ISSN:2302-8149
e-ISSN:2540-9719

Determining Travel Time and Fastest Route Using Dijkstra Algorithm and Google Map

[1]Suardinata*, [2]Rusdisal Rusmi, [3]Muhammad Amrin Lubis
Information System, STMIK Indonesia Padang,
Padang, Sumatera Barat 25137, Indonesia
*e-mail: suardinata@stmikindonesia.ac.id

(***received***: 30 Desember 2021, ***revised***: 24 Februari 2022, ***accepted***: 25 Maret 2022)

Abstract:

Dijkstra's algorithm is commonly used to determine the shortest route connecting a point as a starting node to another which acts as the end node. In this study, the UNP student dormitory acted as the starting node, while the library which is frequently visited by students was sampled from the campus as the end node. Due to the fact that students generally live around campus and move on foot, an alternative route is needed to determine the fastest travel time. Therefore, this study aims to determine the route with the fastest travel time from the start to the end of nodes using the Dijkstra algorithm, in comparison with the route displayed by Google Map. Data were obtained from Google Map, which showed the availability of many routes with the possibility of students taking the fastest travel time. The results show that by using the Dijkstra algorithm there are 14 alternatives pedestrian routes with the fastest travel time of 15 minutes, while with Google map there are 3 alternative routes with the fastest travel time of 21 minutes. Based on these data, it is concluded that the travel time through the fastest route obtained using the Dijkstra algorithm was 6 minutes faster than data found in the Google Map.

Keywords: *Travel time, fastest route, Dijkstra Algorithm, Google Map.*

1 Introduction

The shortest path problem uses the graph theory to calculate a path between two nodes or vertices such that the sum of the weights of its constituent edges are minimized. Therefore, to determine the shortest path between the nodes of a graph, different algorithms like Bellman-Ford [1], Dijkstra [2], Floyd-Warshall [3], Johnson [4] and [5] are frequently used. Some of the reasons the authors use the Djikstra algorithm are because there are many references, this algorithm is used in many similar studies to determine the shortest distance, for example to save fuel, time and energy [6], search for trans Semarang bus routes [7] and also other researchers [8];[9];[10].

Padang State University (UNP) is one of the tertiary institutions in West Sumatera Province, located in the city of Padang. This campus is for students within and outside of this province to continue their education to a higher level. Generally, students of UNP temporarily live in rented dormitories located around the campus [7]. These students come from families with varying levels of economic ability [9] ranging from low to high. In addition, there is a yearly increase in campus capacity with 3,203 new students in /2019 academic year thereby, leading to road congestion due to a rise in the number of road users.

Some factors considered by students when choosing dormitories include distance, rent cost, route, travel time to campus, room facilities and the availability of public facilities. However, this research only considered the time and route criteria taken from the UNP student dormitory located in Patenggangan Street No.14e, Parupuk Tabing Village, Koto Tangah District, Padang City, West Sumatera Province with zip code 25173, and the central library located in the front of the UNP FMIPA building. This dormitory was used as a sample to carry out this research, and it was also referred to as the starting node because it represented students in all faculties at UNP meanwhile the library was used as a destination due to its importance and daily use by students to carry out researches, read books and sort for kinds of literature.

The route taken by pedestrian students is also accessible by cars. However, this study only examined those walking because its location is spread close to the UNP campus and the trip is relatively short. Data displayed by Google Map (https://www.google.co.id/maps/dir) shows that the normal travel time on foot from the dormitory to library ranges from 21-25 minutes with 3 alternative routes namely (1) Srigunting street with a travel time of 21 minutes and distance of 1.7 km, (2) Walet street with a travel time of 24 minutes and a distance

ISSN:2302-8149
e-ISSN:2540-9719

of 2.0 km and (3) Bhakti / Ikhwanul Muslimin street with a travel time of 25 minutes and a distance of 2.0 km as shown in Figure 1.

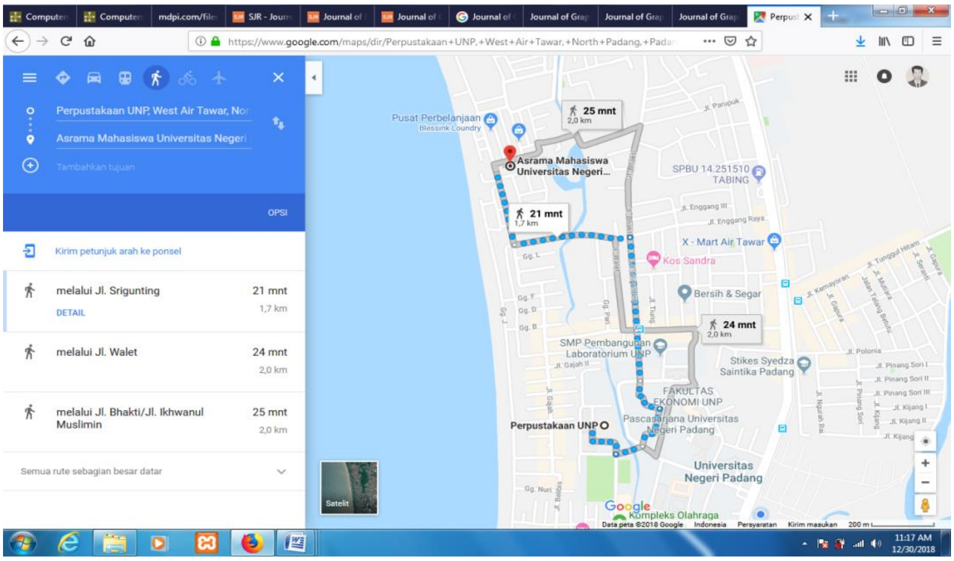

Figure 1. Road Map from the UNP Student Dormitory to the UNP Campus Library with Google Map (Source: [8]

The field surveys using time and distance data between location points displayed by Google Map showed that there were many alternative routes to the dormitory and library. Therefore, it is important to determine other alternative routes that are better than those available on the Google map.

2. Literature Review

According to previous studies, determining the shortest route to the dormitory and library is one of the solutions to the problem [10];[11]; [12] and [13]. For example, the searching for the shortest distance is represented by a game board with starting and finish nodes. Using of this Djikstra algorithm to optimize the route for vehicle evacuation Incidents or emergency events that often occur in the community. Society or government needs major emergency evacuation movement of people from the incident area to a safe area in the event of an emergency, causing urban traffic jams and even system. [18] said in his research, it is an important issue in the field of public safety that how to use the fastest speed to evacuate crowd to a safe area after the incident. In an emergency evacuation, it is necessary to provide the shortest path from a the specified origin node to another destination node and use the shortest time in the entire evacuation process [18]. However, the board comprises of several obstacles, therefore, it is essential to determine the shortest distance passed from the start to the finish points [13]. According to [14] students or newcomers, they have difficulty in determining routes when planning a trip, locating the UNP building, library, dormitories and culinary due to the unavailability of data describing these areas for this moment.

2.1 The Shortest Path Algorithm

The shortest path algorithm is widely applied in various fields of science and engineering, such as road network applications, transportation, routing in communication channels and scheduling problems to determine the shortest distance [15]. Several shortest path algorithms are widely known, including Dijkstra, Floyd, Two Queues [12] and Branch & Bound Algorithms [13] and [16]. According to (Kuliner et al., 2016;Ardana & Saputra, 2016), the Dijkstra algorithm is a method used to solve the problem of finding the shortest route, and the production process with minimal costs [17]. The research is also used to locate the shortest path based on the smallest weight from one point to another. The Dijkstra method calculates all the smallest possible weights of each point and line that represents the building and road, respectively [10]. In this research also utilized the Dijkstra Algorithm to determine the fastest travel time and shortest distance or routes between the UNP Student Dormitory and Library.

ISSN:2302-8149
e-ISSN:2540-9719

2.2 Dijkstra Algorithm

This algorithm is also known as the "Greedy Algorithm," discovered by Edsger W. Dijkstra and published in 1959 [19], [20] in a journal Numerische Mathematic entitled "A Note on Two Problems in Connections with Graphs." Dijkstra is one of the popular algorithms used in solving optimization related problemsand in determining the shortest path.It has a minimum length from vertex a to z in a weighted graph, which is a positive number, therefore, it cannot be passed by negative nodes, as stated in the following expressions [21].

- The length of a trajectory in a weighted graph is the sum of the weights $-(u, v)$denoted by $l(u, v)$. For example $v_1, v_2, \cdots, v_n$, is a path with a starting node v_1 and ending node v_n, then the length of the path $-(v_1, v_n)$ is expressed by:

$$(v_1, v_n) = \sum_{i=1,\, 2,\, \cdots,\, n-1} w(v_i, v_{i+1}) \qquad (1)$$

- The shortest path with the initial v_0 and end nodes v_k is defined as a path with a minimum length from v_0 to v_k.

  If there are m different paths, then the shortest is between v_0 and v_k expressed as

$$l_t(v_0, v_k) = \min_{i=1,\cdots,m} l_i(v_0, v_k) \qquad (2)$$

The Dijkstra algorithm is used to solve problems associated with the travel time and the shortest distance between the initial and final nodes in a network. The idea associated with this algorithm is to calculate the shortest distance from the initial node while avoiding longer distances when adding networks. The interconnection of nodes and branches is called a network.

3. Reserach Method

This research method is to explain how to determine the distance or the shortest route with the Djikstra algorithm experimental approach, the Djikstra algorithm Pesudocode using google maps to determine the point that connects the UNP student dormitory with the UNP Padang library.

This research is started from research preparation, namely surveys and data collection (data taken from the field and from the google map), collecting literature studies from previous researchers, then selecting tools that are appropriate to the research, namely the djikstra algorithm and using google maps, recognizing and identifying problems, conducting research survey and re-collection of data, collecting previous research including collecting, processing, comparing, writing and writing research, building and implementing it into the Djikstra Algorithm, building Pseudocode Djikstra algorithm, finding results and discussing and concluding research results. This explanation can be seen and illustrated in Figure 2 below.

ISSN:2302-8149
e-ISSN:2540-9719

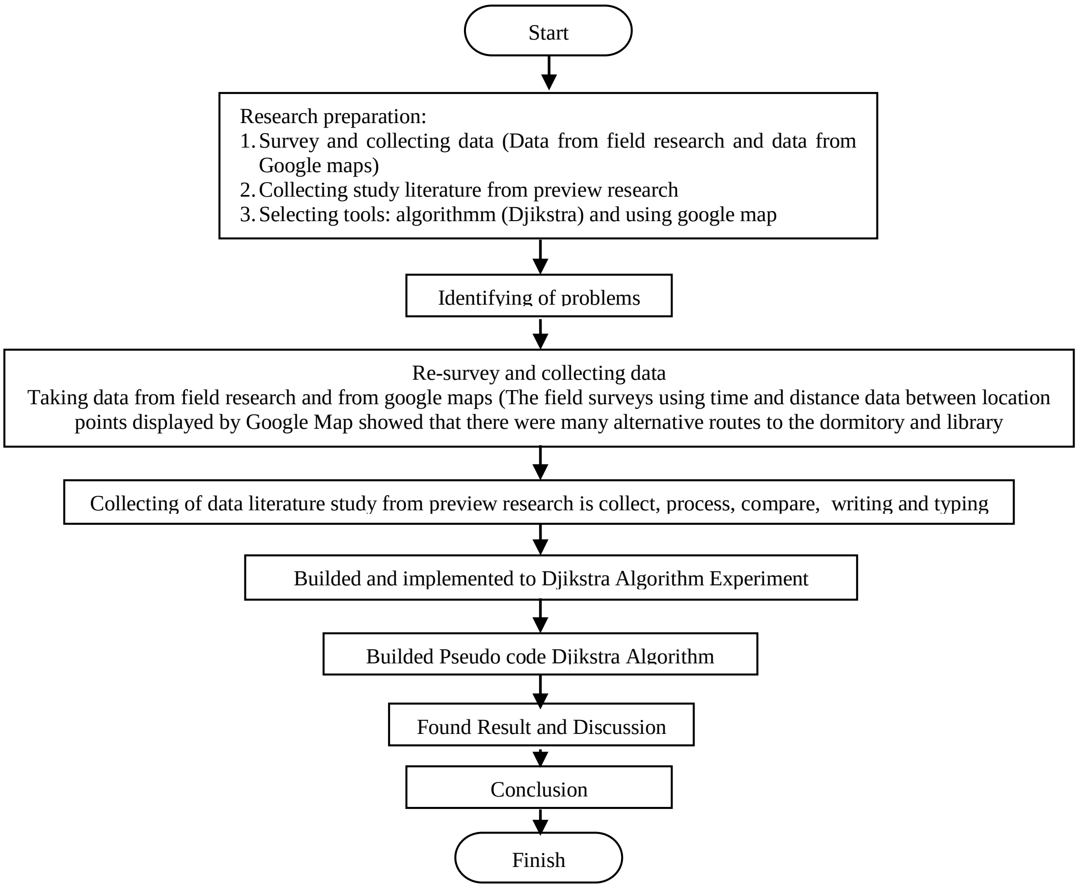

Figure 2. Research Method framework

3.1 Dijkstra Algorithm Experiment

a. Select the starting node (Node 0 / UNP student dormitory).
b. Determine the nodes that are directly connected to the initial.
c. Choose the node with the fastest travel time.
d. Make a permanent setting that connects the initial and the selected nodes in step 1.
e. Determine all nodes that are directly related to those in permanent settings.
f. Choose the node with the fastest travel time and directly related to those on the permanent settings.
g. Repeat steps 4, 5 and 6 until the final node (Node T / UNP Library) is incorporated in the permanent settings.

3.2 Pseudo Code Dijkstra Algorithm

```
function Dijkstra(Graph, source):
for each vertex v in Graph:        // Initialization
dist[v] := infinity // initial distance from source to vertex v is set to //infinite
previous[v] := undefined   // Previous node in optimal path from source
dist[source] := 0   // Distance from source to  source
Q := the set of all nodes in Graph // all nodes in the graph are //unoptimized - thus
are in Q
while Q is not empty:       // main loop
u := node in Q with smallest dist[ ]
remove u from Q
for each neighbor v of u:  // where v has not yet been removed from Q.
alt := dist[u] + dist_between(u, v)
if alt <dist[v]     // Relax (u,v)
dist[v] := alt
previous[v] := u
return previous[ ]
```

Figure 3. Dijkstra's Pseudo Code Algorithm [22]

ISSN:2302-8149
e-ISSN:2540-9719

4. Result and Discussion

The results and discussion associated with the Network Map between the UNP Student Dormitory are shown in Figure 4 and Table 1. The field surveys which were used to obtain the time data between locations of the UNP Library from Google Map as well as the Data Processing Results using the Dijkstra Algorithm are shown in Tables 2 and 3.

4.1. Network Map between The UNP Student Dormitory and the UNP Library

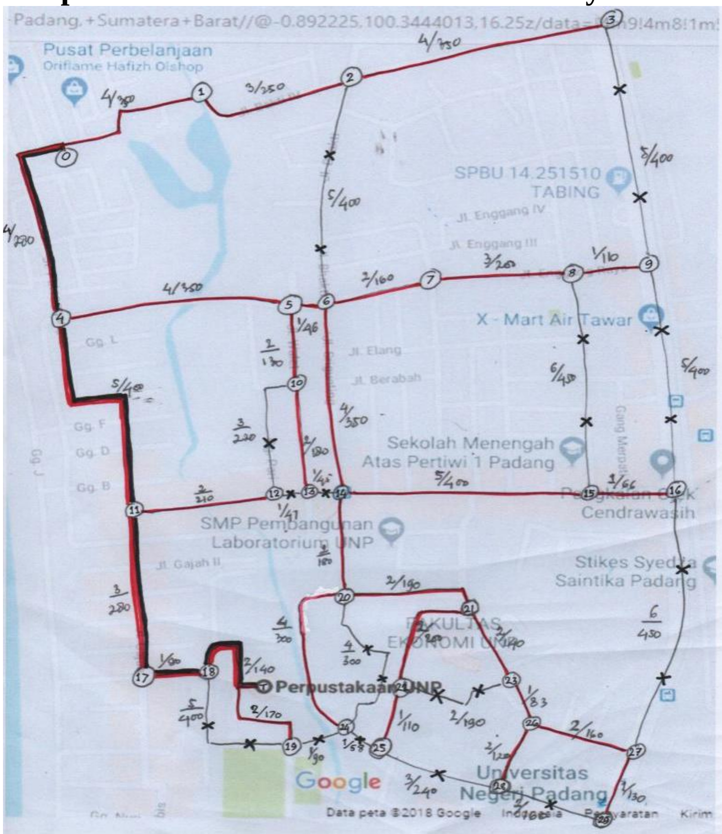

Figure 4. Network map between the UNP Student Dormitory and the UNP Library

Table 1 Caption of Figure 4.

Symbols	Description
x—x	Branch that is not recommended
a •—x/y—• b	X is the travel time (minutes), y is the distance (m) from node a to node b obtained from google map by making a as source and b as destination
—	Branches that can be traversed but not the fastest route
═	The branch that is traversed with the fastest route
0	UNP Student Dormitory
1	The intersection of Bakti Street
2	The Intersection of Ikhwanul Muslimin Street
3	T-junction of Parupuk Tabing Street
4	The intersection of Patenggangan Street
5	T-junction of Walet Street
6	T-junction of Sri Gunting Street
7	T-junction of Tekukur Street
8	T-junction of Enggang Street
9	T-junction of Enggang Street from Hamka Street
10	T-junction of Walet Street-Pari Street
11	T-junction of Gajah street-Cendrawasih Street-Patenggangan Street

 ISSN:2302-8149
e-ISSN:2540-9719

12	T-junction of Cendrawasih Sreet-Pari Street
13	T-junction of Cendrawasih Street-Walet Street
14	The intersection of Sri Gunting Street-Gurami Street
15	T-junction of Merpati Street
16	T-junction of Hamka Street - Cendrawasih Street
17	The intersection of Gajah VI Street-Sri Gunting-Gurami Street
18	Entrance from Gajah VI Street to FMIPA UNP Campus
19	FMIPA UNP Campus Gate
20	The intersection of Gedung Micro Teaching UNP
21	T-junction in front of the UNP FE Library
22	T-junction in front of the UNP Postgraduate Building
23	T-junction in front of FIS UNP Building
24	T-junction in front of the Engku Syafei Building, LPMP UNP
25	T-junction of Jalan Teratai
26	T-junction in front of FIS UNP Building
27	T-junction on the left side of the UNP Rectorate building
28	T-junction behind the UNP Rectorate building
29	Main Gate of the UNP Campus
T	UNP Library Building

4.2. Alternative Route of the UNP Student Dormitory Towards the Library based on field surveys and time data between locations from the Google Map

In Figure 1, the Google Map showed 3 alternative routes accessible by walking from the UNP student Dormitory to the library with the fastest travel time of 21 minutes. Also, alternative routes were obtained based on surveys and using travel time between nodes from Google Map, as shown in table 2.

Table 2 Alternative Routes of the UNP Student Dormitory to the UNP Library based on Field Surveys and Time Data between Locations from the Google Map

No.	Routes	Time (minutes)
1	0-4-5-10-13-14-20-24-19-T	4+4+2+2+1+2+4+1+2=22
2	0-4-5-6-14-20-24-19-T	4+4+1+4+2+4+1+2=22
3	0-4-11-12-13-14-20-24-19-T	4+5+2+1+1+2+4=19
4	0-4-5-10-13-14-20-21-22-25-24-19-T	4+4+2+2+1+2+4+1+2=22
5	0-4-5-6-14-20-21-22-25-24-19-T	1+4+1+4+2+4+1+2=19
6	0-4-11-12-13-14-20-21-22-25-24-19-T	4+5+2+1+1+2+4+1+2=22
7	**0-4-11-17-18-T**	**4+5+3+1+2=15**
8	0-1-2-3-9-16-27-29-25-24-19-T	4+3+4+5+5+6+1+2+3+1+1+2=37
9	0-1-2-6-14-20-24-19-T	4+3+5+4+2+4+1+2=25
10	0-4-5-6-7-8-9-16-27-29-25-24-19-T	4+4+1+4+2+4+1+2=22
11	0-4-5-6-7-8-15-16-27-29-25-24-19-T	4+4+1+2+3+6+1+6+1+2+3+1+1+2=37
12	0-1-2-6-7-8-9-16-27-29-25-24-19-T	4+3+5+2+3+1+5+6+1+2+3+1+1+2=39
13	0-1-2-6-7-8-15-16-27-29-25-24-19-T	4+3+5+2+3+6+1+6+1+2+3+1+1+2=40
14	0-1-2-3-9-16-15-5+14-20-24-19-T	4+3+4+5+5+1+5+2+4+1+2=36

Out of the 14 routes shown in table 2, a route number 7: 0-4-11-17-18-T was obtained with the fastest travel time of 15 minutes.

ISSN:2302-8149
e-ISSN:2540-9719

4.3. Results of Data Processing Using Dijkstra's Algorithm

Table 3 The Fastest Time and Route taken by Pedestrian Students from the UNP Student Dormitory to the Librarywas obtained from the data processing results using Dijkstra's algorithm.

No.	Permanent Set	Branch	Time	Description
1	{O}	0 - 1	4	The Fastest Time
		0 - 4	4	
2	{O, 1}	0 - 4	4	The Fastest Time
		1 - 2	7	
3	{O, 1, 4}	1 - 2	7	The Fastest Time
		4 - 5	8	
		4 - 11	9	
4	{O, 1, 2, 4}	2 - 3	11	
		2 - 6	12	
		4 - 5	8	The Fastest Time
		4 - 11	9	
5	{O, 1, 2, 4, 5}	2 - 3	11	
		2 - 6	12	
		4 - 11	9	
		5- 6	9	The Fastest Time
		5 - 10	10	
6	{O, 1, 2, 4, 5, 6}	2 - 3	11	
		4 - 11	9	The Fastest Time
		5 - 10	10	
		6 - 7	11	
		6 - 14	13	
7	{O, 1, 2, 4, 5, 6, 11}	2 - 3	11	
		5 - 10	10	The Fastest Time
		6 - 7	11	
		6 - 14	13	
		11 - 12	11	
		11 - 17	12	
8	{O, 1, 2, 4, 5, 6, 10, 11}	2 - 3	11	The Fastest Time
		6 - 7	11	
		6 - 14	13	
		11 - 12	11	
		11 - 17	12	
		10 - 12	13	
		10 - 13	12	
9	{O, 1, 2, 3, 4, 5, 6, 10, 11}	6 - 7	11	The Fastest Time
		6 - 14	13	
		11 - 12	11	
		11 - 17	12	

ISSN:2302-8149
e-ISSN:2540-9719

		10 - 12	13	
		10 - 13	12	
		3 - 9	16	
10	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11}	6 - 14	13	
		11 - 12	11	The Fastest Time
		11 - 17	12	
		10 - 12	13	
		10 - 13	12	
		3 - 9	16	
		7 - 8	14	
11	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12}	6 - 14	13	
		11 - 17	12	
		10 - 13	12	The Fastest Time
		3 - 9	16	
		7 - 8	14	
		12 - 13	12	
12	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13}	6 - 14	13	
		11 - 17	12	The Fastest Time
		3 - 9	16	
		7 - 8	14	
		13 - 14	13	
13	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 17}	6 - 14	13	
		3 - 9	16	
		7 - 8	14	
		13 - 14	13	
		17 - 18	13	The Fastest Time
14	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 17, 18}	6 - 14	13	The Fastest Time
		3 - 9	16	
		7 - 8	14	
		13 - 14	13	
		18 - 19	18	
		18 - T	15	
15	{O, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 17, 18}	3 - 9	16	
		7 - 8	14	The Fastest Time
		18 - 19	18	
		18 - T	15	
		14 - 15	18	
		14 - 20	15	
16	{O, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 17, 18}	3 - 9	16	
		18 - 19	18	
		18 - T	15	The Fastest Time
		14 - 15	18	
		14 - 20	15	
		8 - 9	15	
		8 - 15	20	

 ISSN:2302-8149
e-ISSN:2540-9719

Table 3 shows that the fastest travel time needed by students from the dormitory to the library is 15 minutes.This timeframe was obtained by passing 7 routes as shown in table 1, namely 0 - 4 - 11 - 17 - 18 - T and the nodes in Figure 4. Figure 1, shows that the travel time is 6 minutes faster than the fastest time displayed by Google Map.

5. Conclusion

According to Table 2, there are 14 alternatives pedestrian routes were obtained using the Dijkstra algorithm, with a travel time of 15 minutes, namely 0 - 4 - 11 - 17 - 18 - T. Meanwhile, the data obtained from Google Map showed 3 alternative routes that could be taken by students from the UNP dormitory to the campus library with the fastest travel time of 21 minutes, namely routes 0 - 4 - 5 - 6 - 14 - 20 - 24 - 19 – T. Therefore, based on these findings, it is concluded that the travel time obtained using the Dijkstra algorithm is 6 minutes faster than those from the Google Map.

References

[1] R. Bellman, “On a routing problem,” *Tech. report, DTIC Doc.*, 1956.
[2] T. J. M. and P. L. Frana, “An interview with Edsger W. Dijkstra,” *Commun. ACM*, vol. Vol. 53, N, pp. 41-47., 2010.
[3] R. W. Floyd, “‘Algorithm 97: shortest path,’” *Commun. ACM*, vol. Vol. 5, No, p. 345., 1962.
[4] D. B. Johnson, “Efficient algorithms for shortest paths in sparse networks.,” *J. ACM*, vol. Vol. 24, N, pp. 1–13, 1977.
[5] Q. Abbas, Q. Hussain, T. Zia, and A. Mansoor, “Reduced solution set shortest path problem: Capton algoritm with special reference to Dijkstra’s algorithm,” *Malaysian J. Comput. Sci.*, vol. 31, no. 3, pp. 175–187, 2018, doi: 10.22452/mjcs.vol31no3.1.
[6] F. Ardiani, “Penentuan jarak terpendek dan waktu tempuh menggunakan algoritma Dijkstra dengan pemrograman berbasis objek.,” *Skripsi Univ. Islam Negeri Sunan Kalijaga*, 2011.
[7] KBBI, “Kamus Besar Bahasa Indonesia,” 2019. .
[8] Google, “Google Map,” 2019. .
[9] L. Lutfi, “Permasalahan Dalam Penetapan Level Uang.” Univesitas Negeri Padang, Padang, p. 2, 2013.
[10] D. Ardana and R. Saputra, “Penerapan Algoritma Dijkstra pada Aplikasi Pencarian Rute Bus Trans Semarang,” no. Snik, pp. 299–306, 2016.
[11] L. Joni, E. Dewi, and T. Lot, “Pencarian Rute Terpendek Tempat Wisata Di Bali Dengan Menggunakan Algoritma Dijkstra,” vol. 2010, no. Snati, pp. 2008–2011, 2010.
[12] Y. Purwananto, D. Purwitasari, and W. A. Wibowo, “Implementasi dan Analisis Algoritma Pencarian Rute Terpendek di Kota Surabaya,” *J. Penelit. dan …*, vol. 10, no. 2, pp. 94–101, 2005.
[13] B. F. Search and B. First, “Algoritma Branch _ And _ Bound Untuk Mencari Jarak Terpendek,” pp. 3–5, 2008.
[14] D. A. N. Kuliner, M. Metode, D. Sekitar, and U. D. Nuswantoro, “Aplikasi pencarian rute gedung udinus, kos-kosan dan kuliner menggunakan metode dijkstra sekitar Universitas Dian Nuswantoro,” 2016.
[15] G. Kumar, R. Kumar, and N. Gandotra, “Algorithm for Shortest Path Problem in a Network with Interval-valued Intuitionistic Trapezoidal Fuzzy Number,” vol. 70, pp. 123–129, 2015, doi: 10.1016/j.procs.2015.10.056.
[16] R. Munir, *Diktat Kuliah IF2251 Strategi Algoritmik*. Departemen Teknik Informatika, Institut Teknologi Bandung, 2007.
[17] W. Shu-xi, “Procedia Engineering The Improved Dijkstra ’ s Shortest Path Algorithm and Its Application,” vol. 29, pp. 1186–1190, 2012, doi: 10.1016/j.proeng.2012.01.110.
[18] Y. Z. Chen, S. F. Shen, T. Chen, and R. Yang, “Path optimization study for vehicles evacuation based on Dijkstra algorithm,” *Procedia Eng.*, vol. 71, pp. 159–165, 2014, doi: 10.1016/j.proeng.2014.04.023.
[19] R. Munir, *Matematika Diskrit*. Bandung: Informatika, 2007.
[20] J. J. Siang, *Matematika Diskrit dan aplikasinya pada ilmu komputer*. Yogyakarta: Andi, 2002.
[21] U. S. R. Bondy, J.A. and Murty, *Graph Theory With Applications*. NorthHolland, New York:

 ISSN:2302-8149
e-ISSN:2540-9719

University of Waterloo, 1982.
[22] "Geographic Information Technology Training Alliance (GITTA)." .