Path Selection of Garbage Truck using A* Algorithm and Population Density Score

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Abstract

The high growth of urban population and the increasing of development activities in various sectors caused various problems in urban areas such as slums and garbage. Based on data from the Settlement and Spatial Office of Tegal City, in 2015 there are about 600 m3 of Garbage per day transported from TPST to TPA. In the process of transporting garbage only focuses on finding the shortest path but do not pay attention to the comfort of the residents who are in one of the garbage truck routes. The purpose of this research is to search the shortest path and avoid path that have too many civilian activity from a TPST track to TPA Mataram, Tegal City . A* algorithm is used to search the shortest path and avoid path that have too many civilian activity of garbage truck in Tegal City.The calculation begins by creating a network graph of garbage transport first. TPST, TPA and intersection as nodes and roads connect between nodes as edge. After the network is formed, then the matrix is based on the population density of each neighboring node on the network and performs the calculation process using the A * algorithm to obtain the path matrix value with the corresponding population density between each optimum point. Implementation of this algorithm is done in Tegal City because there is no exact route in the process of transporting garbage from TPST to TPA. The A * algorithm is used in this case because in the process of tracking algorithm A * using heuristic value, so that in route selection can be produced an accurate route. In this case the result to be achieved is the optimum route by minimizing through the crowded lanes

Keywords: A*, node, path, TPST, TPA, intersection ,garbage transport, population density.

1. Introduction

Everyday, people produce lots of trash from their activities. Trash is any substance which is discarded after primary use, or it is worthless, defective and of no use. These trashes or garbage are produced everyday in every region in the world. Hence, all region must have a TPS. Tegal city has 27 villages in 4 subdistricts and there is 600 m3 of trash pile that must be delivered daily from 12 TPST and 56 TPS to TPA every day. In the process, each truck transports garbage from two to seven TPS/TPST every day and each villages have a TPS[1]. Each city usually has 1 TPA. To carry the garbage from TPS to TPA, a particular vehicle is used, called garbage truck. There are many systems have been used to carry garbage from TPS to TPA. Garbage truck driver in major cities usually pick the fastest route and drive through populated area, which could caused discomfort for the citizen. This issue happens because the truck driver in many cities does not have a map showing the best route to transport garbage. By selecting routes only from the shortest path, the truck driver could drive past the civilian area and make them uncomfortable .

The smells of the garbage in the garbage truck is very bad and the water that the garbage produce can make people uncomfortable. Therefore, it is important for the truck driver to know the most best route selection without driving past areas that have too much civilian activity. To resolve the problem, an application that can help the driver to choose the shortest path without driving past areas with too much civilian activities can be developed. A* algorithm can be used to develop such application, because it calculates the shortest path from on place to another. In this project, researcher will use the A* algorithm not only to find the shortest path, but also to avoid path that have too many civilian activities. Beside A* algorithm, Researcher will also use GIS to identify the coordinates of the TPA and TPS that help the researcher calculate the distance of one place to another. A* is one of the most efficient and outperforms other classic shortest path algorithms when spatial coordinates are present in the database[2].

2. literature review

2.1. A* Algorithm

A* is a best-first, graph search algorithm that finds the least-cost path from a given initial node to one goal node (out of one or more possible goals). The algorithm traverses various paths from start to goal. For each node x traversed, it maintains 3[3].

- g(x): the actual shortest distance traveled from initial node to current node
- h(x): the estimated (or ”heuristic”) distance from current node to goal
- f(x): the sum of g(x) and h(x)

The Algorithm start with initial node. The lower f(x) for a given node x, the higher its priority. At each step of the algorithm, the node with the lowest f(x) value is removed from the queue. The f and h values of its neighbors are updated accordingly, and these neighbors are added to the queue. The algorithm continues until a goal node has a lower f value than any node in the queue (or until the queue is empty). (Goal nodes may be passed over multiple times if there remain other nodes with lower f values, as they may lead to a shorter path to a goal.) The f value of the goal is then the length of the shortest path, since h at the goal is zero in an admissible heuristic. If the actual shortest path is desired, the algorithm may also update each neighbor with its immediate predecessor in the best path found so far; this information can then be used to reconstruct the path by working backwards from the goal node. Additionally, if the heuristic is monotonic (see below), a closed set of nodes already traversed may be used to make the search more efficient[3].

2.2. GIS(Geografic Information System)

2.2.1. Points

Point is a 0 dimensional object and has only the property of location (x,y). Points can be used to Model features such as a well, building, power, pole, sample location .Other name for a point are vertex, node

2.2.2. Lines (polyline)

Line is a one-dimensional object that has the property of length. It can be used to represent road, streams, faults, dikes, maker beds, boundary, contacts. Line are also called an edge, link, chain, arc.

2.2.3. Areas(polygon)

Polygon is a two-dimensional object with properties of area and perimeter. It can represent a city, geologic formation, dike, lake, river. Other name of polygon is face, zone

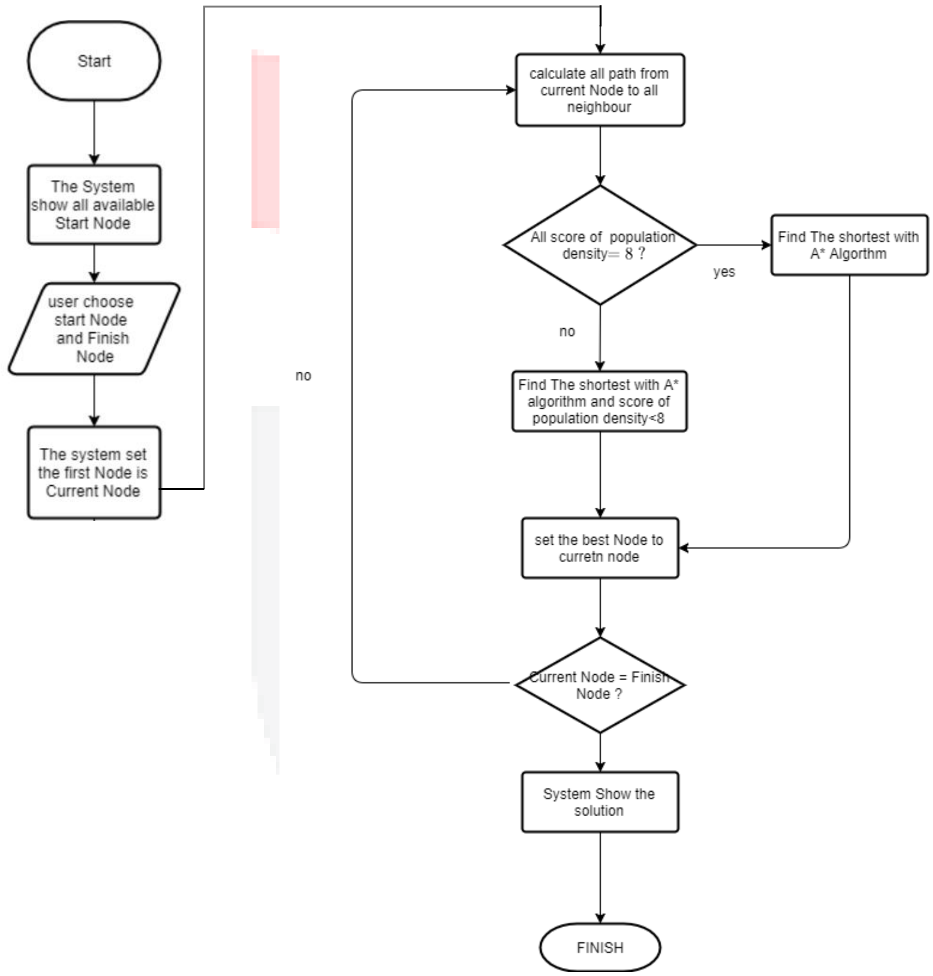
2.2.4. Euclidean Distance

Euclidean Distance can use To find distance between to point use longitude and latitude . The formula from Euclidean Distance[4] :

$$n = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2} \qquad (1)$$

n : Distance
x_1 : Coordinate latitude point 1
x_2 : Coordinate latitude point 2
y_1 : Coordinate longitude point 1
y_2 : Coordinate longitude point 2

2.3. Flowchart



This is the explanation of the flowchart

1. System show all the available start Node in this phase, this System will be show all the Available TPST.
2. User choose the Start Node and finish Node In this phase the driver choose the start Node and finish node that the driver need.
3. calculate all path from current node to all neighbor. In This phase System put all neighbor from current node into open Node
4. all score all population density = 8 ?

   If yes :

   a. System find shortest path from all open node System find the shortest path from all open node

   If no :

   a. System find shortest path with score of population density < 8 from all open node
5. Set the best node to current node in this phase the system will be put the best node that have shortest score into close node and the best node set to current node
6. current node = finish node ?

   If yes :

   a. system show the solution In this phase the system show all solution path in close node.

   If no :

a. calculate all path from current node to all neighbor. In this phase the system has not find the solution, so back to phase 4.

3. Results and Discussion

3.1. Scale of Population Density

Table 1. Scale of population density[16]

No	Population density per km^2	Score
1.	< 500	1
2.	500 – 1249	2
3.	1250 – 2499	3
4.	2500 – 3999	4
5.	4000 – 5999	5
6.	6000 – 7499	6
7.	7500 – 8499	7
8.	>8500	8

3.2. Data of Population Density

Table 2 Shows data of population density score in city tegal and has added score of population density based on table 1.

Table 2. Data of population density in tegal city

No	Urban Village	Total Population per km^2	Score
1.	Kalinyamat Wetan	4430	5
2.	Bandung	8841	8
3.	Debong Kidul	14620	8
4.	Tunon	7601	7
5.	Keturen	6906	6
6.	Debong Kulon	6242	6
7.	Debong Tengah	11509	8
8.	Randugunting	12467	8
9.	Kejambon	13844	8
10.	Slerok	11223	8
11.	Panggung	13024	8
12.	Mangkukusuman	10023	8
13.	Mintaragen	11049	8
14.	Pesurungan Kidul	6965	6
15.	Debong Lor	6613	6
16.	Kemandungan	6539	6
17.	Pekauman	7963	7
18.	Kraton	11574	8
19.	Tegalsari	10488	8
20.	Muarareja	698	2
21.	Kaligangsa	3606	4
22.	Krandon	3675	4
No	**Urban Village**	**Total Population per km^2**	**Score**
23.	Cabawan	3398	4
24.	Margadana	4915	5

25.	Kalinyamat Kulon	2928	3
26	Sumurpanggang	6621	6
27.	Pesurungan Lor	2777	3

The map in figure 2 is based on population density data in table 2. Lines in areas with a population density of 8 are colored red while the paths in areas with a population density of less than 8 are colored iru. Black truck icon represents tpst while red truck icon represents tpa. To another point represents an intersection

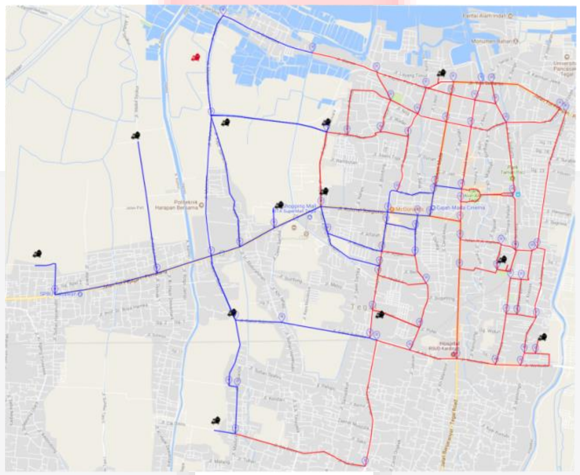


Figure 1. Road network

3.3. Results of Path selection Process using A* with population density score

Table 3. Result

No	First node	Path	Distance	Red Distance
1.	TPST Mulya jaya	Jl. banda Aceh-Jl. Pantura-Jl. mataram	4.972	0
2.	TPST Al hikmah	Jl. gatot subroto-Jl. mataram	3.153	0
3.	TPST fajar jaya	Jl Abdul Syukur-Jl. Pantura-Jl. mataram	4.678	0
4.	TPST rapi jaya	Jl. PendidikanJl. PanturaJl. kapt simandikunJl. mataram	3.108	0
5.	TPST sejahtera mandiri	Jl. SipelemJl. PanturaJl. kapt simandikunJl. mataram	3.563	0.155
6.	TPST bersama kita maju	Jl. Sawo barat-Jl. Sawo BaratJl. mataram	2.147	0
7.	TPST bandeng sari	Jl. bandengJl. Kapten Piere Tendean-Jl. belanak-Jl. Brawijaya-Jl. mataram	3.553	1.701
No	First node	Path	Distance	Red Distance
8.	TPST Melati Jaya	Jl. wijayakusumaJl. melati-Jl. RA kartiniJl.tegalcilacapJl. jend sudirman-Jl.	6.383	1.624

		gajahmadaJl. PanturaJl. kapt simandikunJl. mataram		
9.	TPST sumbodro	Jl. sumbodro-Jl. werkudoro-Jl. KS tubunJl. gatot subroto-Jl. mataram	7.248	2.287
10.	TPST arum karya	Jl. arumJl. Kapt sudibyoJl. gatot subroto-Jl. mataram	5.328	0.46
11.	TPST bahari asri	Jl. cikditroJl. Ir juanda-Jl. ir juanda-Jl. ir juandaJl. gatot subroto-Jl. mataram	5.239	0
12.	TPST keminclong	Jl. Sawo Barat-Jl. mataram	0.814	0

3.4. Difference path using A* algorithm with population density score, A* algorithm without population density score and Driver

To see if Algorithm A * combined with population density score can minimize or avoid paths with a population density score more than 8 evaluated by inputting result of the path selection process using A * with population density score into the case study. The results of the difference distance graph can be seen in figure 2. No is the number of route that the garbage truck choose and distance is the distance that the garbage truck choose.

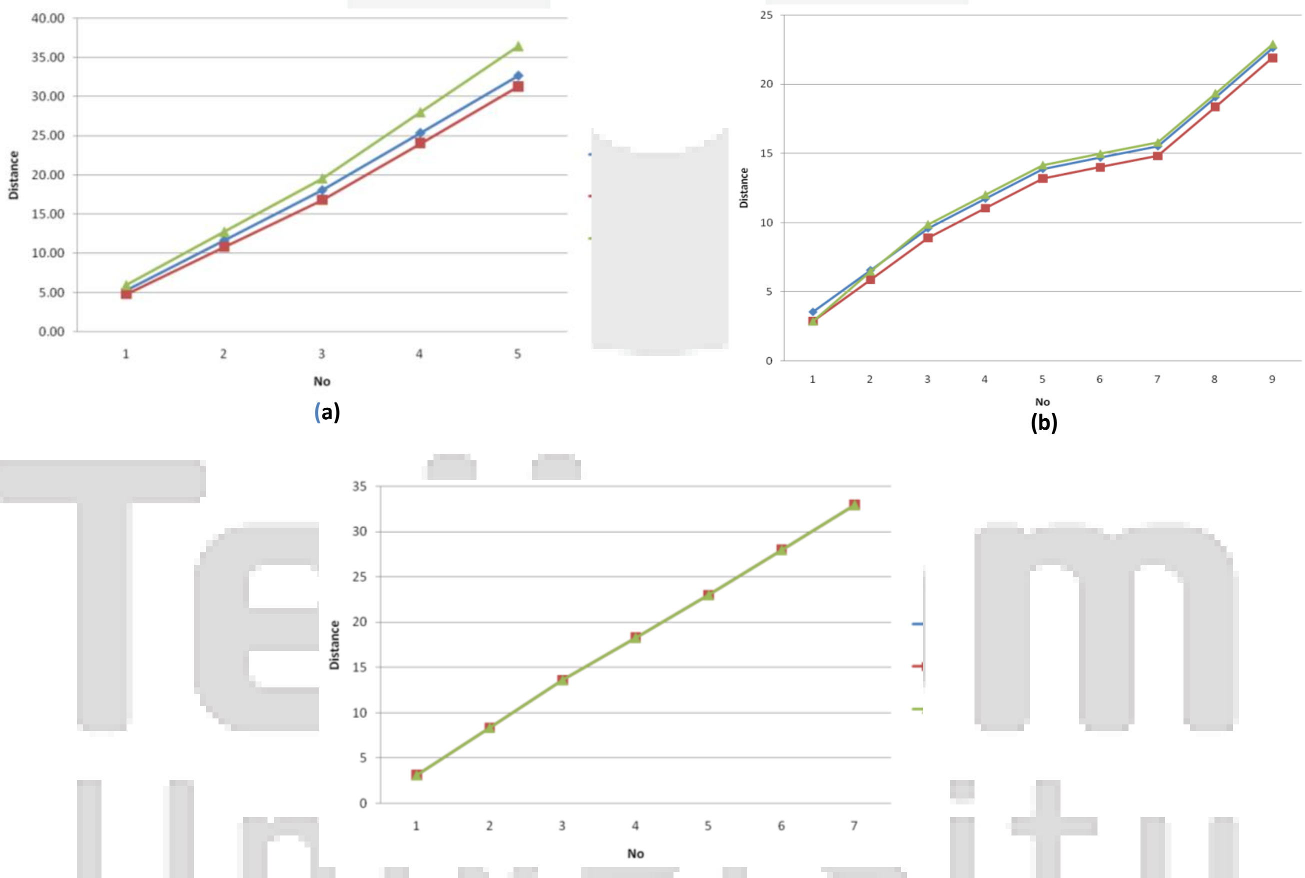


Figure 2 (a) Graph distance in case that all TPST is on the area with population density score = 8. (b) Graph distance in case with several tps within the area with a population density score = 8. (c) Graph distance in case that all TPST is on the area with population density score < 8.

The blue line is the graph for A* algorithm with population density score, The red line is the graph for A* algorithm without population density score and the green line is the graph for distance based on the path that the driver choose. The results of the evaluation shown in Figure 2 (a) and 2 (b) can be seen the A * algorithm with the population density score does not always choose the shortest path as generated by the A* algorithm without the population density score. This is because the A * Algorithm with the population density score in this case will find the fastest path to exit the red area and after that the A * Algorithm with skorket density will not pay attention to paths with a population density score over 8 . In figure 2(c) A* algorithm with or without population density score and path by the driver choose the same path . But the A * algorithm with population density scores can minimize the use of paths with population density scores = 8 can be seen in Graph figure 3(a) and 3(b)

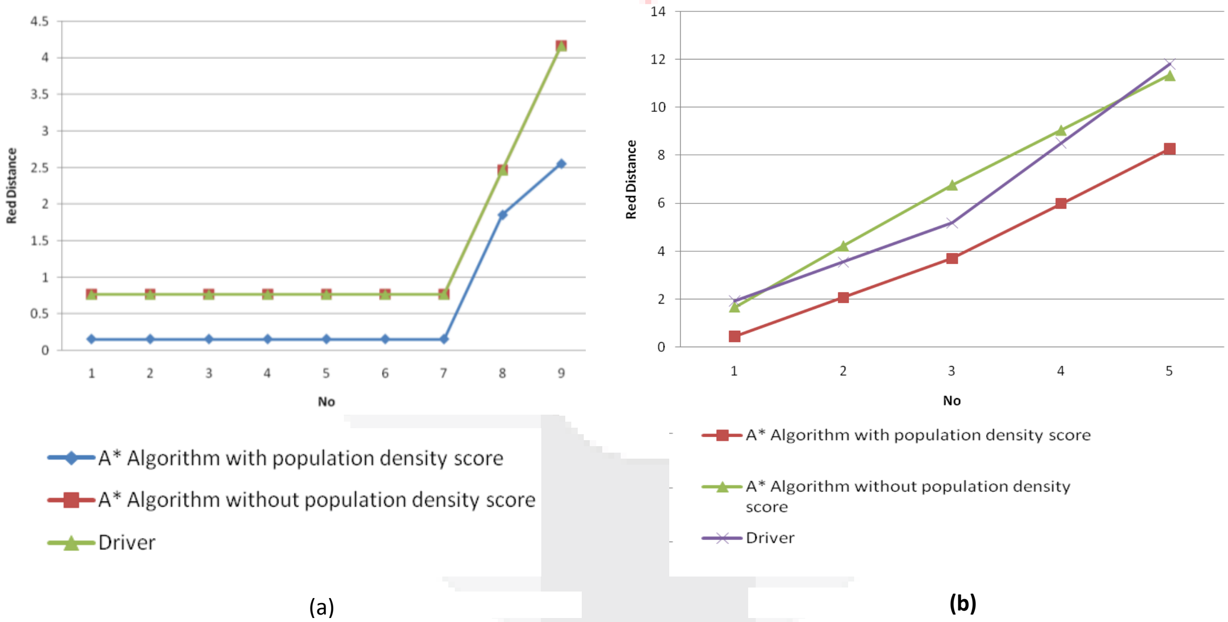


Figure 3 (a) Graph red distance case that all TPST is on the area with population density score = 8. (b) Graph red distance case with several TPST within the area with a population density score = 8.

4. Conclusion

1. TPST in area with population density score < 8 A* algorithm with population density score always choose shortest path like A* algorithm without population density score
2. TPST in area with population density = 8 A* algorithm with population density score not always choose shortest path because A* algorithm with population density score must be find shortest path to exit area with population density score = 8
3. A * Algorithm with population density scores can find a path with shortest red paths than A* Algorithm without population density score and the path selected by garbage truck drivers

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