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# Determination Of The Shortest Route of Electrical Scooters Maintenance Patrol in Bandung Using Nearest Neighbor and Genetic Algorithm Approaches

**Sely P. Oktaviani, Rispianda**

Department of Industrial Engineering, Institut Teknologi Nasional (Itenas), Bandung - INDONESIA

e-mail: selyoctavian@gmail.com

**Abstract**

The increasing number of parking spot locations has increased the number of Electrical Scooters fleet maintenance patrols. For this reason, it is necessary to determine the shortest route for maintenance crew for patrolling through all parking spots. In this study, the determination the number of routes is done using the Nearest Neighbor approach and the shortest route path using the Genetic Algorithm approach. Based on the results of calculations, the best number of routes that can be used is 3 routes with each patrol time of 460, 414, and 417 minutes. With this research, it is expected that company can minimize patrol time and shortest mileage.

*Keywords: Electrical Scooters, Nearest Neighbor, Genetic Algorithm*

## 1. Introduction

Electric scooters are one of the modes of transportation that are in demand in the city of Bandung both as a short distance transportation or as a means of recreation. The number of electric scooter parking spots is 35 location points. From each location point there are 5 electric scooters. It is necessary that this electric scooter needs to be checked and maintained periodically to ensure that the electric scooter engine is safe to drive.

Increasing number of parking spot locations makes increasing maintenance patrol locations also. This resulted in the number of patrol routes possibly increasing. To minimize patrol time, it is necessary to find a route or the shortest path to minimize time and distance. Problems such as optimal route search are commonly referred to as Vehicle Routing Problems.

Many methods or approaches can be used to solve Vehicle Routing Problems, one of which is using the Nearest Neighbor approach. In general this approach is to sort each existing location point based on the shortest distance to the furthest distance. The advantage of this method is the simplicity of efficient and effective analytical techniques in the fields of pattern recognition, text categorization, subject recognition, etc., but has limitations on memory requirements and computational complexity (Bhatia and Vandana, 2010). The aim of using Genetic Algorithm is to improve the solution obtained by the Nearest Neighbor (NN). It is expected that the use of Genetic Algorithms makes the results of completion of the shortest route more optimal.

## 2. Literature Review

Our work is mainly related to the issue of extended Vehicle Routes Problem (VRP) and the shortest route determination approach, we review some of the most relevant studies in this section.

### *2.1. Vehicle Routes Problem (VRP)*

Vehicle Routing Problem (VRP) according to Miller (1999) is a matter of determining the delivery route which involves a set of vehicle routes that are centered on one depot or more to serve customers scattered in various shipping areas with their respective requests.

Vehicle Routing Problems (VRP) have important applications in the field of distribution management, so they are one of the examples of problems that are widely studied in the combinatorial optimization literature and are recognized as one of the most successful experiences in operations research. The VRP type is generally described as a case where a number of vehicles with a certain capacity must send a number of goods from a depot assuming the distance between customers is known so the purpose of this problem is to minimize vehicle mileage so that vehicle operating costs are minimal with various constraints (Arvianto et al, 2018).

### 2.2. Saving Matrix

Saving Matrix is a method used to determine the distance, route, time or cost in the delivery of goods from companies to consumers. This method aims to deliver goods according to customer orders can be done in an effective and efficient manner, so that companies can save costs, labor, and delivery time (Istantiningrum, 2010 in Suparjo, 2017).

The Saving Matrix method consists of several steps. According to Istantiningrum (2010) in Suparjo (2017) the steps in the saving matrix method are as follows:

1. Determining the Distance Matrix

In determining the distance matrix, the distance data between the company and location and location to other locations is very necessary. After knowing the coordinates of each location, the distance between the two locations can be calculated using the following formula:

$$j(1,2) = \sqrt{(x_1 - x_2) + (y_1 - y_2)}^2 \quad (1)$$

However, if the distance between the two the coordinates are known, then calculations using formulas not used and use existing distance.

2. Determine the Savings Matrix

After knowing the overall distance between the plant and one location and another, then in this step it is assumed that every location will be bypassed one truck exclusively. The meaning will be there are several different routes that are will be bypassed for each destination. As such there will be savings if there are merging routes that are considered one-way with the other route. For looking for a savings matrix can The following formula is used:

$$S(x,y) = J(x,y) + J(x,y) - J(x,y) \quad (2)$$

S (x, y) is distance savings that is, from the combination of route x by route y.

3. Vehicle and Route Allocation Based on Location

After the savings matrix is known, then the next step is the allocation of locations to the route or vehicle. Meaning in this step will be determined route new shipping based on the above merging routes in step second above. The result is delivery location 1 and location 2 will done using 1 route.

4. Sorting Destination Locations Within A Route

This step determines the order visit.

### 2.3. Nearest Neighbour

The nearest neighbor algorithm is a search method with the concept of adding the closest point to the previous point until all points in one path are exhausted (Hutasoit et al, 2014). At this stage, the Warehouse is set as the starting point ($t_0$) of travel. The nearest location is searched and added then considered as the end point ($t_1$). $t_1$ is assumed as $t_0$, then the above procedure is repeated until all points are exhausted and returned to the warehouse as the end of the journey.

### 2.4. Genetic Algorithm

Genetic algorithms were first developed in 1975 by John Hollan of Michigan University (Randy, 2004). Genetic algorithm is an algorithm that utilizes the natural selection process known as the evolutionary process proposed by Charles Darwin. In the process of evolution, individuals continually undergo changes in genes to adapt to their environment. "Only strong individuals can survive." Genetic algorithms may not always achieve the best results, but often solve problems quite well. Genetic algorithms represent a solution to the problem as chromosomes. There are several important aspects in genetic algorithms, including the definition of fitness function, definition and implementation of genetic representations, definition and implementation of genetic operations.

Some important terms in genetic algorithms (Prayoga, 2016) include genes, chromosomes, generation, mutation, crossover, and fitness value. A gene is a value that expresses the basic unit that forms a certain meaning and a gene unity is called a chromosome. generation is a one-unit cycle of the evolutionary process. Mutation is an operator function to change the genetic information of an individual so that new individuals are generated by mutations based on the probability of mutations that have been determined. Crossovers are function operators for combining genetic information between two individuals to produce new individuals. Fitness value is a value that states how good the value of an individual or the solution obtained.

# 3. **Problem Formulation**

## *3.1. Problem Definition*

The process flow that will be carried out in this study can be seen in Fig. 1.

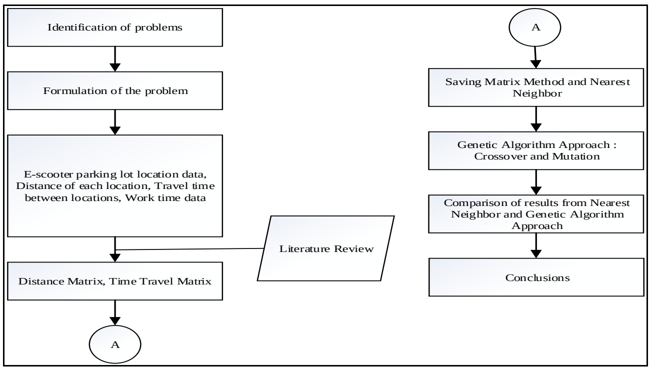


**Fig. 1: Process Flow Diagram**

The number of electric scooter parking spots is 35 location points. From each location point there are 5 electric scooters. The starting point of the patrol departure location is in the company office at Pasirkaliki street. Data of distance obtained from the Google Earth application. The following is a distance matrix obtained assuming the distances a to b and b to a are the same:

**Table 1: Distance Matrix**

| NO | Distance (km) | P0 | PP | UR | UB | SE | UK | ND |
|---|---|---|---|---|---|---|---|---|
| 0 | P0 | - | 5,500 | 5,300 | ... | ... | ... | 6,000 |
| 1 | PP | 5,500 | - | 2,300 | ... | ... | ... | 5,700 |
| 2 | UR | 5,300 | 2,300 | - | ... | ... | ... | 4,100 |
| ... | UB | 5,000 | 3,100 | 0,750 | ... | ... | ... | 3,500 |
| 34 | UK | 3,900 | 4,000 | 2,300 | ... | ... | ... | 2,800 |
| 35 | ND | 6,000 | 5,700 | 4,100 | ... | ... | ... | - |
| | | P0 | PP | UR | UB | SE | UK | ND |

The following is a time allocation matrix for each location and assumptions:

**Table 2: Time Matrix**

| NO | Time (minutes) | P0 | PP | UR | UB | SE | UK | ND |
|---|---|---|---|---|---|---|---|---|
| 0 | P0 | - | ... | ... | ... | ... | ... | ... |
| 1 | PP | 55,0 | - | ... | ... | ... | ... | ... |
| 2 | UR | 48,0 | 36,0 | - | ... | ... | ... | ... |
| ... | UB | 47,0 | 38,0 | 28,0 | - | ... | ... | ... |
| 34 | UK | 43,0 | 43,0 | 33,0 | 35,0 | 32,0 | ... | ... |
| 35 | ND | 49,0 | 50,0 | 41,0 | 40,0 | 41,0 | 34,0 | |
| | | P0 | PP | UR | UB | SE | UK | ND |

**Table 3: Assumptions**

| | | |
|---|---|---|
| Electric Scooters/ parking spot | 5 | Unit |
| Regular Patrol Team | 1 | Team |
| Assumptions | | |
| Time check/ scooters | 5 | Minutes |
| Time check/ parking spot | 25 | Minutes |
| Road Conditions | weekend | |
| Work Time | 8 | Hours |
| Work Time | 480 | Minutes/ Days |

## *3.2. Saving Matrix Between Distance and Time*

The following is the result of saving the distance matrix over time:

**Table 4: Distance Vs Time Matrix**

| Distance Vs Time | PP | UR | UB | ... | UK | ND |
|---|---|---|---|---|---|---|
| PP | - | | | | | |
| UR | 8,500 | - | | | | |
| UB | 7,400 | 9,550 | - | | | |
| ... | 8,200 | 7,800 | 6,800 | - | | |
| UK | 5,400 | 6,900 | 6,900 | 5,300 | - | |
| ND | 5,800 | 7,200 | 7,500 | 5,200 | 7,100 | - |
| | PP | UR | UB | ... | UK | ND |

**Table 5: Results Order of Saving Matriks**

| No | Location Pairs | Saving |
|---|---|---|
| 1 | SS & WUB | 12,590 |
| 2 | WUB & BCC | 11,800 |
| 3 | TU & SS | 11,550 |
| 4 | BCC & KKIC | 11,400 |
| ... | KB & WUP | 4,650 |
| 34 | XP & HS | 1,300 |

## *3.3. Nearest Neighbour*

The Nearest neighbor approach is based on the results of the largest order of saving matrix. This is done so that the distance from the resulting route has a large saving value. Determination of the number of routes is influenced by the work time limit which is assumed to be 480 minutes.

**Table 6: Results of Nearest Neighbour**

| Route | Location Pairs | Time (Minutes) |
|---|---|---|
| Route 1 | P0 - WUS - WUD - EC - TU - SS - WUB - BCC - KKIC - CR - UB - NB - HS - SE - P0 | 460 |
| Route 2 | P0 - Ecc - HBS - BD - DC - AH - WUR - UR - HoA -XDB - XGB - PP - P0 | 458 |
| Route 3 | P0 - WUP - KB - XBC - SP - BBC - SBC - SPN - XP - GC - ND - UK - P0 | 387 |
| Total | | 1305 |

Calculation example for Route 1:

Make a comparison of the distance between the points P0 with the location that has the largest saving matrix value. Select the location with the closest distance and calculate the travel time between the selected locations (WUS). Comparison of distance values, location determination, and time calculations are repeated until the time travel total of all location from the last point to the starting point P0 is $\leq$ 480 minutes.

### 3.4. Genetics Algorithms

Genetic algorithm approach is used to make the optimal route solution at Nearest Neighbor. Genetic algorithms may not always achieve the best results, but usually used to try to solve problem well. The aim of using Genetic Algorithm is to improve the solution obtained by the Nearest Neighbor (NN).

**Table 7: Parameters and Assumptions Genetics Algorithm**

| | |
|---|---|
| Population Size | 35 |
| Crossover Probability | 0,5 |
| Mutation Probability | 0,5 |
| Generation Minimum | 8 |

### 3.4.1 Determination of the parent chromosome

The determination of the route Genetic Algorithm is based on the fitness value. Route 2 is made a parent based on a random value that is smaller than the value of the selection probability. For individual crossover pairs, only route 3 is chosen because the random selection crossover value is smaller than the crossover probability value.

**Table 8: Determination of Parent Individuals**

| Individu | Time Fitness (minutes) | Selection Probability (Pi) | Selection Probability Cumulative (Qi) | Random Selection (ri) |
|---|---|---|---|---|
| 1 | 460 | 0,352 | 0,352 | 0,545 |
| 2 | 458 | 0,351 | 0,703 | 0,141 |
| 3 | 387 | 0,297 | 1,000 | 0,616 |
| Total | 1305 | 1 | | |

**Table 9: Determination of Individual Crossover Pairs**

| Individu | Time Fitness (minutes) | Selection Probability (Pi) | Selection Probability Cumulative (Qi) | Random Crossover (rc) |
|---|---|---|---|---|
| 1 | 460 | 0,352 | 0,352 | 0,791 |
| 2 | 458 | 0,351 | 0,703 | 0,148 |
| 3 | 387 | 0,297 | 1,000 | 0,401 |

### 3.4.2 Crossover

Exchange genes by combining the same number of genes as the minimum number of generations. The selected crossover result is a pair of routes that have the smallest total fitness value. From 8 trials, the 6th trial was chosen.

**Table 10: 6th Trial of Crossover**

| Individu | Gen/ Parking Spot | Time Fitness (minutes) |
|---|---|---|
| 2 | P0 - WUP - KB - XBC - SP - BBC - SBC - SPN - XP - GC - ND - PP - P0 | 414 |
| 3 | P0 - Ecc - HBS - BD - DC - AH - WUR - UR - HoA -XDB - XGB - UK - P0 | 417 |
| Total | | 831 |

### 3.4.3 Mutation

Each individual has a gene mutation with a mutation probability determined. Mutated genes are genes that have a smaller random probability than mutation probabilities. mutated genes are WUB and BD so the results as shown here are obtained:

**Table 11: Mutation**

| Individu | Gen/ Parking Spot | Time Fitness (minutes) |
|---|---|---|
| 1 | P0 - WUS - WUD - EC - TU - SS - BD - BCC - KKIC - CR - UB - NB - HS - SE - P0 | 476 |
| 2 | P0 - Ecc - HBS - WUB - DC - AH - WUR - UR - HoA -XDB - XGB - PP - P0 | 475 |
| 3 | P0 - WUP - KB - XBC - SP - BBC - SBC - SPN - XP - GC - ND - UK - P0 | 387 |
| Total | | 1338 |

### 3.4.4 Results

The following is the result of the calculation of Nearest Neighbor (NN) and Genetic Algorithm (GA).

**Table 12: Results**

| Methods | Fitness (minutes) |
|---|---|
| NN | 1305 |
| CO | 1291 |

## 4. Conclusion

Based on the results of the calculation of the nearest neighbor obtained 3 routes that can be used with a total travel time of 1,305 minutes. To maximize this solution a review of the route results is carried out using a genetic algorithm approach. The genetic algorithm itself consists of a crossover process with travel time of 1,291. From these results it can be concluded that the route results from the genetic crossover algorithm approach were chosen because they have a smaller total travel time. The best number of routes that can be used from is 3 routes with the shortest path P0 - WUS - WUD - EC - TU - SS - WUB - BCC - KKIC - CR - UB - NB - HS - SE - P0, P0 - WUP - KB - XBC - SP - BBC - SBC - SPN - XP - GC - ND - PP - P0, P0 - Ecc - HBS - BD - DC - AH - WUR - UR - HoA -XDB - XGB - UK - P0 with each patrol time of 460, 414, and 417 minutes. With this research, it is expected that company can minimize patrol time and shortest mileage. For further research can be developed with other methods that are more flexible and computerized (software programs) for the number of locations might change.

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