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Optimalization Route to Tourism Places in West Java Using A-STAR Algorithm

Muhammad Herlambang Prakasa Yudha*, Sudradjat Supian, Herlina Napitupulu

Departement of Mathematics, Faculty of Mathematics and Natural Science, Universitas Padjadjaran, Sumedang, Indonesia

Email: muhammad16088@mail.unpad.ac.id

ABSTRACT

Indonesia has many tourism places, one of which is West Java Province. Tourist places in West Java Province are scattered in various regions, then many roads can be passed by tourists to reach these tourist places. West Java also has a complex route; therefore, an optimal route is needed to pass the complex route to tourism places in West Java Province. Based on these problems, the algorithm used is the A-STAR Algorithm. The purpose of this research is to use the A-STAR Algorithm to find the optimal route to tourism places which is influenced by distance and traffic density. The steps taken are to describe all the main lines in West Java into a graph, then process the data that has been obtained from several government agencies in the province of West Java so that it can be solved using the A-STAR Algorithm. The results of the calculation of the A-STAR Algorithm can produce an optimal route. By using the help of python, the optimal route to tourism in the Province of West Java can be obtained. This optimal route can help tourists to go to tourism places with the shortest distance in the province of West Java.

Keywords: A-STAR algorithm; optimal route; road density; graph.

INTRODUCTION

Tourism is a variety of tourism activities and is supported by various facilities and services provided by the community, businessmen, government, and local governments. Each region throughout Indonesia has a variety of diversity and uniqueness of each, the province of West Java is one of them. West Java Province has tourism spots scattered in each district and city. This province has all the potential of mountains, seas, beaches, rice fields, valleys, waterfalls, and local wisdom. West Java Province has a complex route one of them is traffic density, where the route is one of the tools used to reach tourism places.

Optimal route search has been widely applied to various navigation applications. The process of finding the optimal route finding the smallest cost or value of a route from the starting nodes to the destination nodes. Optimal route search techniques that are often used are; blind search and heuristic search. Blind search is easier to understand than heuristic search, but the solution search time is faster and the results obtained are more varied than the heuristic search [1]. One of the optimal route search algorithms using heuristic search is the A-STAR Algorithm. This algorithm is a planning method that can be applied to situations where information about the global

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environment has been obtained and also has a heuristic value that can be used as a basis for consideration [2], [3].

Several previous studies have discussed finding the optimal route using the A-STAR Algorithm. Research and testing on the application of finding the closest culinary route in Bandar Lampung, it was concluded that the tests carried out on the algorithm manually and the application got valid results with the same distance [4]. Determining the best route can be done with the A-STAR Algorithm, this simulation determines the starting nodes to the end nodes with the obstacles given in each route and gets the best route compared to other routes [1]. The search for the closest route between hospitals in Samarinda is obtained using the A-STAR Algorithm [2]. The A-STAR algorithm generates the shortest path for making roguelike games in the process of pursuing enemies against the player character. [5]. semi-optimized crane placement and configuration in a modular construction was successful in resulting in significant total cost reductions compared to lift planning algorithms [6].

Based on the description above, the motivation for this research is to use the A-STAR Algorithm to find the optimal route which is affected by the distance and road density to tourist places in West Java Province. The parameter that is used to obtain the optimal route is the distance unit, with the use of four-wheeled vehicles. The road used in the study is a two-way road.

METHODS

The method used in this research is the A-STAR Algorithm. In finding the shortest route with this algorithm, the route is drawn using a graph. In this graph, each edge has two values, namely the weight value, and the heuristic value. Then the A-STAR Algorithm calculates the weight value at the nth node plus the heuristic value at the nth node. After that, the algorithm calculates the weight value of the $n-1$ node to the nth node plus the heuristic value of the nth node until it reaches the destination node. When the optimal value has been obtained, the algorithm performs a callback to call the route that has been passed or can be referred to as the optimal route.

Graph

A graph is a configuration of edge pairs and vertices. Many things can be represented as a graph, for example, a highway as an edge and a bus station as a node [7]

A linear graph or graph $G = (V, E)$ consists of a non-empty set of $V = \{v_1, v_2, v_3, \dots\}$ called vertices or nodes, and the set $E = \{e_1, e_2, e_3, \dots\}$ called edge that connects a pair of vertices [8]. A graph G is called connected if every node of the graph has a path connecting the two vertices, or it can be said to be connected if a node v_i and v_j there is at least one edge [9]. If e is an edge, then $e = (v_i, v_j)$ where v_i and v_j are different elements of V. Edge $e = (v_i, v_j)$ is a pair of vertices v_i and vertices v_j, for an undirected graph, can also be denoted as $v_i v_j$ or $v_j v_i$ [1].

Graphs can be implemented for optimal route finding. Intersections, starting nodes, and ending nodes are represented as vertices. Then, the length of the road segment is represented as an edge.

Shortest Path Problem

The shortest route problem is a problem to find a path between two or more vertices in a weighted graph, the weight sought is the weight of the smallest edge that traversed [2], [10]. The shortest route problem is an optimization problem that uses a weighted graph, where the weights can represent the distance between cities, delivery times, travel costs, and so on [10]. The shortest route obtained will optimize a special linear function of the route in the form of distance, time, and or costs that will be faced during the trip [9]. The shortest route problem can be applied to both directed and undirected graphs [11].

Several kinds of shortest path problems, among others; Search for the shortest path between two nodes, search for the shortest path between all pairs of nodes, search for the shortest path from a certain node to all other nodes, and search for the shortest path between two nodes that pass through certain nodes [8].

Decision Tree

A tree in Discrete Mathematics means an undirected graph that is connected and does not contain circuits [12]. A tree has many applications such as; expression tree, binary search tree, prefix code, Huffman code, and decision tree [12].

Decision trees have many advantages in modeling optimization problems, including; being easy to interpret, easy to understand, allowing for exploring all possibilities, more accurate in terms of modeling, and complex decision-making can be changed to be simpler [12].

A-STAR Algorithm

Optimal route-finding algorithms have played many important roles in various scientific disciplines such as cybernetics, satellite navigation systems for vehicles on highways, vehicle path planning, and robotic path planning [6]. The A-STAR Algorithm is the best first search algorithm because it modifies the heuristic value, this algorithm minimizes the total cost of the path and under the right conditions can provide the best solution with optimal time [13]. In 1968 Peter Hart, Nils Nilsson, and Bertram Raphael of the Stanford Research Institute described the A-STAR Algorithm for the first time. The algorithm is an extension of Dijkstra's Algorithm which produces better time performance by using heuristic values [14].

The heuristic function contained in the A-STAR Algorithm to calculate the estimated value of a node that has been traversed is [15].

$$F(n) = G(n) + H(n) \quad (1)$$

where
$F(n)$: total estimated cost
$G(n)$: cost from starting node to nth node
$H(n)$: estimated cost to arrive at a destination from the n-th node

The A-STAR Algorithm uses two list, namely OPEN and CLOSED. OPEN is a list that is used to store nodes/vertices that have been calculated and their heuristic values have also been calculated but have not been selected as the best node ($F(n)$). In other words, the list contains nodes that still have a chance to be selected as the best node. CLOSED is a list to store the nodes that have been calculated and have been selected as the best node ($F(n)$). In other words, the opportunity to be selected from the nodes in CLOSED does not exist (Dalem, 2018). In the A-STAR Algorithm, the value of each iteration of the OPEN list is compared and the smallest value is selected. Then the value of the next OPEN list is calculated and then compared with other $F(n)$ values. When the value of $F(n)$ is the smallest and there is a destination node, then the iteration stops.

RESULT AND DISCUSSION

Case Study

The A-STAR Algorithm can be used when the processed data has a heuristic value which is a benchmark for calculations in the algorithm. In this study, the data were secondary data obtained from several related Departement in the Province of West Java. The data used are as follows: 2016 track distance data from the Department of Spatial Planning; 2016 provincial traffic density data from the Department of Transportation; and 2019 tourism places data from the Department of Tourism and Culture. The form of data obtained is data on distances between provincial boundaries, the road ends, and intersections. The data can be seen at the link https://bit.ly/3oiddGc.

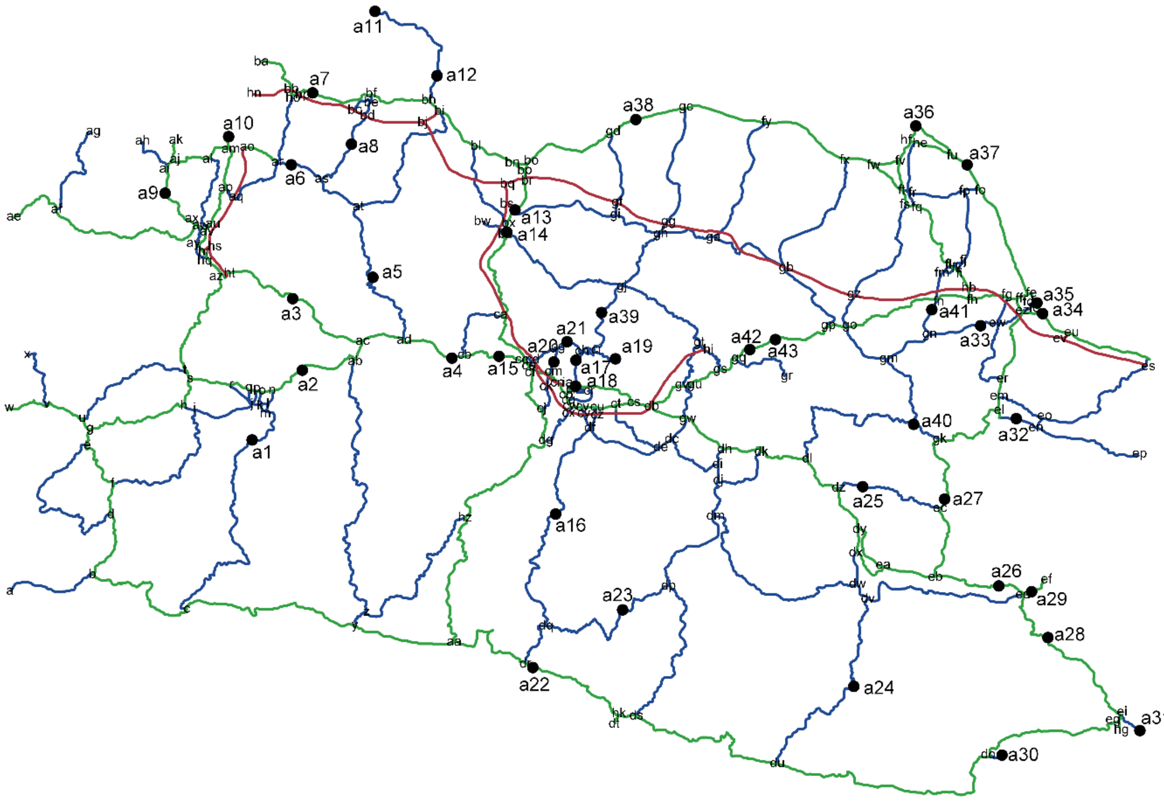


Figure 1. Provincial, National Toll Road, National Non-Toll Road, and West Java Province Tourism Places

Figure 1 is a combination of the Provincial Road (Blue), National Non-Toll Road (Green), and National Toll Road (Red) in 2016. Then, on the Provincial Road, the density value is obtained from the value of the volume of the road divided by the capacity of the road with a value range of 0.00 – 1.00 from the Department of Transportation of West Java Province which was managed in 2016. Non-Toll National Route with the distance value between each node obtained with the help of Google Maps. The Department of Transportation of West Java Province does not have density data from the National Non-Toll Road because the route is managed by the Ministry of Transportation, then the lane is considered to have 0 density value. National Toll Road with the value of the distance between each node obtained with the help of Google Maps. If the toll road is considered unimpeded, then the lane is considered to have 0 density value.

Figure 1 contains 239 nodes stating: provincial boundaries; road boundaries; intersections; and tourism in West Java Province A total of 208 nodes are: provincial boundaries; road boundaries; and intersections. Furthermore, there are 43 tourism places adjacent to the main route in West Java Province. Then the tourism place is drawn by passing the nearest route (regency/city road or village road) so that the node that states the tourism place is located on the main route. However, among the 43 nodes resulting from the withdrawal of the tourism sites, there are 11 nodes adjacent to the provincial boundary nodes, road boundaries, and intersections. Thus, 11 of the 208 nodes were converted into tourism nodes, and 32 other tourism nodes were added. Apart from the 43 tourism places nodes, the rest of the nodes are used as starting nodes. Complete data related to road names, calculating distances and density values of the 239 interrelated nodes can be seen in full at the link https://bit.ly/3oiddGc.

Table 1. Tourist Places from Each City/Regency

City/Regency	Node	Tourism Places
Kabupaten Kota Sukabumi	a1	Curug Bibijilan
	a2	Bukit Sabak
Kabupaten Cianjur	a3	Taman Wisata Alam Sevillage
	a4	Wana Wisata POKLAND
Kabupaten Kota Bogor	a5	Wana Wisata Rusa
	a6	Taman Buah Mekarsari
Kabupaten Kota Bekasi	a7	Gedung Juang
	a8	Taman Buaya Indonesia Jaya
Kota Depok	a9	Taman Herbal Insani
	a10	Taman Rekreasi Wiladatika
Kabupaten Karawang	a11	Candi Jiwa
	a12	Sian Djin Ku Poh Temple
Kabupaten Purwakarta	a13	Green Valley Waterpark
	a14	Bale Panyawangan Diorama Nusantara
Kabupaten Bandung Barat	a15	Gua Pawon
		Stone Garden Citatah
Kabupaten Bandung	a16	Situ Cileunca
	a17	Farm House Susu Lembang
Kota Bandung	a18	Alun Alun Kota Bandung
	a19	Bukit Moko
Kota Cimahi	a20	Alam Wisata Cimahi
	a21	Curug Tilu Leuwi Opat
Kabupaten Garut	a22	Pucak Guha
	a23	Curug Sanghyang Taraje
Kabupaten Kota Tasikmalaya	a24	Taman Wisata Curug Cikoja
	a25	Wisata Alam Pasir Kirisik
Kabupaten Ciamis	a26	Wisata Alam Ciung Wanara
	a27	Objek Wisata Situ Wangi
Kota Banjar	a28	Curug Panganten
	a29	Ecopark Kota Banjar
Kabupaten Pangandaran	a30	Batu Karas
	a31	Pantai Karapyak
Kabupaten Kuningan	a32	Wisata Bukit Panembongan
	a33	Telaga Remis Pasawahan
Kabupaten Kota Cirebon	a34	Pantai Kejawanan
	a35	Keraton Kasepuhan Cirebon
Kabupaten Indramayu	a36	Museum Bandar Cimanuk
	a37	Pantai Tirtamaya

Kabupaten Subang	a38	Wisata Buaya Blanakan
	a39	Pemandian Air Panas Ciater
Kabupaten Majalengka	a40	Curug Cilutung
	a41	Taman Wisata Alam Cadas Gantung
Kabupaten Sumedang	a42	Cadas Pangeran
	a43	Curug Cipongkor

Table 1 describes two names of tourism places given from each city/regency in West Java Province.

Numeric Result

How to calculate the A-STAR Algorithm is done as in the example below:

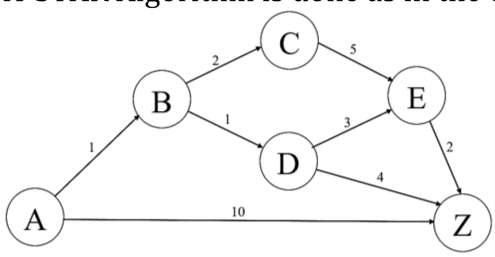


Figure 2. Graph for A-STAR Algorithm Example

Given the value of $H(n)$ at nodes AB, AZ, BC, BD, CE, DE, DZ, and EZ sequentially, namely 5, 3, 4, 2, 6, 3, 1, and 2. Based on Figure 2, the route from the starting node to the destination node can be modeled as follows

1 $A \to B = F(n) = G(n)_{AB} + H(n)_{AB}$

$A \to Z = F(n) = G(n)_{AZ} + H(n)_{AZ}$

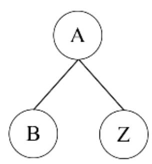
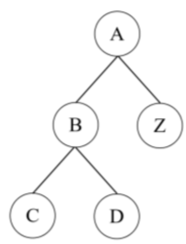
2 $A \to B \to C = F(n) = G(n)_{ABC} + H(n)_{BC}$

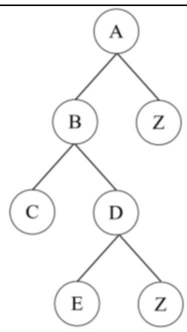
$A \to B \to D = F(n) = G(n)_{ABD} + H(n)_{BD}$

3 $A \to B \to D \to E = F(n) = G(n)_{ABDE} + H(n)_{DE}$

$A \to B \to D \to Z = F(n) = G(n)_{ABDZ} + H(n)_{DZ}$

Table 2. Decision Tree Drawing

Iteration	*OPEN list*	*CLOSED list*	*Hold*	Decision Tree
0	$B - Z$	A	$-$	
1	$C - D - Z$	$A - B$	Z	
2	$C - E - Z$	$A - B - D$	$C - Z$	

Iteration	*OPEN list*	*CLOSED list*	*Hold*	Decision Tree
3	$-$	$A-B-D-Z$	$-$	

The flow used by A-STAR Algorithm starts with the initial node initiation into the OPEN list then the Current Node (the current node) is made the Best Node (F score). As long as the Current Node is not the destination node, then move the Current Node into the CLOSED list. Then calculate and compare the F score values of all OPEN lists. After the Current Node with the smallest F score value is the destination node, then the iteration is stopped and performs a backtrack to display the route.

Python is used to help find the Optimal Route by using Equation (1) where $F(n)$ is the total distance value, $G(n)$ is the distance from the starting node to the nth node, and $H(n)$ is a heuristic estimate of traffic density between nodes.

Numerical is done by finding the optimal route which is the optimal distance and the route traversed by the A-STAR Algorithm. The initial node used is the southwest node of West Java Province in Sukabumi Regency (node a), with the destination node being 43 Tourism Places nodes. The route column in Table 2 is depicted with symbols representing provincial boundary nodes; road boundaries; and intersections. between these nodes is the name of the road traversed by the optimal route generated from the A-STAR Algorithm. Full data on the road can be seen at the link https://bit.ly/3oiddGc.

Table 3. Distance and Route from Node a to Tourist Places

Destination Node	Tourism Places	Distances	Route
a1	Curug Bibijilan	128.36	a, b, c, a1
a2	Bukit Sabak	141.24	a, b, d, f, i, j, q, p, o, n, a2
a3	Taman Wisata Alam Sevillage	180.84	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, a3
a4	Wana Wisata POKLAND	179.04	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4
a5	Wana Wisata Rusa	199.84	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a5
a6	Taman Buah Mekarsari	213.71	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, aq, ao, ar, a6
a7	Gedung Juang	239.67	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, aq, ao, ar, ho, hp, a7
a8	Taman Buaya Indonesia Jaya	242.91	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, aq, ao, ar, a6, as, a8
a9	Taman Herbal Insani	191.81	a, b, d, f, i, h, s, t, az, hq, ay, aw, ax, a9
a10	Taman Rekreasi Wiladatika	197.01	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, am, a10
a11	Candi Jiwa	310.50	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, aq, ao, ar, a6, as, a8, bd, be, bf, bh, a12, a11
a12	Sian Djin Ku Poh Temple	284.31	a, b, d, f, i, h, s, t, az, hq, ay, av, au, ap, aq, ao, ar, a6, as, a8, bd, be, bf, bh, a12

Destination Node	Tourism Places	Distances	Route
a13	Green Valley Waterpark	244.34	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, ca, bz, a14, bx, a13
a14	Bale Panyawangan Diorama Nusantara	238.54	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, ca, bz, a14
a15	Gua Pawon Stone Garden Citatah	195.64	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, a15
a16	Situ Cileunca	230.98	a, b, c, y, z, hz, dg, cx, cy, df, a16
a17	Farm House Susu Lembang	219.32	a, b, c, y, z, hz, dg, cx, cw, cq, co, cl, a18, a17
a18	Alun Alun Kota Bandung	214.31	a, b, c, y, z, hz, dg, cx, cw, cq, co, cl, a18
a19	Bukit Moko	232.12	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, a15, cc, cd, cg, a21, ch, ci, a19
a20	Alam Wisata Cimahi	214.54	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, a15, cc, ce, cf, cm, a20
a21	Curug Tilu Leuwi Opat	215.94	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, a15, cc, cd, cg, a21
a22	Pucak Guha	167.90	a, b, c, y, aa, dr, a22
a23	Curug Sanghyang Taraje	220.73	a, b, c, y, aa, dr, dq, a23
a24	Taman Wisata Curug Cikoja	270.60	a, b, c, y, aa, dr, a22, hk, ds, du, a24
a25	Wisata Alam Pasir Kirisik	293.51	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, dz, a25
a26	Wisata Alam Ciung Wanara	341.01	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, dz, dy, ea, eb, a26
a27	Objek Wisata Situ Wangi	316.91	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, dz, a25, ec, a27
a28	Curug Panganten	355.71	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, dz, dy, ea, eb, a26, ed, a28
a29	Ecopark Kota Banjar	350.11	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, dz, dy, ea, eb, a26, ed, a29
a30	Batu Karas	292.25	a, b, c, y, aa, dr, a22, hk, ds, du, do, a30
a31	Pantai Karapyak	342.20	a, b, c, y, aa, dr, a22, hk, ds, du, do, eg, ei, a31
a32	Wisata Bukit Panembongan	363.67	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, a40, gk, el, a32
a33	Telaga Remis Pasawahan	335.67	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, gm, gn, a33
a34	Pantai Kejawanan	350.61	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, fn, fh, fg, ff, ez, a34
a35	Keraton Kasepuhan Cirebon	349.81	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, fn, fh, fg, ff, fe, a35
a36	Museum Bandar Cimanuk	359.31	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, gz, fs, ft, fv, hf, a36
a37	Pantai Tirtamaya	362.15	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, fn, fm, fk, fj, fp, fo, a37
a38	Wisata Buaya Blanakan	285.94	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, ca, bz, a14, bx, a13, br, bp, bo, gd, a38
a39	Pemandian Air Panas Ciater	253.08	a, b, d, f, i, j, q, p, o, n, a2, ab, ac, ad, a4, cb, a15, cc, cd, cg, a21, ch, ci, a39
a40	Curug Cilutung	326.31	a, b, c, y, z, hz, dg, cx, cy, cz, db, gw, dh, dk, dl, a40

Destination Node	Tourism Places	Distances	Route
a41	Taman Wisata Alam Cadas Gantung	323.81	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43, gp, go, fn, a41
a42	Cadas Pangeran	251.11	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42
a43	Curug Cipongkor	254.51	a, b, c, y, z, hz, dg, cx, cy, cz, db, hi, gs, gq, a42, a43

Based on Table 3 for the tourism destination of Curug Bibijilan (node a1), the optimal route chosen is a, b, c, a1. In other words, the route it takes is Jl. Raya Ciracap – Jl. Surade – Tegalbuleud – Jl. Sagaranten – Cidolog - Curug Bibijilan with a route distance of 128.36 km. All search results for the optimal route along with the road names from each point can be seen at the link https://bit.ly/3oiddGc. Based on these numerical results, the conclusion that can be drawn is that optimizing the route to tourism in West Java using the A-STAR Algorithm can produce an optimal route. In particular, it can be concluded that the search for optimal routes that are affected by Distance and Traffic Density can be solved by the A-STAR Algorithm.

CONCLUSIONS

Based on the research, the A-STAR Algorithm can be used when information about the distance and traffic density has been obtained. In this case, traffic density becomes a heuristic value that can be used as a basis for consideration. It can be concluded that the optimal route which is affected by the distance and traffic density can be found using the A-STAR Algorithm. This research can also help tourists to get through the most optimal route to tourism places in West Java Province.

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