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The comparison between the nearest neighbor algorithm and the a-star algorithm to determine the optimal route for distributing napkin tissue

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Abstract
Distribution is a factor that greatly influences the success of a company in selling its products. PT. Medan Jutarasa is a company that operates in the napkin tissue industry and has a Distribution Center (DC) to supply products to distributors. Distribution of products to consumers requires appropriate planning and consideration of which route to use to obtain more time-efficient transportation costs. In the delivery process, the company experienced problems, especially in the distribution route. The Nearest Neighbor algorithm searches for customers to serve based on the shortest distance from the vehicle's last location for further distribution. Meanwhile, the A-Star algorithm finds the shortest path using minimum cost. This research aims to compare the Nearest Neighbor algorithm and the A-Star algorithm to determine the optimal route for distributing tissue napkins by PT. Millionaire Medan. Based on the research results, it was found that the route using the Nearest Neighbor algorithm was more optimal than the A-Star algorithm in the distribution of tissue napkins by PT. Millionaire Medan.

Keywords: Distribution, Graph, Nearest neighbor algorithm, A-star algorithm

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Introduction

Distribution significantly impacts a company's success in selling its products. It refers to the marketing activity that streamlines the process of delivering goods and services from producers to consumers, ensuring they are used appropriately based on their needs (Muhammad et al., 2017). Distribution includes both physical activities that we can see with the naked eye, such as storing and sending products, as well as non-physical functions in the form of information processing activities and services to customers (Rohandi et al., 2014). Distribution plays a very important role in ensuring the availability of products needed by the community (Sitepua & Putra, 2022).

PT. Medan Jutarasa operates in the tissue napkin industry. The company is located at Jl. Tanjung Morawa Km. 12, established in 2019. PT. Medan Jutarasa maintains a Distribution Center (DC) to supply products to distributors. Product distribution occurs via land transportation using trucks. To optimize transportation costs, careful planning is essential when distributing products to consumers. PT. Medan Jutarasa serves consumers across North Sumatra, with each vehicle having a limited capacity of 1625 bales of tissue.

In the delivery process, the company faces challenges, particularly related to the distribution route. PT. Medan Jutarasa serves 33 consumers in North Sumatra. Currently, product delivery occurs randomly, relying on the driver's and their companion's experience to choose routes. Unfortunately, this approach results in suboptimal distribution times, leading to excessive distances and higher fuel costs. To improve profitability, optimizing the distribution of goods is essential. This optimization involves considering shipping costs, transit time, and the appropriate distance (Perdana et al., 2020). Therefore, analyzing the shortest route for the distribution process becomes crucial. An approach to determining distribution routes is needed to obtain a good route (Hutasoit et al., 2014). Failure to achieve time efficiency can lead to consumer dissatisfaction, as desired or necessary goods may not arrive promptly. Ultimately, finding the shortest route involves identifying the shortest distance among available alternative travel routes (Wahyuni et al., 2022).

There are several methods for determining the optimal route. One such method is the nearest-neighbor approach, which identifies the shortest route between customers (Oktaviana & Setiafindari, 2019). The using of nearest neighbor algorithm is a heuristic method with the principle of adding the shop that is closest to the last visited shop (Koswara, 2018). By utilizing this algorithm, we can effectively serve consumers based on their proximity to the last location of the distributing vehicle in metric space (Suyudi et al., 2015). New routes are initiated in the same way if there are no feasible positions to place new customers (Prasetyo & Tamyiz, 2017).

The A-Star algorithm, designed for finding the shortest path with minimal cost, offers an optimal route in terms of time. The A-Star algorithm is an optimal and complete route search algorithm (Purnama et al., 2018). This algorithm minimizes the total path cost, and under the right conditions will provide the best solution in optimal time (Widodo et al., 2017). One defining characteristic of the A-Star algorithm is the creation of a 'closed list' to calculate the distance of one path, then save it and then calculate the distance of the other path (Hermanto & Dermawan, 2018). This list records adjacent regions that have undergone evaluation, calculating the distance traveled from the starting point to the estimated destination point. Conceptually, the A-Star algorithm operates with two lists: the 'open list,' which includes passable points, and the 'closed list,' which contains impassable points (Fernando et al., 2020). Functionally, the closed list prevents the algorithm from re-evaluating points it has already been processed, so the opportunity to be selected is closed (Dalem, 2018). The algorithm terminates when there are no more points in the open list or when the endpoint is reached.

Based on this, the researcher is interested in conducting research with the title "The Comparison between the Nearest Neighbor Algorithm and The A-Star Algorithm to Determine the Optimal Route for Distributing Napkin Tissue".

Methods

In this study, we will employ both quantitative evaluation research and a field study approach. The quantitative evaluation research focuses on assessing the effectiveness of a running system. Meanwhile, field studies involve collecting data by examining sources of information and gathering data from the objects under study. Specifically, we will compare the nearest neighbor algorithm and the A-Star algorithm to determine the optimal route for distributing napkin tissue by PT. Medan Jutarasa.

In this study, we utilize secondary data as our primary data sources. Specifically, we collect information related to agent areas, vehicles, and driver wages and assistance. These data were obtained from PT. Medan Jutarasa, situated at Jl. Tanjung Morawa Km. 12 in North Sumatra.

The data obtained is processed according to the nearest neighbor algorithm and the A-Star algorithm to determine the optimal route in the distribution of tissue napkins by PT. Medan Jutarasa. Then the results of the two algorithms are compared to determine the optimal route in the distribution of tissue napkins by PT. Medan Jutarasa.

Results

Based on the results of the Euclidean distance calculation, a distance matrix between customers and PT. Medan Jutarasa is obtained, which can be seen in Table 1.

Table 1. Distance Matrix

	0	**A**	**B**	**C**	**D**	**E**	**F**
0	0	6,4	7,4	9,3	9,7	8,4	10,1
A	6,4	0	2,9	3,8	4,1	3,3	4,9
B	7,4	2,9	0	6,1	6,3	5,9	7,2
C	9,3	3,8	6,1	0	0,4	0,9	1,1
D	9,7	4,1	6,3	0,4	0	1,4	0,9
E	8,4	3,3	5,9	0,9	1,4	0	1,7
F	10,1	4,9	7,2	1,1	0,9	1,7	0

To begin finding a route using the nearest neighbor algorithm, we first identify the starting point, which in this case is PT. Medan Jutarasa. Next, we locate the point with the smallest distance from the starting point. Based on the distance matrix, we find that point A is 6.4 km away. Finally, we combine these two points, and the resulting combination can be visualized in the following graph.

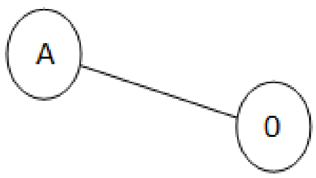

Figure 1. Graph 0-A

The last visited point A serves as the starting point. Next, it searches among the remaining points—namely B, C, D, E, and F—for the one with the closest distance to point A. Based on the distance matrix, point B is identified at a distance of 2.9 km. Finally, these points are combined, and the resulting combination can be visualized in the following graph.

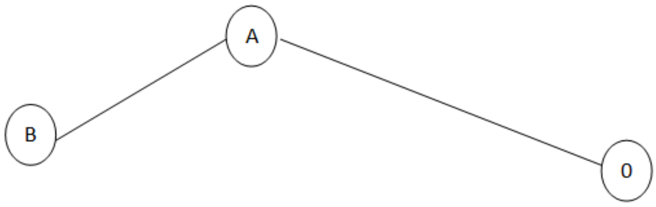

Figure 2. Graph 0-A-B

The last visited point B serves as the starting point. Next, it searches among the remaining points—namely C, D, E, and F—for the one with the closest distance to point B. Based on the distance matrix, point E is identified at a distance of 5.9 km. Finally, these points are combined, and the resulting combination can be visualized in the following graph.

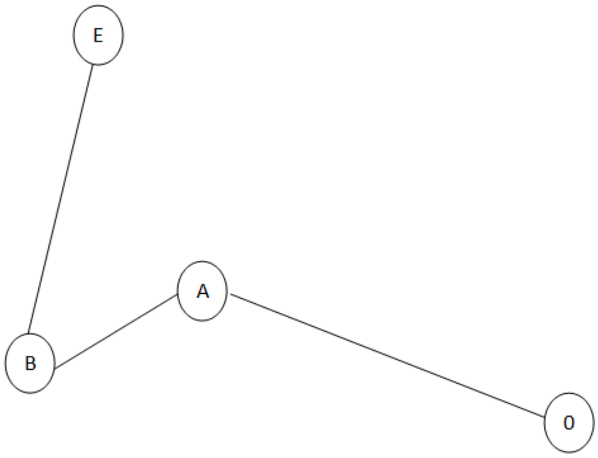

Figure 3. Graph 0-A-B-E

Starting from the last visited point E, we search for other points—specifically C, D, and F—that have not yet been selected. These points are chosen based on their proximity to the starting point E, as determined by the distance matrix. Point C, with a distance of 0.9 km from E, is then identified. Finally, we combine these points, and the resulting combination can be visualized in the following graph.

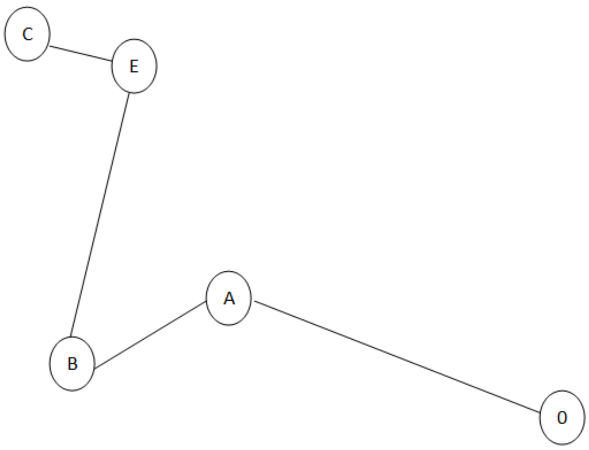

Figure 4. Graph 0-A-B-E-C

Starting from the last visited point C, we search for other points—specifically D and F—that have not yet been selected. These points are chosen based on their proximity to the starting point C, as determined by the distance matrix. Point D, located at a distance of 0.4 km from C, is then identified. Finally, we combine these points, and the resulting combination can be visualized in the following graph.

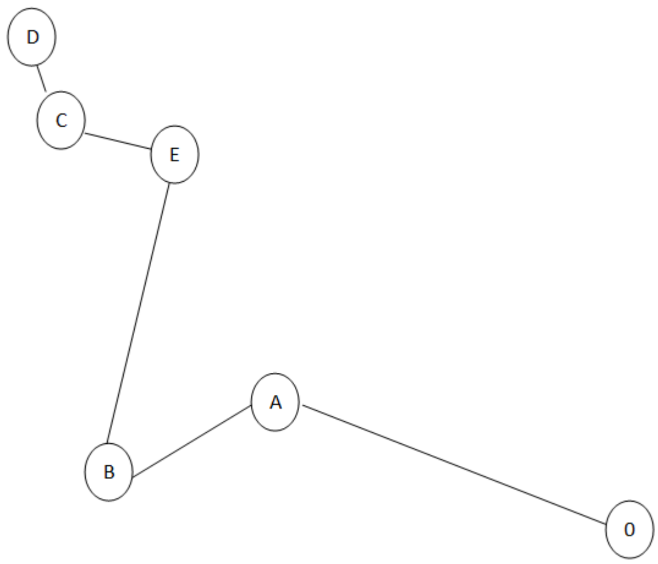

Figure 5. Graph 0-A-B-E-C-D

Starting from the last visited point D, we then select the remaining point that has not been chosen—namely point F—with a distance of 0.9 km from D to F. This relationship is evident from the distance matrix. Finally, we combine these points, and the resulting combination can be visualized in the following graph.

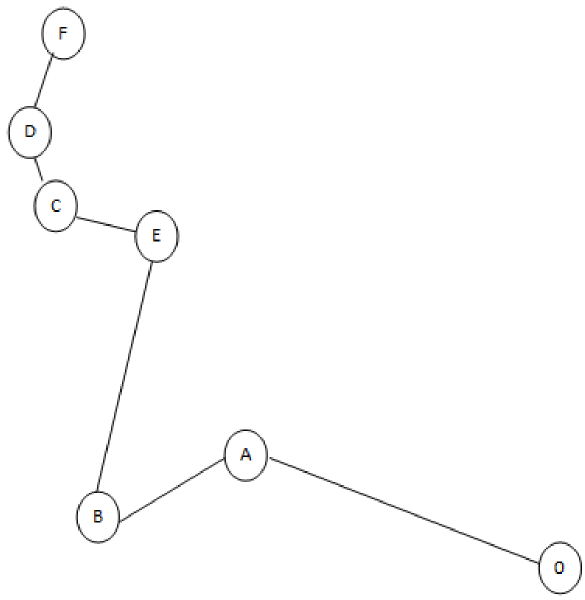

Figure 6. Graph 0-A-B-E-C-D-F

The route obtained for distributing tissue napkins using the nearest neighbor algorithm is 0-A-B-E-C-D-F, with a total distance of 6.4 + 2.9 + 5.9 + 0.9 + 0.4 + 0.9 = 17.4 km.

Meanwhile, for the A-Star algorithm, before starting, the heuristic value is first determined, namely:

Table 2. Heuristic Value

N	A	B	C	D	E	F
h(n)	10,1	4,9	7,2	1,1	0,9	1,7

The first stage, because in open only has 1 node (i.e. 0), then 0 is selected as the best node. The next best node is f (A) = g (0 to A) + h (n) = 6.4 + 10.1 = 16.5.

Closed : 0

Open: A

In the second stage, A with the lowest cost is selected as the best node and moved to the closed list, all successors of A are opened namely A, B, C, D, E, and F then added to the open list. The next best node is f (E) = 6.4 + 3.3 + 0.9 = 10.6.

Closed : 0, A

Open: B, C, D, E, F

In the third stage, E with the lowest cost is selected as the best node and moved to the closed list, all successors of E are opened, namely B, C, D, and F, and then added to the open list. The next best node is f(D) = 6.4 + 4.1 + 1.1 = 11.6.

Closed : 0, A, E

Open: B, C, D, F

Fourth stage, D with the lowest cost is selected as the best node and moved to the closed list, all successors of D are opened, namely B, C, and F, and then added to the open list. The next best node is f(F) = 6.4 + 4.9 + 1.7 = 13.

Closed : 0, A, E, F.

Open: B, C.

The fifth stage, F with the lowest cost is selected as the best node. Because the best node is the same as the goal, it means that the solution has been found. So the route results obtained in the distribution of napkin tissue using the A-Star algorithm are 0-A-E-F-D-B-C with a total distance of 6.4 + 3.3 + 1.7 + 0.9 + 6.3 + 6.1 = 24.7 km.

Discussion

Based on the research results, the results of the route for distributing tissue napkins using the nearest neighbor algorithm with a total distance of 17.4 km are 0-A-B-E-C-D-F, namely: PT. Medan Juta Rasa - Jl. SM. Raja - Jl. Brigjend Zein Hamid - Jl. Japaris Indah - Jl. Kapuas - Jl. Cirebon - Jl. Veteran. Meanwhile, the route results obtained in distributing tissue napkins using the A-Star algorithm with a total distance of 24.7 km are 0-A-E-F-D-B-C, namely: PT. Medan Juta Rasa - Jl. SM. Raja - Jl. Japaris Indah - Jl. Veteran - Jl. Cirebon - Jl. Brigjend Zein Hamid - Jl. Kapuas.

The distribution of tissue napkins using the nearest neighbor algorithm terminates at Jl. Veteran, whereas the distribution using the A-Star algorithm concludes at Jl. Kapuas. The total distance covered in the napkin distribution process with the nearest neighbor algorithm is shorter than when using the A-Star algorithm, resulting in reduced transportation costs.

This study compares the nearest neighbor algorithm with the A-Star algorithm to determine the optimal route for distributing tissue napkins by PT. Medan Jutarasa. Previously, (Lestari et al., 2022). conducted a study focused solely on the nearest neighbor method for determining the distribution route of tissue napkins by the same company. According to this study, the company's pre-existing distribution route was suboptimal because it led to increased distribution costs and time. In contrast, the distribution route using the nearest neighbor method resulted in shorter total distance, reduced time, and lower distribution costs.

In their study, (Sitepua & Putra, 2022) exclusively investigated the A-Star algorithm for determining the shortest route. Based on the data processing results using the A-Star algorithm, it was found that this method can accept graph input, display the shortest path along with its distance, handle map input via the Google Map API, and provide information about the program's processing time in determining the shortest route.

Meanwhile, (Idayat & Handayani, 2022) utilized the A-Star algorithm with graph-based implementation to determine the shortest route in Bekasi, specifically for visiting Lippo Cikarang Mall. The trajectory generated by the A-Star Algorithm revealed 21 distinct shortest routes from the Bekasi terminal to the mall. This study highlights the effectiveness of the web-based A-Star Algorithm, which leverages the A-Star method, in identifying the shortest travel route using Google Maps.

Conclusion

Based on the study results, the following conclusions can be drawn: (1) The total distance covered in tissue napkin distribution using the nearest neighbor algorithm is 17.4 km, whereas the A-Star algorithm covers a total distance of 24.7 km; and (2) The route generated by the nearest neighbor algorithm is shorter than that of the A-Star algorithm. Consequently, the use of the nearest neighbor algorithm is more optimal for tissue napkin distribution by PT. Medan Jutarasa, based on data from 2022.

Declarations

Author Contribution	:	RSL: Conceptualization, Writing - Original Draft, Editing and Visualization.
		RA: Writing - Review & Editing, Formal analysis, and Methodology.
		RR: Validation and Supervision.
		SH: Validation and Supervision.
Conflict of Interest	:	The authors declare no conflict of interest.

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