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The best route determination using nearest neighbor approach

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ABSTRACT

This research constitutes an application of heuristic optimization using the nearest neighbor (NN) method. It is a method used to design a route based on the next closest distance. The case here is the garbage freight of Yogyakarta City which becomes one of the Environmental Services Department duties. The sector of this research object is Malioboro-Kranggan because it has the highest number of TPS locations. There are 34 TPS locations, and 2 depots with an average volume of total garbage are 197 m^3/day. Several alternative routes have resulted because the same distance was found when deciding the next distance (TPS 26 and TPS 31). The best alternative was determined based on the best scenario parameter of total mileage and operational time. The first scenario chose the garbage volume that is close to the remaining capacity, meanwhile, the second scenario chose the smallest garbage volume. At TPS 27, an alternative with the same closest distance appeared again (TPS 15 and TPS 18). Hence, the whole algorithm results in four alternative decisions. The first alternative results 13.59 hours as the total time and 40.092 km as the total distance, the second results 13.50 hours with 40.315 km, the third results 13.57 hours with 41.393 km, and the fourth results 13.803 hours with 40.41 km. The best alternative goes to the first alternative based on the parameter set before. It means that the scenario taken is by choosing the TPS with the closest remaining volume of the vehicle.

1. Introduction

One of the Environmental Services Department (ESD) duties of Yogyakarta City is freighting garbage. The sector of this research object is Malioboro-Kranggan, which constitutes a sector with the highest number of locations that are 34 garbage dump locations (TPS) and 2 depots with an average volume of total garbage is 197 m^3/day. At the moment, ESD is operating 6 vehicles of garbage hauler. In the operation of those six vehicles, there is an unequal workload that happened to those vehicles. There is a vehicle that must finish the job two hours slower than others. This situation emerges envy among the drivers. Table 1 shows the locations of 34 TPS and 2 depots which become the working area of Malioboro-Kranggan sector. Meanwhile, Figure 1 shows the matrix of the distance between TPS locations. The location and matrix were taken from Google Maps.

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Table 1. The Locations of Garbage Dump (TPS) Sector Malioboro-Kranggan

No	Name of TPS	Volume (m^3)	Longitude Coordinate
1.	TPS Tegalrejo	2	S 07°47'14.58", E 110°21'06.20"
2.	TPS Wongsodirjan	24	S 07°47'16.50", E 110°21'38.53"
3.	TPS Jl. Am Sangaji	1	S 07°46'55.35", E 110°21'57.18"
4.	TPS Bangunrejo 01	2	S 07°46'33.16", E 110°21'06.92"
5.	TPS Bangunrejo 02	2	S 07°46'32.11", E 110°21'07.34"
6.	TPS Bangunrejo 03	2	S 07°45'24.34", E 110°21'12.27"
7.	TPS Bangunrejo 04	2	S 07°46'51.117", E 110°21'06.74"
8.	TPS Kricak 01	4	S 07°46'27.98", E 110°21'35.89"
9.	TPS Kricak 02	4	S 07°46'28.81", E 110°21'36.80"
10.	TPS Jati	24	S 07°47'09.19", E 110°21'31.06"
11.	TPS Gowongan	2	S 07°47'06.85", E 110°21'52.21"
12.	TPS Gedongtengen 01	2	S 07°47'21.68", E 110°21'35.15"
13.	TPS Gedongtengen 02	2	S 07°47'21.23", E 110°21'35.07"
14.	TPS Gedongtengen	2	S 07°48'12.80", E 110°21'18.59"
15.	TPS Rw 11 Bener	3	S 07°46'36.72", E 110°21'25.59"
16.	TPS Rw 04 Bener	2	S 07°46'35.61", E 110°21'24.44"
17.	TPS North Serangan	4	S 07°47'58.57", E 110°21'20.95"
18.	TPS South Serangan	3	S 07°48'03.39", E 110°21'19.91"
19.	TPS Sitisewu 01	8	S 07°47'18.81", E 110°21'46.03"
20.	TPS Kedaulatan Rakyat	1	S 07°47'07.66", E 110°22'00.47"
21.	TPS West Sarkem	4	S 07°47'23.81", E 110°21'44.54"
22.	TPS Gondolayu	2	S 07°47'01.98", E 110°22'11.74"
23.	TPS Kleringan 03	2	S 07°47'08.25", E 110°22'03.36"
24.	TPS Sitisewu 02	8	S 07°47'19.38", E 110°21'51.99"
25.	TPS Kleringan 02	2	S 07°47'11.94", E 110°22'02.31"
26.	TPS East Sarkem	4	S 07°47'23.71", E 110°21'55.83"
27.	TPS Pasar Senin	4	S 07°47'44.26", E 110°21'40.84"
28.	TPS Kleringan 01	2	S 07°47'19.46", E 110°22'03.28"
29.	TPS UPT Malioboro	6	S 07°47'29.27", E 110°21'57.78"
30.	TPS Pathok Market	2	S 07°47'48.99", E 110°21'45.42"
31.	TPS DPRD	1	S 07°47'32.94", E 110°21'58.25"
32.	TPS Inna Garuda	2	S 07°47'28.18", E 110°22'03.17"
33.	TPS Gedung Agung	6	S 07°47'57.32", E 110°21'46.44"
34.	TPS Kepatihan	8	S 07°47'43.81", E 110°22'04.62"
35.	Makam Utoroloyo Depot	24	S 07°46'59.33", E 110°21'19.71"
36.	Pringgokusuma Depot	24	S 07°47'29.97", E 110°21'25.92"
	ESD of Yogyakarta City	-	S 07°46'73.2", E 110°23'16.77"
	Final location of garbage dump Piyungan	-	S 07°52'10.82", E 110°25'43.36"
	Total amount of garbage volume	**197**	

Figure 1. The Matrix of Distance between TPS Locations in Malioboro-Kranggan Sector

Tempat	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	X
0		5	5,2	3,2	4,1	5,2	7	5,6	4,4	4,5	3,8	3,5	4,4	4,4	6	4,6	4,8	6,6	4,2	4,1	3,1	3,8	2,5	2,7	4	2,7	3,8	4,9	2,9	3,8	4,7	2,8	3,7	4,5	3,2	4,1	4,6	14
1	5,2		1,8	2,6	2,3	1,9	5,7	2,3	3,1	1,8	2	3,1	1,6	1,6	2,4	2	1,1	3,8	0,8	2,3	2,8	1,9	3,4	3,4	2,3	3,4	2,2	3,5	2,5	2,8	3,3	3,7	3,3	3,5	3,7	0,8	1,1	17,3
2	3,4	2		1,4	1,6	3	4,9	3,3	2,4	0,95	0,55	0,85	0,75	0,75	2,9	2,9	0,85	4,2	1,5	0,55	1,5	1	1,8	1,6	0,55	1,6	0,95	2,8	1,4	1	2,6	1,9	1,5	2,7	1,9	1,5	0,7	16,2
3	3,1	2,5	1,3		0,95	4,8	5,5	2,8	1,8	2,2	1,3	0,65	1,9	1,9	4,1	1,7	2,1	4,6	1,7	1	0,4	1,8	0,6	0,85	1	0,85	1,7	2,9	1,1	1,8	2,7	2,1	1,6	2,8	1,8	1,7	2	16,3
4	4,1	2,2	1	0,95		2,3	3,6	2,6	1	1,9	0,75	1,6	1,7	1,7	3	1	2,1	4,4	1,4	1,6	1,3	1,9	1,9	2,2	1,6	2,2	2,2	3,2	2,4	2,7	3,1	3	2,5	3,5	3	1,4	1,6	16,3
5	5,5	2,1	2,5	2,5	2,2		5,6	0,45	1,4	2,9	2,7	3	2,7	2,7	4	0,75	2,8	5,4	1,6	3	2,8	3	3,3	3,9	3	3,9	3,2	4,3	3,8	3,8	4,1	4,4	4	4,5	4,4	1,6	2,6	18,9
6	5,5	5,6	4,4	4,3	3,6	5,9		5,8	4,6	4,7	4,2	3,7	4,6	4,6	5,2	4,8	5	6,6	4,4	5	4,7	5,3	5,3	5,5	5	5,5	5,6	6,6	5,8	6,1	6,4	6,3	5,9	6,9	6,3	4,6	4,6	19,7
7	5,8	2,2	2,8	2,8	2	0,45	5,9		1	3,2	3	3,3	3	3	4,3	1,1	3,1	5,7	2,7	3,3	3,1	3,3	3,6	4,4	3,3	4,4	3,5	4,6	4,1	4,1	4,4	4,7	4,3	4,8	4,9	2,7	2,9	18,1
8	4,6	2,9	1,9	1,7	1	1,4	2,7	1,7		2,7	1,6	2,4	2,5	2,5	3,8	0,65	2,6	5,2	1,8	2,4	2,2	2,7	2,7	3	2,4	3	3	4,1	3,2	3,5	3,9	3,8	3,3	4,3	3,8	1,8	2,4	17,1
9	3,9	1,4	0,95	2,1	1,8	2,8	5,2	3,1	2,7		1,2	2,8	0,2	0,2	1,8	2,6	0,55	3,1	1,8	1,1	2,4	0,45	2,8	2,6	1,1	2,6	0,7	0,5	2,4	0,7	0,9	0,8	2,3	2,2	2,3	1,8	0,35	15,4
10	4,4	1,8	0,55	1,7	0,8	1,7	4,8	2	2,2	1,4		2,2	1	1	2,6	2	1,3	3,9	0,9	1,1	1,9	1,5	2,4	2,2	1,1	2,2	1,7	2,8	1,9	2,2	2,6	2,5	2,1	3,3	2,5	0,9	1,1	15,9
11	3,4	2,1	0,85	0,65	1,6	3,1	5	3,4	2,5	1,8	1,6		0,95	0,95	2,9	2,4	1,7	4,3	2,1	0,35	0,27	0,5	0,95	1	0,35	1	0,4	2,3	0,85	0,45	2	0,75	0,65	2,2	1,4	2,1	1,5	14,8
12	3,4	1,2	0,75	1,9	1,6	2,6	5	2,9	2,5	0,2	1	0,95		0,004	2	2,4	0,7	3,3	1,6	0,9	2,2	0,26	2,2	2,4	0,9	2,4	0,55	0,7	2,2	0,8	2	1,9	1,4	1,8	1,8	1,6	0,5	15,2
13	3,4	1,2	0,75	1,9	1,6	2,6	5	2,9	2,5	0,2	1	0,95	0,004		2	2,4	0,7	3,3	1,6	0,9	2,2	0,26	2,2	2,4	0,9	2,4	0,55	0,7	2,2	0,8	2	1,9	1,4	1,8	1,8	1,6	0,5	15,2
14	5,2	2,4	2,2	3,3	3	4	6,4	4,3	3,8	2,2	2,4	3,8	2	2		3,8	1,2	1,6	3	2,7	3,5	2,3	4	3,8	2,7	3,8	2,6	1,7	3,5	2,3	1,6	3,7	3	2,4	2,5	3	1,4	14,9
15	4,8	2,2	1,8	1,7	1	0,75	3,6	1,1	0,65	2,7	1,6	2,4	2,4	2,4	3,8		2,6	5,1	1,1	2,4	2,1	2,7	2,7	2,9	2,4	2,9	3	4,2	3,2	3,5	3,8	3,8	3,3	4,3	4	1,1	2,4	17,3
16	4,4	1,1	0,85	2,1	1,7	2,7	5,1	3,1	2,6	0,55	1,1	2,6	0,7	0,7	1,2	2,5		2,6	1,7	1,5	2,4	0,95	2,8	2,5	1,5	2,5	1,3	0,65	2,3	2,6	1,3	2,9	2,3	1,8	1,8	1,7	0,19	14,9
17	6,6	3,9	3,5	4,9	4,3	5,4	7,7	5,7	5,1	3,5	3,7	5,1	3,4	3,4	1,6	5,3	2,6		4,3	4,1	4,9	3,6	5,3	5,1	4,1	5,1	3,9	2,8	4,9	3,6	2,8	5,4	4,2	3,7	3,7	4,3	2,8	13,3
18	4,4	0,8	1,5	1,5	1,4	1,5	4,6	1,8	2	1,7	0,9	2	1,5	1,5	2,8	1,8	1,6	4,2		2	1,8	1,8	2,3	3	2	3,1	2	3,1	2,8	3,1	2,9	3,4	3	3,3	3,4	0,11	1,4	16,8
19	4,1	2,8	0,55	1	3,4	4,5	6,5	4,8	3,9	1,1	2,6	0,35	0,9	0,9	3,6	3,9	2,3	5,3	3,5		0,6	0,65	1,3	1	0,18	1	0,35	1,3	0,8	0,4	2	0,7	0,65	2,1	1,4	3,5	2,2	14,7
20	3,2	2,4	1,2	0,4	1,9	3,3	5,3	3,6	2,7	2	1,9	0,27	1,8	1,8	3,2	2,7	2	4,6	2,3	0,6		1	0,65	0,9	0,6	0,9	0,65	2,5	1,1	0,75	2,3	1,7	0,95	2,4	1,7	2,3	1,8	15
21	3,1	1,5	1	2,2	1,9	2,9	5,3	3,2	2,7	0,45	1,3	0,75	0,26	0,26	2,3	2,7	0,95	3,6	1,9	0,65	1		2	2,2	0,65	2,2	0,29	0,65	1	0,5	1	0,8	0,7	2	1,6	1,9	0,75	14,7
22	3,5	2,9	1,8	0,6	1,5	3	4,9	3,3	2,4	2,6	1,5	0,95	2,4	2,4	3,8	2,3	2,5	5,1	2,2	1,8	0,65	2,1		0,26	1,8	0,26	2	3,2	0,45	2	3	2,3	1,9	3,1	2,3	2	2,3	15,7
23	3,2	3,2	2	0,85	1,8	3,2	5,1	3,5	2,6	2,1	1,8	1	1,9	1,9	3,9	2,6	2,6	5,3	2,2	1	0,9	1,1	0,26		1	0,12	1	2,5	0,2	1	2,3	1,6	1,2	2,4	1,6	2,2	2,4	15
24	0	2,98	0,55	1	3,1	4,3	6,5	4,6	3,9	1,1	2,6	0,35	0,9	0,9	3,6	3,9	2,3	5,3	3,2	0,18	0,6	0,65	1,3	1		1	0,35	1,3	0,8	0,4	2	0,7	0,65	2,1	1,4	3,2	3,2	14,7
25	3,2	3,2	2	0,85	1,8	3,2	5,1	3,5	2,6	2,1	1,8	1	1,9	1,9	3,9	2,6	2,6	5,3	2,2	1	0,9	1,1	0,26	0,12	1		1	2,5	0,2	1	2,3	1,6	1,2	2,4	1,6	2,2	2,4	15
26	2,8	1,8	0,9	2,1	2,2	3,1	5,6	3,4	3	0,75	1,6	0,4	0,55	0,55	2,6	3	1,3	3,9	2,1	0,35	0,65	0,11	1,7	1	0,35	1		0,95	0,75	0,23	1,9	0,5	0,45	2,1	0,9	2,1	1,1	14,6
27	3,8	1,9	1,6	2,7	2,4	3,4	5,7	3,7	3,2	0,5	1,8	3,2	0,7	0,7	1,9	3,2	0,65	3,3	2,3	1,3	2,9	0,65	2,6	2,9	1,3	2,9	0,95		3	0,9	0,35	0,9	1,1	7	1,5	2,3	0,8	14,6
28	2,9	2,8	2,2	1,1	2	3,4	5,4	3,7	2,8	1,9	2	0,85	1,6	1,6	3,7	2,8	2,4	5,4	2,4	0,8	1,1	0,85	0,45	0,2	0,8	0,2	0,75	2,3		1,5	2,1	1,1	0,9	2,2	1,4	2,4	2,2	14,8
29	3,8	2,1	1	2,9	2,5	3,5	5,9	3,8	3,4	0,7	1,9	0,45	0,8	0,8	2,4	3,3	1,2	3,6	2,5	0,4	0,75	0,35	2,8	1	0,4	1	0,23	0,9	0,8		0,9	0,28	0,45	1	0,7	2,5	1	14,2
30	3,6	2,3	1,9	3,1	2,8	3,7	6,1	4	3,6	0,85	2,1	3,7	1,1	1,1	2	3,5	1	3,2	2,7	2,5	3,3	1,1	3	3,2	2,5	3,2	1,3	0,35	3,3	0,55		0,9	1,1	0,35	0,9	2,7	1,2	14,2
31	2,9	2,3	2	2,8	2,8	3,7	6,1	4	3,6	0,85	2,2	0,75	1,1	1,1	2,9	3,5	1,9	4,3	2,7	0,7	2,8	0,8	2,3	2,6	0,7	2,6	0,5	0,9	1,1	0,28	0,9		0,15	1,7	0,4	2,7	1,7	14,1
32	3	2,2	1,8	2,8	2,6	3,6	6	3,9	3,4	1,2	2	0,65	1	1	3	3,4	1,7	4,4	2,6	0,65	0,95	0,55	1,4	2,4	0,65	2,6	0,45	1,1	0,9	0,45	1,1	0,15		1,5	0,45	2,6	1,5	14,2
33	4,2	2,6	2,1	3,4	3,1	4,1	6,5	4,4	3,9	1,2	2,5	3,9	1,5	1,5	1,7	3,9	1,4	3,1	3	2,8	3,6	1,4	3,3	3,6	2,8	3,6	1,6	0,7	0,7	0,7	0,35	2,7	1,9		1	3,1	1,5	14,5
34	3	2,6	2,2	2,5	3,1	4	6,4	4,4	3,9	1,6	2,5	2,8	1,4	1,4	2,5	3,8	2,2	3,9	3	2,8	2,6	1	2,1	2,3	2,8	2,3	0,9	2,1	2,5	0,7	0,9	0,4	0,45	1		3	2	13,3
35	4,5	0,8	1,5	1,5	1,4	0,4	4,6	0,2	2	1,7	0,9	2	1,5	1,5	2,8	1,8	1,6	4,2	0,11	2	1,8	1,8	2,3	2,6	2	2,6	2	3,1	2,8	3,1	2,9	3,4	3,1	3,3	3,4		1,4	16,8
36	4,2	1,1	0,7	1,9	1,6	2,5	4,9	2,8	2,4	0,35	1	2,4	0,5	0,5	1,4	2,3	0,19	2,7	1,5	1,3	2,1	0,75	2,6	2,3	1,3	2,3	1,1	0,8	2,1	2,2	1,5	2,7	2,2	1,9	2	1,5		16
X	13,3	16,3	16,4	15,3	16,2	18,5	19,6	16,8	17,1	14,9	16,5	15,6	14,9	14,9	14,3	17	15,1	13,5	16,7	16,5	15,4	14,6	14,9	15,1	16,5	15,1	14,3	14,2	15,3	14,7	14,2	14,7	13,9	14	13,4	16,7	15,3	

2. Literature Review

Many types of research have been conducted to determine a route or vehicle track of goods distribution. The quantity of solution methods presented in the academic literature has become quickly over the previous decades (Braekers et al. 2015). Several route determinations that have been conducted before are by Fatharani et al. (2013), Muriani (2014), Kurniawati (2015), Cici and Hari (2015), Pan et al. (2020), and Luo et al. (2020). The approach used in those four papers is the nearest neighbor. The results gained to show significant results since they lead to better performance than before. The nearest neighbor method constitutes a heuristic optimization approach. The nearest neighbor is a method used to design a route based on the next closest distance. This method was also applied to classify a scholarship just like what has been conducted by Sumarlin (2015). Furthermore, Luo et al. (2020) applied two nearest neighbor classifiers for categorical data classification.

There were several steps conducted in the application of the nearest neighbor method. Those steps were adopted from Fatharani et al. (2013) by following these eleven steps:

a. Step 1

Determine the loads on the vehicle (Q) = 0 $mm3$. For the first route (k = 1) in the first trip (t = 1), starting location at depot (0).

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b. Step 2

Choose a customer destination that is closest to the starting location. If all customers are already chosen, go to step 11.

c. Step 3

Count loads of the vehicle ($Q = Q + di$).

d. Step 4

If Q < Maximum capacity of vehicle (Qmax), go to step 5. If $Q = Qm$ax, go on to step 7. If $Q > Qm$ax, continue to step 8.

e. Step 5

Count the route completion time (C) according to equation (2.12). If $C \leq$ maximum time of vehicle (Tmax), go on to step 6. If $C > Tm$ax, continue to step 10.

f. Step 6

Set the chosen customers as the starting locations, then repeat step 2.

g. Step 7

Count C. If $C \leq Tm$ax, go on to step 9. If $C > Tm$ax, continue to step 10.

h. Step 8

Cancel the selection of the last customer, and then choose another unselected customer which is closest to the starting location and continue to step 3. If none of all customers deserve, go on to step 9.

i. Step 9

The vehicle is heading to an intermediate facility (X) to load or unload the goods. Set a new trip ($t = t + 1$) with X as the starting location, and then repeat step 1.

j. Step 10

Cancel the selection of the last customer, and then go back to step 1 to set a next route ($k = k + 1$).

k. Step 11

If all customers are already selected, so the route determination is also done.

3. Research Methodology

The stages of research are presented in a flowchart as seen in Figure 2. The data were taken from cases in ESD, meanwhile, the method used was the nearest neighbor. For the steps of the method, they were adopted from the steps conducted by Fatharani (2013) and the algorithm flowchart of the nearest neighbor shown in Figure 3.

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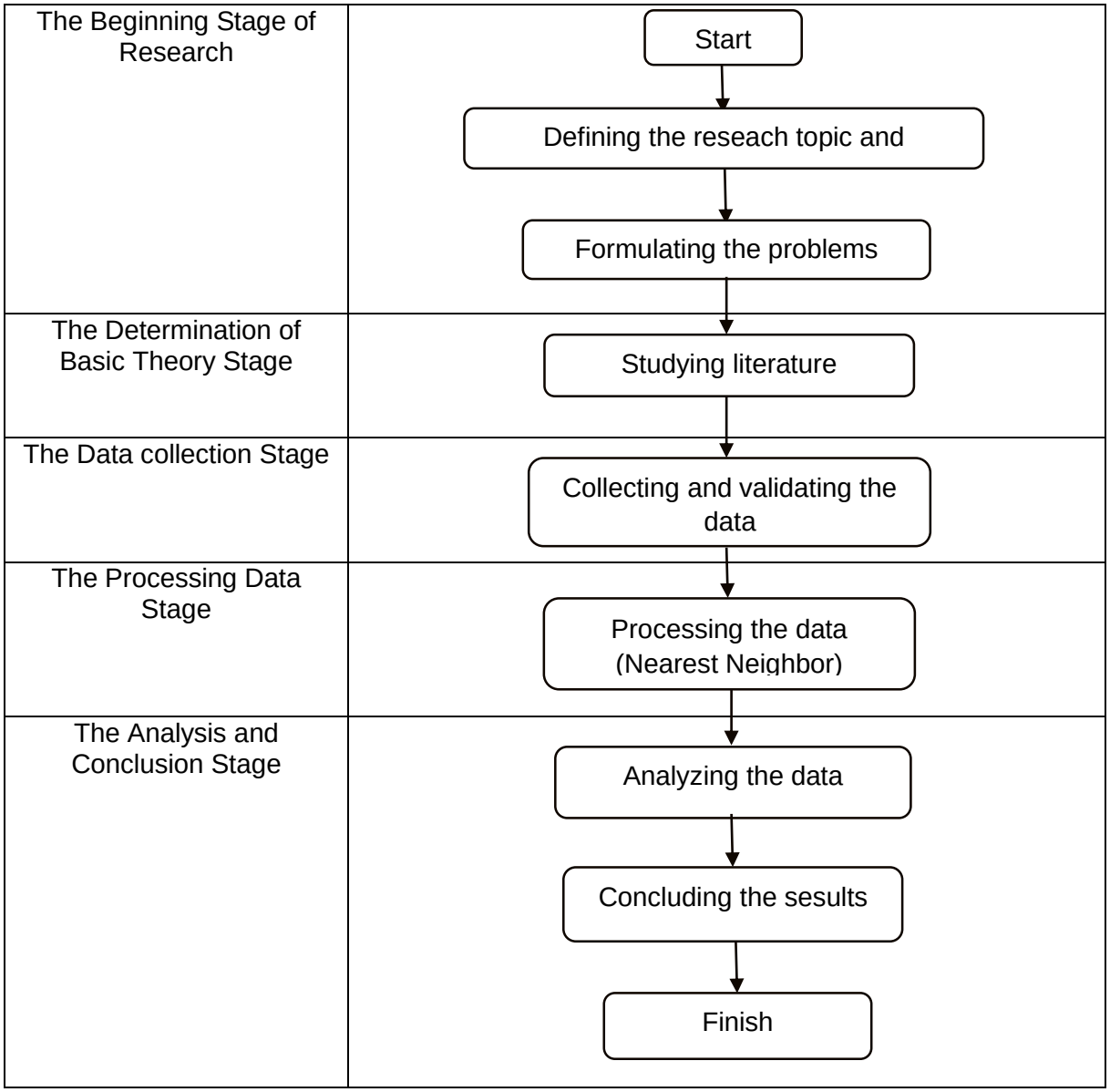

Figure 2. The Research Flowchart

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4. Results and Discussion

The best route determination constitutes a route with the shortest total distance and the smallest total time. The shortest total distance will be closely related to the operational cost, especially fuel cost which oppresses ESD. The smallest total time will then be related to the working hours of ESD, so it is expected that the workload of all operating vehicles will be more balanced.

The completion using the nearest neighbor leads to a solution finding that is much faster. After applying an initial condition, selecting the closest TPS is conducted, and then calculating the remaining capacity of the vehicle. Selecting the closest TPS is conducted once again, if there is still a space of the remaining capacity, and keep going on and on until the remaining capacity of the vehicle is zero. The steps are reflected in Figure 3.

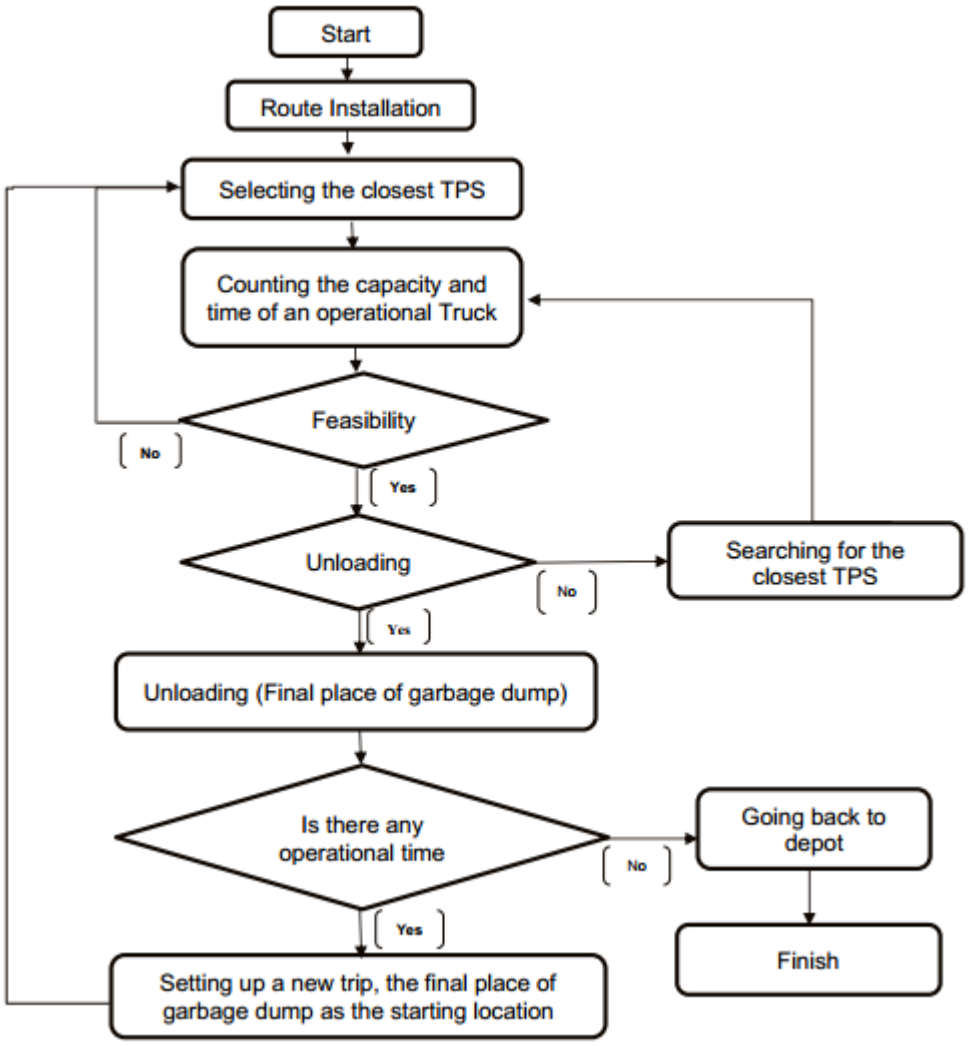

Figure 3. The Methodology of Route Determination

In the process of searching the garbage freight cases in ESD of Yogyakarta City, there is actually a possibility for several TPS locations having the equivalent shortest distance. Table 2 shows the counting results of the nearest neighbor algorithm for the cases in ESD Yogyakarta. In Table 2, route row reflects the route of each vehicle in Malioboro-Kranggan area. For that area, ESD allocates 6 hauling vehicles, which are determined by I, II, III, IV, V, and VI.

Table 2. The Counting Results of Nearest Neighbour

		Alternative I			Alternative II			Alternative III			Alternative IV		
		iteration	Dist	Time	Route	Dist	Time	Route	Dist	Time	Route	Dist	Time
Route	I	0 - 22 - 23 - 25 - 28 - X X - 34 - X X - 17 - 14 - 16 - X X - 32 - 26 - 11 - X - 0	1,9805	6,17075	0 - 22 - 23 - 25 - 28 - X X - 34 - X X - 17 - 14 - 16 - X X - 32 - 31 - 26 - 20 - X - 0	2,028	6,642	0 - 22 - 23 - 25 - 28 - X X - 34 - X X - 17 - 14 - 16 - X X - 32 - 31 - 26 - 20 - X - 0	2,028	6,642	0 - 22 - 23 - 25 - 28 - X X - 34 - X X - 17 - 14 - 16 - X X - 32 - 26 - 11 - X - 0	1,9805	6,17
	II	0 - 31 - 29 - 20 - X X - 33 - 30 - X X - 21 - 12 - 13 - X X - 9 - 7 - 5 - X - 0	2,1382	6,40735	0 - 9 - 11 - 21 - X X - 33 - 30 - X X - 27 - 9 - X X - 29 - 12 - X - 0	2,023	6,135	0 - 9 - 11 - 21 - X X - 33 - 30 - X X - 27 - 9 - X X - 29 - 12 - X - 0	2,0233	7,175	0 - 31 - 29 - 20 - X X - 33 - 30 - X X - 21 - 12 - 13 - X X - 9 - 7 - 5 - X - 0	2,13823	6,4074
	III	0 - 3 - 4 - 8 - X X - 36 - X X - 36 - X X - 36 - X - 0	2,1975	6,39625	0 - 10 - X X - 13 - 1 - 18 - X X - 36 - X X - 36 - X - 0	2,16	6,24	0 - 10 - X X - 13 - 1 - 18 - X X - 36 - X X - 36 - X - 0	2,16	6,24	0 - 3 - 4 - 15 - X X - 36 - X X - 36 - X X - 36 - X - 0	2,23417	6,5513
	IV	0 - 10 - X X - 27 - 15 - X X - 1 - 18 - 6 - X X - 2 - X - 0	2,3283	6,4925	0 - 10 - X X - 36 - X - 0 X - 4 - 8 - 5 - X X - 2 - X - 0	2,243	6,565	0 - 10 - X X - 36 - X - 0 X - 4 - 15 - 5 - X X - 2 - X - 0	2,2325	6,54875	0 - 10 - X X - 27 - 18 - X X - 2 - X X - 2 - X - 0	2,195	6,3925
	V	0 - 10 - X X - 2 - X X - 2 - X X - 2 - X	2,18	6,47	0 - 10 - X X - 2 - X X - 2 - X 0 - 24 - X	2,147	6,42	0 - 10 - X X - 2 - X X - 2 - X 0 - 24 - X	2,1467	6,42	0 - 10 - X X - 2 - X X - 10 - X X - 19 - X	2,15667	6,435
	VI	0 - 24 - X X - 35 - X X - 35 - X X - 35 - X X - 19 - X - 0	2,77	8,155	0 - 19 - X X - 35 - X X - 35 - X X - 35 - X - 0 X - 15 - 7 - 6 - X	2,942	8,3125	0 - 19 - X X - 35 - X X - 35 - X X - 35 - X - 0 X - 8 - 7 - 6 - X	2,9783	8,3675	0 - 24 - X X - 35 - X X - 35 - X X - 35 - X X - 8 - 6 - X - 0	3,09833	8,45
Total			13,595	40,09185	Total	13,54	40,3145	Total	13,569	41,3933	Total	13,8029	40,406

Several types of research that have become the references do not have any conditions as found in the ESD cases here. The load capacity at locations with the same distance is sometimes the same, or sometimes different in each iteration. This research tries to figure out the effects resulted from the locations with the same distance and have the same load capacity of garbage with those which have a different load capacity of garbage.

Reviewing vehicle 1 at TPS 32, there are two alternative decisions come up for the next TPS: TPS 26 and TPS 31. Therefore, making the scenario was needed to find the best decision. Two scenarios were set, the first scenario chose the TPS with the garbage volume reaching the remaining capacity of the vehicle, meanwhile, the second scenario chose the TPS which had the smallest volume of garbage. The results of those scenarios application are shown in column Alternative I and Alternative II.

Reviewing the vehicle IV as well, for the second scenario (choosing the TPS that had the smallest volume of garbage) when arriving at TPS 27, there are also two alternative decisions showing up; those are TPS 15 and TPS 18. TPS 15 has resulted from the first scenario decision, meanwhile, TPS 18 has resulted from the application of the second scenario. The results of the application can be seen in Table 2, column Alternative I and Alternative IV. The total alternative distance I is 13.5 km, meanwhile, on alternative distance II is 13.8 km. It means that the first scenario is better than the second scenario.

On the alternative I, the route I, in the fourth iteration from TPS 32 to the next TPS, it is found the same distance between TPS 26 and TPS 31. Therefore, it causes two alternative completions as well. Those alternatives are alternative I and alternative II. The total distance of alternative I is 13.59 km, meanwhile, the total time is 40.09 hours. On the other hand, the total distance of alternative II is 13.54 km and 40.31 hours as the total time. In the next iteration, on the alternative I, there are also found two alternative TPS locations that have the same distance. To be exact, on route IV, in the second iteration from TPS 27 to the next TPS, it is found the same distance between TPS 15 and TPS 18. So that, the utterance for an alternative that passes through TPS 15 is still called as alternative I. On the other hand, an alternative that passes through TPS 18 is called as alternative III. Besides, on alternative II it is also found the same distance which then resulted in alternative IV. To be exact, on route IV, in the third iteration from TPS 4 to the next TPS, it is found the same distance between TPS 8 and TPS 15.

5. Conclusion

The best decision in selecting the route of hauling garbage is by using the indicator of the shortest distance and the smallest total time. When it is found that several TPS locations have the same distance, then the first scenario is needed to apply. It is by choosing the TPS with the volume of garbage almost reaching the remaining capacity of the vehicle.

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