



Rerouting spare part distribution on pt tam spld with nearest neighbor method

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ABSTRACT

This article presents a study conducted at PT Toyota Astra Motor Spare Parts Logistics Division (SPLD) focusing on improving the rerouting process for spare part distribution to ten part shops in Cikarang and Karawang City. Utilizing the nearest neighbor algorithm, the researcher aimed to devise an efficient route originating from the Centre Warehouse in Kawasan Industri MM 2100. The primary objectives were to minimize distance traveled and consolidate routes to achieve cost savings in transportation. Through meticulous route planning and optimization, the study successfully reduced the total distance from 282 km to 62.8 km, thereby demonstrating significant cost-saving potential. This article provides insights into the methodology, results, and implications of implementing the nearest neighbor algorithm in optimizing spare part distribution logistics for automotive industries.

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1. INTRODUCTION

Transportation vehicle are one of the most tools that helps people going from one places to others. It also helps transports goods and ease supply chain fulfillment process. According to (Allsop 2012), transport systems enable the movement of people and goods, overcoming physical separation and enabling various activities. The increasing number of any types of vehicle also influenced some of many aspects, including the demand of spare parts. Demand for spare parts and accessories increases significantly with the increase in the number of cars worldwide. (Jacyna & Semenov, 2020)

Indonesia citizen also became one of the country that have many vehicle users. Based on data from the (Badan Pusat Statistik, 2023) in a report entitled "Statistik Indonesia" (2023), the number of motorized vehicle users in Indonesia in 2022 will reach 148,212,865 units. With the classification of private/passenger car type motor vehicle owners in Indonesia there are approx 17,175,632 units, there are around 5,528,669 trucks, 241,215 bus type cars, and 125,367,349 motorbike owners.

Based on this data, we can implied that the growth of motorized vehicle users has always increased over the last 3 years. The most common modes of transportation are motorbikes and private/passenger cars in 2nd place. It is also can be inferred that

Indonesia have a big demand of how spare part supply must be organized and have a reliable availability across the city. The reason why it must be organized strengthened by the quote from (Chopra, 2019) supply chains must be designed and managed to be responsive to the demands of the market, both in terms of variety and volume. The value of each spare parts from any car brands can be different but the most important are how the industries can give a reasonable price that consumer can accept including the production cost and logistics cost. Similar argument by (Bo et al., 2018) the cost of logistics significantly affects the competitiveness of goods and services but does not reflect the performance of logistics operations in the country. One of the logistics cost that has significant impact for the price and availability of goods are the transportation costs. (Martínez-Zarzoso & Nowak-Lehmann, 2007) stated, transport costs are influenced by transport conditions, efficiency, service quality, and geographical distance, rather than real distance, and both factors significantly impact international trade. According to (Arif, 2018), in general, supply chain management is a process for integrating, coordinating and controlling the movement from raw materials to final products that are distributed to consumers.

If we can specified for only the supply chain management in car industries, it's related on how the company manage the cost of each spare part. Supply chains in the automotive industry face challenges such as long lead times, unreliable production schedules, excess inventory, and lack of visibility of suppliers, affecting profitability and shareholder value. Lean and agility strategies can improve the automotive industry's supply chain efficiency and adaptability to changing consumer demands. (Ambe & Badenhorst-Weiss, 2010).

In this research, the researcher choose Toyota as an research object as an example on how the transportation cost can improve the logistics performance by reducing the distance, time, and cost. Toyota being choose as the large car industries that had been running in Indonesia since 1970. The good image of these company also being mentioned in one of the journal from (Irawati & Charles, 2010), MNEs like Toyota and Honda have been successful in transferring sophisticated Japanese production management technology to Indonesia, advancing the country's technological capability in the automotive industry.

One specific company that handle all the logistics and distribution activities is PT Toyota Astra Motor Service Parts Logistics Division (PT TAM SPLD). This company is a subsidiary of PT Toyota Astra Motor which is responsible for managing the spare parts supply chain for Toyota product units throughout Indonesia. This company has 6 departments that synergistically work together to support logistics processes and manage the spare parts supply chain for Toyota units throughout Indonesia.

Based on internal data and observations that the researcher obtained while participating in internship activities at the company, the researcher found an obstacle in sending spare parts to Cikarang and Karawang. One of them is at the PT Jasutra Jaya Motor parts shop, which is located in Cikarang, West Java. PT Jasutra Jaya Motor is one of the official Toyota workshops in the Cikarang area. This shop supplies its spare parts through the Toyota Sub-Depo in Bandung. (Yoo & Shekhar, 2005) stated that, Geographical distance is more important for road transport costs, while transport conditions and efficiency are more important for maritime transport costs.

Initial observation results show that the delivery process from the Bandung depot is farther than when sent from the warehouse at PT TAM SPLD. This route also includes delivery to the PT Jasutra Jaya Motor part shop. The comparison of these distances is listed in the table prepared by the researchers along with the calculation of travel time as follows:

To solve this, the researcher will do some kaizen according to the company's procedure on how they manage to build the continuous improvement. According to the (Iijima & Sugawara, 2005) Kaizen factors in the Toyota supply chain lead to lead-time reduction and excellent traceability. One of the method that the researcher choose is the

nearest neighbor method as a guide for the distribution route design stages. According to (Agafonov & Yumaganov, 2018) using a distributed model for short-term traffic flow prediction based on the k nearest neighbors method can help travelers plan routes to avoid traffic congestion, reduce travel time, and improve traffic operation efficiency. Apart from the position of the delivery destination point which is at the intersection of the two distribution warehouses, researchers will also identify distances and travel times that can be and create a more efficient distribution flow. The aim that researchers want to achieve in this research is to be able to contribute to developing an alternative route recommendation. Of course, the recommendation results can also be an option in the chosen distribution route, and help reduce delivery time and distance so that the delivery process can be achieved with cheaper shipping costs. The rerouting process also being mentioned in one of the article made by (Mejjaouli & Babiceanu, 2018) stated that rerouting in logistics aims to achieve significant savings by evaluating actual transportation conditions and rerouting shipments to a closer location.

One of the method that researcher used is nearest neighbor procedure. Based on the statement quoted by (Kosasih et al., 2023) that the nearest neighbor algorithm is a heuristic method used in transportation to design optimal routes. Also according to (Sarjono, 2014) nearest neighbor method in transportation determines the shortest distance in shipping routes for each vehicle owned by the company to deliver goods to consumers. Nearest neighbor itself has a mapping process principle that refers to the closest point around the first customer (C1). According to (Heizer & Render, 2011) in its application the nearest neighbor method will produce several distance mappings which are carried out based on the iteration results of each point being tested. From the overall distance mapping results produced, researchers can choose the most optimal route according to their goals. This goal can be in the form of minimizing costs, travel distance, or travel time in one trip through these destination points

The Nearest Neighbor Procedure is the most effective method for minimizing transportation costs in distributing goods to consumers, as it provides the shortest distance in shipping routes for each vehicle owned by the company. (Sarjono, 2014) it is also strengthened by other statement from (Hermawan, 2018) Optimizing waste transportation routes using the nearest neighbor method can reduce operational costs, greenhouse gas emissions, and social impacts. The nearest neighbor method can indeed provide fast and efficient solutions in solving complex problems involving a series of points or locations that must be connected.

The reason why the researcher choose nearest neighbor as the research method because of the effectiveness and also very convenience. The Nearest Neighbor Algorithm can reduce distance, distribution time, fuel, driver and assistance costs, and overall distribution costs by (Prasetyo & Tamyiz, 2019) Apart from that, the application of the nearest neighbor method is also in accordance with the characteristics of the problems at PT TAM SPLD which are similar to the case study description in Traveling Salesman Program (TSP).

The research presented in this journal article builds upon previous research conducted by (Leymana et al., 2019), who investigated the optimization of distribution routes at PT. KALOG, a company specializing in goods delivery. Leymana's study utilized the saving matrix method to determine distribution distances and the nearest neighbor method for route determination. At PT. KALOG, couriers often experienced fatigue, and many shipments were delayed due to the limited number of delivery vehicles. To mitigate these delays without incurring additional costs for purchasing new delivery vehicles, Leymana implemented an optimal distribution route plan using the nearest neighbor method. The results of this method were analyzed to determine the optimal distribution flow. The study demonstrated that using the nearest neighbor method optimized distribution distances based on saving values and distances between locations. Leymana's calculations resulted in significant route changes for the five available delivery vehicles, thereby enhancing distribution efficiency at PT. KALOG.

Following a similar approach, the research in this journal applies the nearest neighbor method to examine route changes at PT TAM SPLD, aiming to find the most efficient solutions in terms of cost, distance, or travel time. By iterating from each tested point, various distance mapping results will be generated and compared to select the most optimal route according to the research objectives. Through the application of this method, it is expected to identify transportation routes that not only reduce costs and travel time but also enhance the operational efficiency of the company.

The traveling salesman problem is a simple way to solve problems in various contexts, such as computer wiring, vehicle routing, clustering, and job-shop scheduling (Lenstra & Kan, 1975). The new genetic algorithm based on nearest neighbor strategy significantly increases convergence speed and has better effect on solving the travelling salesman problem compared to traditional method (Li, 2009). The nearest neighbor procedure provides the shortest distance in shipping routes for each vehicle owned by the company to deliver goods to consumers (Sarjono, 2014).

As with TSP, at PT TAM SPLD there are also a series of points or locations that the transportation fleet must pass through to maximize the company's operational effectiveness. By using the nearest neighbor method, companies can find solutions that are close to optimal in determining the best routes for delivery of their goods or services. This allows companies to increase operational efficiency, reduce shipping costs, and significantly increase customer satisfaction. (Ghosh, 1999) stated that the nearest neighbor method allows companies to identify alternative routes that are close to optimal by considering various factors such as distance, travel time, and customer needs.

2. RESEARCH METHOD

This process begins by collecting the necessary data. At this stage the data required is collecting data on the distance from the sub-depot to each outlet, the distance between each outlet in the city. By using a route mapping tool, namely google maps, the distance to each destination is obtained in kilometers (km) and then compiled into a table as below:

Table 2. 1 The example of Distance Metrics

		City distance matrix x							
Distance.	0	1	2	3	4	5	6	7	8
0	0	318	340	395	298	420	467	288	114
1	318	0	207	685	39	37	480	672	679
2	340	207	0	337	562	545	378	614	464
3	395	685	337	0	275	525	671	270	588
4	298	39	562	275	0	250	23	428	392
5	420	37	545	525	250	0	240	112	275
6	467	480	378	671	23	240	0	194	104
7	288	672	614	270	428	112	194	0	69
8	114	679	464	588	392	275	104	69	0

These are called distance metrics, According to (Wang et al., 2007) A simple adaptive distance measure significantly improves the performance of the k-nearest neighbor rule in pattern classification when patterns overlap in feature space. Also (Myles & Hand, 1990) stated that Local metrics can effectively generalize to the multi-class case in nearest neighbor rules, resulting in better distance classification accuracy. (a) Identifying the farthest distance, at this stage the researcher will rank the smallest distance into a separate route group. The researcher will group from the lowest distance to the next lowest distance and eliminate rows and columns at the selected destination (b) Next, the destination point that has been selected will become the next reference by looking at the closest distance between that point and the next destination, the nearest destination will be the next delivery destination. (c) After everything has been collected in one route, the group of routes will add up the total distance in one series and a reduction

in the distance of the total journey the vehicle will take will be obtained. Researchers will include this point for discussion with the trucking team. (d) The results of discussions with the trucking party will result in new shipping costs. This delivery cost will be compared with the cost of truck delivery to Cikarang and Karawang on the previous route. Researchers will also combine individual part shop deliveries to see the rates paid if the transportation volumes of two destination cities are combined in one transportation trip. (e) Calculate the estimated distribution time, this is done by looking at the outbound schedule in accordance with the delivery objectives. Next, see the travel time by entering the destination point using Google Maps in the specified order.

These process are proven based on the previous journal that applied the NNS-DML (nearest neighbor search model distance metrics learning) to their research. (Ruan et al., 2021) said, The NNS-DML method outperforms state-of-the-art distance metric learning methods by selecting optimal nearest-neighbor numbers for different training instances, improving performance.

3. RESULTS AND DISCUSSIONS

There are 11 part shops and some of them will have their transportation routes moved from the Bandung Sub Depo to the PT TAM SPLD Warehouse. There are certain conditions that must be considered when researchers move transportation routes. Based on the results of the interview with PIC Supply Operation Mr. Juwanto, in the case of determining transportation routes in the LK1 route group, ensure that the new route has a distance between the destination (partshop) and the warehouse of no more than or equal to 50 km. The reason is that the aim of determining this new transportation route prioritizes distance and cost efficiency, so the estimated fare must be smaller by minimizing the distance between vehicles on the new route. It is also being clarified based on the journal from (Chisholm & Norman, 2012) to gain a lower cost, they have to reduce the distance, and this can lead to broader and more overlapped product lines.

From the total distance between each part shop, the researcher determined the destination points through which 6 part shops would pass. These six partshops were chosen as new destination points from the TAM SPLD central warehouse while the other 4 partshops will remain included in the LK1 Bandung route. The division results obtained by researchers are as follows:

Table 3. 1 The result of part shop grouping

Partshop name	Supplied from	Mileage	Location
Auto2000 Purwakarta	Sub-Depo Bdg	(85,0 km)	Purwakarta
Frans Motor	Sub-Depo Bdg	(81,7 km)	Purwakarta
Wijaya Toyota Subang	Sub-Depo Bdg	(147 km)	Subang
Pamanukan Motor	Sub-Depo Bdg	(148 km)	Subang
Surya Motor (1)	Gudang Pusat	(49,3 km)	Karawang
Jasutra Motor (2)	Gudang Pusat	(6,1 km)	Karawang
Pamor One (3)	Gudang Pusat	(50 km)	Karawang
Karoto Seiko Indonesia (4)	Gudang Pusat	(34,1 km)	Karawang
CV. Selamat Jaya Abadi (5)	Gudang Pusat	(28,9 km)	Karawang
PT. Jasutra Jaya Motor (6)	Gudang Pusat	(36,0 km)	Cikarang

The next stage is to construct a distance matrix. In this stage, the researcher will carry out an assessment by including the distance between the warehouse and the six destination partshops and the distance that connects the six partshops to each other.

Table 2. Distance metrics from PT TAM SPLD Warehouse 6 partshop

Distance.	New Transportation Path Distance Matrix (KM)						
	0	1	2	3	4	5	6
Gudang	0						
1	49,3	0					
2	7	26,1	0				

New Transportation Path Distance Matrix (KM)							
Distance.	0	1	2	3	4	5	6
3	50	29,4	45,7	0			
4	34,1	5,7	27,1	25,4	0		
5	28,9	2,6	23,6	38,7	5,4	0	
6	40	6,5	32	24,5	1,1	6,3	0

The next stage is an iteration process. The implementation process is to place each destination point as the initial goal. Next, after selecting one of the destination points, the next destination point is selected which has the shortest distance to the initial destination point. This mapping process is carried out until all destination points are listed in one route, and each destination point takes its turn to become the starting point of the journey.

In this iteration process, the journey from the PT TAM SPLD warehouse continues with the shortest distance to the next destination point. Based on the distance matrix, it was found that the shortest distance was to go to the Jasutra Motor part shop which was denoted as number 2. After arriving at the Jasutra Motor part shop, the next point was Jasutra Jaya Motor. The selection of the destination point continues until the final journey point ends at the Pamor One Motor part shop. The results of the iteration obtained the total distance traveled and the sequence as follows:

Table 3. 3 iteration result

Route Design	Distance order (km)	Total distance (km)
G-2-5-1-4-6-3	7+6.5+1.1+5.7+2.6+38.7	65.6

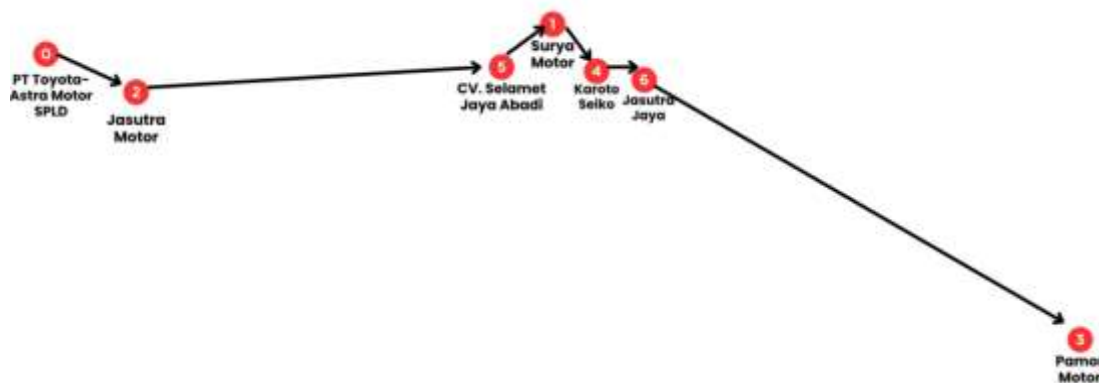


Figure 1 Transportation route scheme from 2nd iteration result

More details regarding other indicators that are met are as follows: (a) The nearest neighbor method succeeded in reducing the distance traveled to 65.6 km on the route with a distance difference of 208.4 km with the distance traveled on the previous route which was 270 km. (b) The iteration results of the nearest neighbor method obtained a time saving of 1 hour 41 minutes.

These results maybe different than the previous research by (Leymena et al., 2019) at PT. KALOG. Both are aim to optimize distribution routes, but they differ in methodology, transportation mode, and objectives. On the previous research, they attempt to utilized a combination of the saving matrix method and the nearest neighbor method. The saving matrix method was used initially to determine distribution distances, while the nearest neighbor method refined and optimized the route determination process. In contrast, the current study at PT TAM SPLD focuses exclusively on the nearest neighbor method, applying it directly to identify the most efficient transportation routes without the preliminary step of using the saving matrix method.

The transportation mode also differs between the two studies. Leymana's research involved optimizing routes for a variety of delivery vehicles, addressing issues such as courier fatigue and shipment delays due to a limited number of vehicles. On the other hand, the current study at PT TAM SPLD specifically focuses on Less-than-Container Load (LCL) transportation. This involves optimizing routes for smaller, consolidated shipments that are transported together but do not fill an entire container.

The objectives and outcomes of the studies further distinguish them. Leymana's research aimed to reduce shipment delays and optimize distribution routes without incurring additional costs for purchasing new delivery vehicles. This resulted in significant changes to the routes of the five available delivery vehicles, enhancing overall distribution efficiency. In contrast, the primary objective of the current study at PT TAM SPLD is to determine the optimal arrangement for LCL shipments to minimize travel distances. The focus is on achieving a transportation route configuration that ensures the shortest possible travel distances, thereby enhancing efficiency and reducing operational costs.

4. CONCLUSION

In the context of PT TAM SPLD, the application of the nearest neighbor method has been proven to be effective and in accordance with the researcher's case study. Because in the process of sending spare parts, PT TAM SPLD only makes one trip for delivery to several destination points. This is what makes the nearest neighbor method suitable and suitable for case studies in the field. Thanks to the application of the nearest neighbor method, researchers succeeded in solving the problem of moving routes to find a route with a distance and travel time that was smaller than the previous route. More details regarding other indicators that are met are as follows The nearest neighbor method succeeded in reducing the distance traveled to 65.6 km on the route with a distance difference of 208.4 km with the distance traveled on the previous route which was 270 km. The iteration results of the nearest neighbor method obtained a time saving of 1 hour 41 minutes.

In summary, There are differences between both research. While both studies aim to improve distribution efficiency through route optimization, The previous research are focused on minimize the vehicle and organize the new route to improve the ETA Delivery. However, the current study at PT TAM SPLD takes a more streamlined approach by using only the nearest neighbor method. It focuses on LCL transportation and has a specific goal of minimizing travel distances, highlighting different applications and objectives of route optimization within the logistics field.

For the next suggestion on the further research, these implementation are so simple and being limited by the access of some data like the total delivery cost, labour cost, lead time for the outbound and inbound process, etc. The next research also suggested to combine the nearest neighbor method with another heuristic algorithm so the results would be detail and complete, especially if the research are to aim the cost reduction on the distribution process.

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