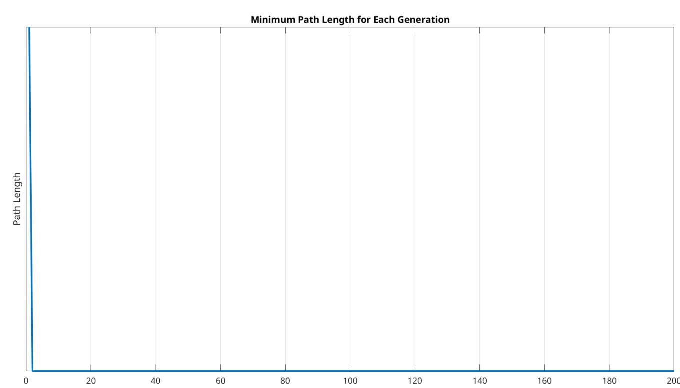

Fig. 4. Minimum Route Over Time Manhattan

VIII. Conclusion

Both Euclidean and Manhattan distance achieve different result for optimal route and achieve optimal route at different rate.

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