Implementing the Shortest Time Route Search Algorithm in Semarang Using the Best First Search Method

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Abstract. The purpose of this research was to find the shortest route so that the search for the destination is more effective and efficient to avoid traffic jams using the best first search method. The best first search method is a search method by selecting the best value from different data. The aim was to find the shortest time route between regions in Semarang using the Best First Search algorithm according to the distance of each region, road width, and traffic density of motorized vehicles to get better time efficiency. Using the best first search usually tries to estimate the distance at the end of the path with a solution. The shortest time search system in the city of Semarang on traffic density, road width to determine the desired time efficiency. Analysis of the Best First Search algorithm by using the output of the path used as input in the search for the shortest route, between the starting point to the destination point. Conducting trials with the software as a result of recording data according to the field. The impact of the system on searching for route research becomes solution for road users to reach their destination a short time.

1. Introduction
The progress of information technology cannot be avoided from human life, because the progress of information technology with the current science. Technology is not only demands speed, dissemination of information but also in the field of Artificial Intelligence, science is very much needed in the development of information technology systems. In searching and tracking the shortest path is important in building a system. The search with the shortest time will determine the path that can shorten the time well [1].

Public transportation services such as buses within the city, greatly benefit workers, students, or the public who want to work every day. Now, bus transportation within the city is less attractive to the public, due to congestion during rush hour in urban areas and more and more people prefer private vehicles such as cars or motorbikes rather than using city bus facilities. Using private vehicles is a reason for the community to shorten the travel time to achieve the desired goals [2].

Route planning in a multimodal transportation network is increasingly important for transportation needs in the community. Domestic and foreign tourists request an efficient routing method that allows them to reach destinations that will be traversed with a complex multimodal transportation scheme. To calculate the shortest multi-modal lane, consider only railroad, bus and pedestrian paths. Travel costs based on estimated travel time according to the function of the mode of transportation. The combination of two meta-heuristics: Genetic Algorithm and Variable Neighborhood by comparing the shortest path algorithm in the dijsktra method that has been updated for multi-modal environments with pure Genetic Algorithms. Shows that the degree of success in centralized matters is more optimal [3].
One of the most interesting shortest route search applications is transportation problems. While strategies can explain events in frequency base models, research is needed in the context of scheduled models. When the transit service is adjusted from the schedule, passengers can coordinate their departure times with the schedule already, and there will be a reduction in waiting time at the first stop. But it is not always true in a base network that cannot be seeded, although real time information can influence the decision making of passengers in travel time can propose to choose the transit route model as the shortest route based online [4].

Best First Search is a combination of the Depth First search method and the Breadth First method by taking advantage of both methods, if the Hill Climbing method is not allowed to return to nodes at the lower level even though the nodes at the lower level have values better heuristics. With the Best First Search method search is allowed to visit nodes that are at a lower level [5].

The best first search algorithm is a combination of the depth first search algorithm with the breadth first search algorithm by taking advantage of the two algorithms. If there is a search with the hill climbing method can not return to the node at the lower level even though the node at the lower level has a better heuristic value, another case with this best first search method. In the best first search method, a search can visit nodes at a lower level, if nodes at a higher level have worse heuristic values [6].

The purpose of using the Best First Search method is to find the route with the shortest time to pass through several regions in the city of Semarang with a predetermined path. When someone wants to go to another area, the application system that uses the best first search algorithm will analyze the route that is considered to have a faster or more efficient time. Traveling in the city of Semarang with traffic density and a large amount of traffic light due to the number of vehicles in the increasingly crowded city of Semarang, finding the route with the shortest time is the most appropriate solution for road users to reach their destination in a relatively short time.

2. Method
Search technique is a technique contained in the heuristic search method, as follows: Generate and Test, Simple Hill Climbing, Simulated Annealing Best First Search, Greedy Search, A * algorithm. The method uses a function that calculates the estimated time of the node contained in a particular node leading to the destination being inferred. Its function is called the heuristic function [7].

1. Generate and Test, is the simplest method in the search for heuristics. If the Possible Solution generation is carried out systematically, the procedure will find a solution (if any). The algorithm used in the Generated and Test method is the Depth First Search procedure because a solution must be prepared in full before the test, this algorithm is systematic.
2. Hill Climbing, different from Generate and Test Hill Climbing is often used when there is an appropriate heuristic function to evaluate a state. There are two different types of Hill Climbing, namely Simple Hill Climbing and Steepest-ascent Hill Climbing (Hill Climbing with the steepest slope).
3. Simulated Annealing, which is a method that uses probability theory to find the minimum global optimization problem. Simulated annealing is generally used for grouping variables.
4. Best First Search, used to select new nodes that have the smallest cost among all leaf nodes (nodes at the lowest level) that have been compiled. Thus, the Best First Search algorithm performs more calculations than Hill Climbing or Simulated Annealing. There are two types of Best First Search algorithms including: the Greedy Best First Search algorithm only calculates the estimated cost and the A * algorithm which calculates the combined two costs, the actual cost and the estimated cost.
5. Greedy Best First Search, is one of the simplest types of algorithms by only calculating the estimated cost of \( f(n) = h(n) \), the actual cost is not calculated by only calculating the estimated cost that is not necessarily correct, then this algorithm is not optimal.
6. Algorithm A*, is the best first search algorithm that combines uniform cost search and greedy best first search. The calculated cost is obtained from the actual cost plus the estimated cost, written as follows: \( f(n) = g(n) + h(n) \). With such calculations the A* algorithm becomes complete and optimal.

Explained in number 4 in the research that was made, Best first search looks for the shortest mileage and passes the red light that stops not taking a long time, the road is relatively wide and the traffic density does not cause congestion. In this study there are some previous references.

The Best First Search method in previous research has been implemented for interactive multimedia-based mathematics learning, in that research discusses measuring the smallest time value in the test result data by comparing three ways of multiplication calculation [8].

The Best First Search method is also used for marketing solar bread products with speed and accuracy in carrying out the process of calculating distance and range can provide convenience to distribute products [9]. The shortest route search is also used to solve the traveling salesman problem, with the Recursive Best First Search method discussing program calculations that can be used to provide alternative solutions for decision makers to obtain the shortest route to be traveled so that it is more effective and efficient. The Best First Search method and the A* method in the route search application on the map for road user efficiency. Using the application to determine the optimum route using a digital map that is a factor of traffic jams, road conditions and distance [10].

Best First Search is a method of searching or finding the route with the shortest time by selecting the best value from some data.

\[
G(n) = h(n) \sqrt{X_n^2 + Y_n^2} \\
H(n) = X(\text{Target}) - x(n) + |Y(\text{Target}) - Y(n)|
\]

Note:
- \( h(n) \) = Estimated cost to arrive at the destination starting at \( n \)
- \( g(n) \) = costs that have been incurred from the initial state to the situation \( n \)

Thus it can be done:
1. If \( h^* = h \), the tracking process has arrived at its destination.
2. If \( g = h^* = 0 \), then \( f \) is random, meaning that the system can be controlled by anything.
3. If \( g = k \) (ordinary constant 1) and \( h^* = 0 \) means the system uses brendth-first search.

Steps - steps taken Best Best Search algorithm:
1. Generating node A, then all successor A is raised, and the minimum cost is sought
2. Node D was chosen because the lowest cost is 1
3. All successors D are funded then the costs will be compared with the costs of B and C.

It turns out that the cost of node B is the smallest compared to the cost of nodes C, E and F so that it is selected and subsequently will be raised by all successors B, and so on until finding the destination node.

3. Results and Discussion
This study uses a map of the Semarang Public Works Department of Public Works, which only covers the center of Semarang City. nipping points at each intersection. Addressed by figure 1.
Figure 1. Semarang City Centre on The Map

The picture explains the main vehicle lane of each route which covers several areas in the city of Semarang for points at each traffic light. Simpang lima, Randusari, Pleburan, Karangkidul, Kembangsa, Bundaran bubakan, Kauman, Rejomulya, Purwodinata, Sekayu (Tugu muda), Pekunden, Salama mloyo, Randusari, Pendirikan kidul. From Figure 1 above steps will be taken to determine the route with the shortest time.

Step 1:
From Figure 1 in this study, the route map at each intersection for traffic light piercing is divided into 76 columns, give a number for each column in the table like Figure 2 below.

Figure 2. Map of Semarang City Area

To facilitate calculations the map area is taken as in Figure 3.
Figure 3. Screen Area

Node data:
H= Value (Heuristik)
G= Value (Movement Cost)

Open list
List of nodes that need to be checked

Close list
List of nodes that have been checked

From Figure 3 an ordinary lane map is made to determine each red light pull in Semarang, which is shown in Figure 4 as follows.
Second step:
Give the value of \( g \ h \) based on equations 1, 2 and 3 so that the following values are obtained:

Node 1 coordinates (1, 7):

\[
G_1 = \sqrt{1^2 + 3^2}
\]

\[
= 1 + 9
\]

\[
= \sqrt{10}
\]

\[
= 3.1
\]

\[
H_1 = |7 - 1| + |7 - 3|
\]

\[
= 6 + 4
\]

\[
= 10
\]

Furthermore, after the calculation is obtained results like the results in Figure 5 below.

| 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 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 45 | G=3,1 H=12 | G=3,6 H=9 | G=4,2 H=8 | G=48 | G=49 | G=50 | G=51 | G=52 | G=53 | G=54 |
| 55 | G=2,2 H=11 | G=3,9 H=9 | G=56 | G=58 | G=60 | G=61 | G=62 | G=63 | G=64 | G=65 |
| 66 | G=1,8 H=12 | G=2,2 H=11 | G=3,1 H=10 | G=69 | G=70 | G=71 | G=72 | G=73 | G=74 | G=75 | G=76 |

**Figure 5. Node Calculation**

From each of these values a decision is taken by taking the smallest step value of \( h \).

Third step:
After the first part is completed, then it is done from steps 1 and 2. In order to obtain the results of the smallest \( h \) value of the route node. As shown in Figure 6 below.
Figure 6. Node calculations

After getting the data from the route calculation results, to determine the exclusion of traffic signs there are 16 points in figure 6, namely in columns 6, 7, 8, 11, 16, 21, 26, 31, 37, 41, 47, 50, 56, 58, 60 and 70. Routes through Simpang lima, Randusari, Pleburan, Karangkidul, Kembangsari, Bundaran bubakan, Kauman, Rejomulya, Purwodinata, Sekayu (Tugu muda), Pekunden, Salaman mloyo, Randusari, Pendirikan kidul.

After obtaining the results of the Best First Search route, here is a comparison between normal routes and routes using Best First Search shown in Figure 7 below.

Figure 7. Route Normal Comparison

Based on Figure 8, the red points show the normal path of 8 points of piercing by passing through areas in Semarang City such as passing through the pleburan, bundaran bubakan, kauman, randusari, rejomulyo. Furthermore, in figure 8, the red points show the path with the Best First Search as many as 16 piercing routes that pass through several areas in Semarang which pass Simpang lima, Randusari, Pleburan, Karangkidul, Kembangsari, Bundaran bubakan, Kauman, Rejomulya, Purwodinata, Sekayu (Tugu muda), Pekunden, Salaman mloyo, Randusari, Pendirikan kidul.
To test the Best First Search algorithm compared to the Hill Climbing method, this Best First Search method is able to keep involving the nodes that were visited before in the search process. In BFS there are two important components, [OPEN] and [CLOSE]. [OPEN] is a place that contains nodes that have been visited while [CLOSE] contains nodes that are considered solutions. While Hill Climbing there is no guarantee that the solution obtained is the best solution. Nodes can be a better solution. If the search process has been completed and a solution has been found, whether the solution is the best solution, this is the drawback of searching for the Hill Climbing route (See Table 1).

Table 1. Measurement algorithm

|                  | Normal Route | Route Best First Search |
|------------------|--------------|-------------------------|
| Count point Traffic Light | 8            | 16                      |

Based on Table 1 above the comparison between normal routes with the Best First Search algorithm, has fewer traffic light points than the Best First Search. Even though the normal route has the same pin point, the number of traffic light points is much different compared to the Best First Search. Normal routes only have a few bullet points, whereas by using the Best First Search algorithm the bullet points increase which will determine the destination route by looking at the smallest value of each route in the traffic light points [11].

4. Conclusion

In this study the Best First Search method can not only be applied in the case of marketing food products, but can be used to search for the shortest route in urban areas. Based on the results of research on the route search with the shortest time carried out through traffic light points pinching in every area of Semarang city that is traversed, it can be concluded that Best First Search has a good level of accuracy in searching the route with the shortest time at each point of the traffic light points. So that Best First Search has good results with 16 points of light traffic compared to normal routes which only have 8 points of light traffic in the search for the shortest time route.
Acknowledgment
The author would like to thank everyone who helped in this study. I am grateful to Agus Setiawan Head of the data and information center field, for warm support and thoughtful guidance. Also, to all of the staffs department public work service in Semarang city.

References
[1] A. K. Sen, A. Bagchi, and W. Zhang, 2004. Average-case analysis of best-first search in two representative directed acyclic graphs,” *Artif. Intell.*, **155**(1–2), pp. 183–206
[2] M. Jiang, H. Liu, and L. Niu, 2016. The evaluation studies of regional transportation accessibility based on intelligent transportation system—take the example in Yunnan Province of China, *Proc. - 2015 Int. Conf. Intell. Transp. Big Data Smart City, ICITBS 2015*, pp. 862–865
[3] O. Dib, M. A. Manier, and A. Caminada, 2015. Memetic algorithm for computing shortest paths in multimodal transportation networks,” *Transp. Res. Procedia*, **10**, no. July, pp. 745–755
[4] A. Khani, 2019. An online shortest path algorithm for reliable routing in schedule-based transit networks considering transfer failure probability,” *Transp. Res. Part B Methodol.*, **126**, pp. 549–564, 2019.
[5] D. M. Breuker, H. J. Van den Herik, J. W. H. M. Uiterwijk, and L. V. Allis, 2001. A solution to the GHI problem for best-first search,” *Theor. Comput. Sci.*, **252**(1–2), pp. 121–149
[6] S.-Y. Choi, C.-D. Yoon, and M.-C. Shin, 2003. Feeder Reconfiguration Using Cyclic Best-First Search,” *IFAC Proc. 36*(20), pp. 1097–1102.
[7] Y. Permanasari & Ravi A. Salim, 2006. Representasi Jalur (Path) Pada Traveling Salesman Problem Untuk Menentukan Jarak Terpendek Menggunakan Algoritma Genetika,” *J. Mat.*, **6**(1), pp. 55–62
[8] M. Ichwan, Y. I. N, and A. Pahlevi, 2018. Implementasi Metode Best First Search untuk Pembelajaran Matematika Berbasis Multimedia Interaktif,” *MIND J.*, **1**(1), pp. 38–50, 2018.
[9] A. Juniansyah, 2016. Aplikasi Penentuan Rute Terpendek Untuk Bagian Pemasaran, **12**(1), pp. 31–40
[10] R. Adipranata, A. Handojo, and H. Setiawan, 2007. Aplikasi Pencari Rute Optimum Pada Peta Guna Meningkatkan Efisien waktu Tempuh Pengguna Jalan Dengan Metode a* Dan Best First Search,” *J. Inform.*, **8**(2), pp. 108–108.
[11] U. Hacizade and I. Kaya, 2018. GA Based Traveling Salesman Problem Solution and its Application to Transport Routes Optimization,” *IFAC-PapersOnLine*, **51**(30), pp. 620–625.