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An Application of Bellman-Ford Algorithm on The Ambulance Routing

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Abstract. Ambulance is a transport service for patients to the hospital. In order to minimize the risk level for patients, the ambulance should arrive at the incident site within the targeted time. This is why a mathematical method application can solve the issue by selecting the rigth route. The Bellman-Ford algorithm is an algorithm that is often used in solving a problem, i.e., finding the shortest route. This algorithm uses a vertex as a starting point and is used as a single source to calculate the shortest distance on a weighted graph. Findings reveal that the best route using the Bellman-Ford algorithm from samples that are obtained from several hospitals and health centers in Gorontalo city is 1-2-3-9-10-11-14-15 where the starting point is the Regional Hospital of Otanaha, and the destination point is the regional hospital of Prof. Dr. H. Aloe Saboe, and 1- 3-4-10-11-12 where the starting point is the Health Center of Kota Selatan and the destination point is the Regional Hospital of Prof. Dr. H. Aloe Saboe.

Keywords: bellman-ford algorithm, shortest path, optimal route, ambulance routing

1 Introduction

In today's life, the application of science to several fields of work is quite important. Mathematics is one of the many disciplines that can be applied to make it easier for us to solve a problem both in the fields of economics, health, agriculture, science, and technology. For example, in the world of hospital health is one of the public service services engaged in the health sector whose existence greatly determines the level of public health. Therefore, the level of service is an important indicator in efforts to treat patients. In this case, mathematics can be one of the solutions to improve public health services.

One of the applications of mathematics in the world of health is at the level of hospital ambulance services. Ambulance is one of the means of patient transportation to the hospital, in an effort to serve patients, ambulances require speed and punctuality to get to the destination point in order to minimize patient risks. This problem is one of the factors why the selection of the right route is a part that can be solved by applying existing methods in mathematics, as well as being depicted in the form of graphs and applying an algorithm. Where according to Goodaire [1] a graph is a set of points connected to each other by sides. And according to Cormen [2],an algorithm is a computational procedure that utilizes several values to be inputted which are then processed

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as output so that it can be concluded that the algorithm is a sequence of computational steps that convert input into output.

A person with an emergency request in medicine must immediately need effective assistance with the speed of action from the medical team as well as the need for the speed of the ambulance to the emergency patient's location and take him to the hospital with a short time efficiency so that he can provide help as quickly as possible [3]. Many studies have been conducted regarding the algorithm to find the shortest distance. Some of the algorithms that can be used to complete the determination of the shortest distance are the Djikstra algorithm, the Bellman-Ford algorithm, the a* algorithm, and the Floyd–Warshall algorithm [4].

Research on the application of the Bellman-Ford algorithm has been conducted previously, some of which was conducted by Hasugian [5] who analyzed and implemented the Bellman-Ford algorithm in determining the shortest path for shipping goods in a city. Another study by Serdano [6] compared the Dijkstra and Bellman-Ford algorithms in the Shortest Distance Search at a gas station. [7] implemented Bellman-Ford to optimize waste transportation routes in Palembang. Then carried out by Yusuf [8] who compared the performance of the Floyd-Warshall Algorithm and the Bellman-Ford algorithm in the distribution of LPG GAS.

In this study, the problem regarding the ambulance route was solved using the Bellman-Ford algorithm. The Bellman- Ford algorithm is an algorithm that is often used in solving problems about finding the optimal route. The algorithm uses a single point as a starting point and is a single source and then calculates the shortest distance on a weighted graph. Where the weighted graph is a graph that if the sides of the graph are also accompanied by a certain price which can be said to be a condition of the connection [9]. And as for the shortest word, it is not always interpreted physically as the minimum length, because the shortest word will have different meanings depending on the problem to be solved. In general, the shortest word can be interpreted as the process of minimizing the weight of a trajectory on a graph [10].

In addition, the Bellman-Ford algorithm uses $d[u]$ as the upper limit with the distance $d[u;v]$ from u to v. The algorithm also uses the initialization of distances and starting points as a source of zero points and other points until they are infinite. Progressively, the Bellman-Ford algorithm makes distance improvements for each source point to point v where the trajectory can be said to be Boolean true if the graph contains a circle that is not negative then from the source point it can reach another point [11]. In this study, we will discuss the search for optimal routes for hospital ambulance cars and health centers in the Gorontalo City area.

2 Method

2.1 Time and Place of Research

This research was conducted in the 2021-2022 academic year and was located at the Mathematics Laboratory of the Faculty of Mathematics and Natural Sciences, Gorontalo State University.

2.2 Assumption

1. The determination of the optimal route in this study did not pay attention to road conditions, temporary road closures, traffic lights, or other similar obstacles.
2. The shortest line can be calculated based on the calculation of the distance.
3. Travel time can be calculated based on time calculation.
4. The hospitals that are the starting point and the destination point in this study are as follows:
   a) Multazam hospital.
   b) Gorontalo Islamic hospital.
   c) Otanaha hospital.
   d) Bunda hospital.
   e) Siti Khadijah mother and daughter hospital.
   f) Prof. Dr. H. Aloe Saboe hospital.
   g) Dungingi Health Center.
   h) Kota Selatan Health Center
   i) Kota Utara Health Center
5. The map used is a map of Gorontalo City taken from google Earth.
6. The actual distance is taken from google Maps.

2.3 Bellman-Ford Algorithm

1. Determine the starting point and list the entire vertex as well as the edge.
2. Put a sign at the starting point = 0 and another point with an infinity sign (∞).
3. Start Iteration against all vertex starting from the starting point.
4. Determining the distance from all points related to the starting point carried out using the Bellman-Ford algorithm is generally defined by : :

   $$M[i,v] = \min\left(M[i-1,v], (M[i-1,n] + C_{vn})\right)$$

   i = Iteration, v = point, n = neighboring points, C_{vn} = distance between points.
5. If the distance V is greater than the distance $U+UV$, then the distance V filled with $U+UV$
   U =starting point, V = destination point, UV = The side connecting U and V.
6. Determining the timing of all points associated with the starting point.
7. Do it until all the points are passed.

3 Results and Discussion

3.1 Finding the Optimal Route with the Starting Point of Otanaha Hospital and the Destination Point of Rsud Prof.Dr.H.Aloe Saboe.

Step 1:
Register the starting point = 0 and other points with infinity (∞) which can be presented in the form of the following table.
Step 2 :
The calculation of the first iteration is carried out where the value of each point is still

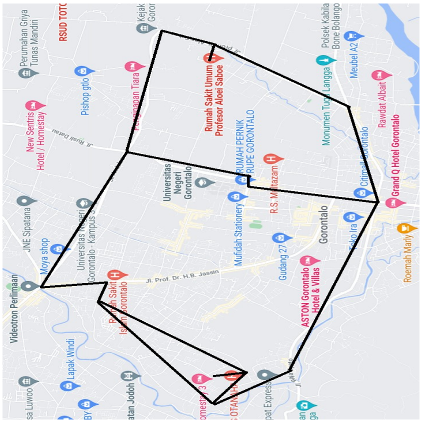

Fig. 1. Marking of the starting point of otanaha hospital and the destination point of Rsud Prof.Dr.H.Aloe Saboe.

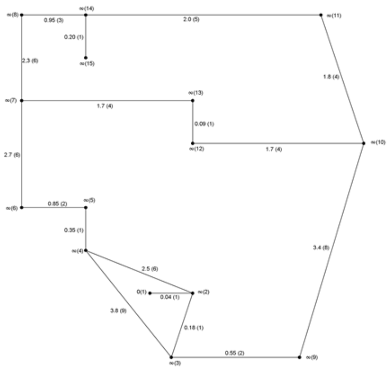

Fig. 2. The weighty graph of Otanaha Hospital went to Prof. Dr.H.Aloe Saboe Hospital.

∞ and the weight of the distance traveled from the starting point to the destination point will be added. Here is the calculation for the first iteration:: Iteration 1 :

$$
\begin{aligned}
M[1.2] &= \min(M[0.2], (M[0.1] + C1, 2)) \\
&= \min(\infty, (0 + 0.04)) \\
&= \min(\infty, 0.04) \\
&= 0.04
\end{aligned}
$$

From the first iteration process, the minimum value for point 2 destination point is 0.04 km. Meanwhile, the other point still remains ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 2 :

$$\begin{aligned} M[2.3] &= \min(M[1.3], (M[1.2] + C2, 3)) \\ &= \min(\infty, (0.04 + 0.18)) \\ &= \min(\infty, 0.22) \\ &= 0.22 \\ M[2.4] &= \min(M[1.4], (M[1.2] + C2, 4)) \\ &= \min(\infty, (0.04 + 2.5)) \\ &= \min(\infty, 2.54) \\ &= 2.54 \end{aligned}$$

From the second iteration process, the minimum values of the destination points of point 3 and point 4 were obtained by 0.22 km and 2.54 km. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 3

$$\begin{aligned} M[3.4] &= \min(M[2.4], (M[2.3] + C3, 4)) \\ &= \min(2.54, (0.22 + 3.8)) \\ &= \min(2.54, 4.02) \\ &= 2.54 \\ M[3.9] &= \min(M[2.9], (M[2.3] + C3, 9)) \\ &= \min(\infty, (0.22 + 0.55)) \\ &= \min(\infty, 0.77) \\ &= 0.77 \end{aligned}$$

$$\begin{aligned} M[3.5] &= \min(M[2.5], (M[2.4] + C4, 5)) \\ &= \min(\infty, (2.54 + 0.35)) \\ &= \min(\infty, 2.89) \\ &= 2.89 \end{aligned}$$

From the third iteration process, the minimum values of the destination points 4, 9 and 5 were obtained by 2.54 km, 0.77 km and 2.89 km. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued. Iteration 4

$$\begin{aligned} M[4.10] &= \min(M[3.10], (M[3.9] + C9, 10)) \\ &= \min(\infty, (0.77 + 3.4)) \\ &= \min(\infty, 4.17) \\ &= 4.17 \end{aligned}$$

$$\begin{aligned} M[4.5] & \min(M[3.5], (M[3.4] + C4, 5)) \\ &= \min(2.89, (2.54 + 0.35)) \\ &= \min(2.89, 2.89) \\ &= 2.89 \end{aligned}$$

$$\begin{aligned} M[4.6] &= \min(M[3.6], (M[3.5] + C5, 6)) \\ &= \min(\infty, (2.89 + 0.85)) \\ &= \min(\infty, 3.74) \\ &= 3.74 \end{aligned}$$

From the fourth iteration process, the minimum values of points 10, 5 and 6 were obtained from 4.17 km, 2.89 km and 3.74 km. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 5

$$\begin{aligned} M[5.11] &= \min(M[4.11], (M[4.10] + C10, 11)) \\ &= \min(\infty, (4.17 + 1.8)) \\ &= \min(\infty, 5.97) \\ &= 5.97 \end{aligned}$$

$$\begin{aligned} M[5.12] &= \min(M[4.12], (M[4.10] + C10, 12)) \\ &= \min(\infty, (4.17 + 1.7)) \\ &= \min(\infty, 5.87) \\ &= 5.87 \end{aligned}$$

$$\begin{aligned} M[5.6] &= \min(M[4.6], (M[4.5] + C5, 6)) \\ &= \min(3.74, (2.89 + 0.85)) \\ &= \min(3.74, 3.74) \\ &= 3.74 \end{aligned}$$

$$\begin{aligned} M[5.7] &= \min(M[4.7], (M[4.6] + C6, 7)) \\ &= \min(\infty, (3.74 + 2.7)) \\ &= \min(\infty, 6.44) \\ &= 6.44 \end{aligned}$$

From the fifth iteration process, the minimum value of the destination points 11, 12, 6, and 7 was obtained by 5.97 km, 5.87 km, 3.74 km. While the others still remain ∞. Karena nilai titik tetangganya terdekat masih bernilai ∞, maka dilanjutkan perhitungan iterasi selanjutnya.

Iteration 6

$$\begin{aligned} M[6.14] &= \min(M[5.14],(M[5.11]+C11,14)) \\ &= \min(\infty,(5.97+2.0)) \\ &= \min(\infty,7.97) \\ &= 7.97 \\ M[6.13] &= \min(M[5.13],(M[5.12]+C12,13)) \\ &= \min(\infty,(5.87+0.09)) \\ &= \min(\infty,5.96) \\ &= 5.96 \\ M[6.7] &= \min(M[5.7],(M[5.6]+C6,7)) \\ &= \min(6.44,(3.74+2.7)) \\ &= \min(6.44,6.44) \\ &= 6.44 \\ M[6.8] &= \min(M[5.8],(M[5.7]+C7,8)) \\ &= \min(\infty,(6.44+2.3)) \\ &= \min(\infty,8.74) \\ &= 8.74 \end{aligned}$$

From the sixth iteration process, the minimum values were obtained from the destination points of points 14, 13, 7, and 8 of 7.97 km, 5.96 km, 6.44 km, and 8.74 km. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 7

$$\begin{aligned} M[7.7] &= \min(M[6.7],(M[6.13]+C13,7)) \\ &= \min(6.44,(5.96+1.7)) \\ &= \min(6.44,7.66) \\ &= 6.44 \\ M[7.8] &= \min(M[6.8],(M[6.7]+C7,8)) \\ &= \min(8.74,(6.44+2.3)) \\ &= \min(8.74,8.74) \\ &= 8.74 \end{aligned}$$

$$\begin{aligned} M[7.14] &= \min(M[6.14],(M[6.8]+C8,14)) \\ &= \min(7.97,(8.74+0.95)) \\ &= \min(7.97,9.69) \\ &= 7.97 \\ M[7.15] &= \min(M[6.15],(M[6.14+C14,15)) \\ &= \min(\infty,(7.97+0.20)) \\ &= \min(\infty,8.17) \\ &= 8.17 \end{aligned}$$

From the seventh iteration process, the minimum values were obtained from the destination points of points 7, 8, 14, and 15 of 6.44 km, 8.74 km, 7.97 km, and 8.17 km.

Table 1. Bellman-Ford Algorithm Iteration Calculation Results.

Iterasi	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
1	0	0.04	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
2	0	0.04	0.22	2.54	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
3	0	0.04	0.22	2.54	2.89	∞	∞	∞	0.77	∞	∞	∞	∞	∞	∞
4	0	0.04	0.22	2.54	2.89	3.74	∞	∞	0.77	4.17	∞	∞	∞	∞	∞
5	0	0.04	0.22	2.54	2.89	3.74	6.44	∞	0.77	4.17	5.97	5.87	∞	∞	∞
6	0	0.04	0.22	2.54	2.89	3.74	6.44	8.74	0.77	4.17	5.97	5.87	5.96	7.97	∞
7	0	0.04	0.22	2.54	2.89	3.74	6.44	8.74	0.77	4.17	5.97	5.87	5.96	7.97	8.17

From the results of the 7th iteration, it is already known that the final value of the entire calculation of point 1 to point 15 is 8.17. Some of the paths shown in figure 2 include (1-2-3-9-10-12-13-7-8-14-15), (1- 2-4-5-6-7-8-14-15), (1-2-3-4-5-6-7-8-14- 15), and (1-2-3-9-10-11-14-15). And based on table 1 of the optimal path to pass from the starting point (point 1) of Otanaha Hospital to the destination point (point 15) of Prof.Dr.H.Aloe Saboe Hospital, namely 1-2-3-9-10-11-14-15. Which starts from Jl.Rambutan Jl.Beringin - Jl.Raja Eyato - Jl.Sultan Botutihe - Jl.Prof.Dr.H.Aloe Saboe.

3.2 Route Search for The Shortest Time with the Starting Point of Otanaha Hospital and the Destination Point of Prof.Dr.H.Aloe Saboe Hospital.

Iteration 1

$$\begin{aligned} M[1.2] &= \min(M[0.2],(M[0.1]+C1,2)) \\ &= \min(\infty,(0+1)) \\ &= \min(\infty,1) \\ &= 1 \end{aligned}$$

From the first iteration process, the minimum value for the destination point of point 2 is 1 minute. Meanwhile, the other point still remains ∞. Because the value of the nearest neighboring point is still worth ∞,the next iteration calculation is continued.

Iteration 2

$$
\begin{aligned}
M[2.3] &= \min(M[1.3], (M[1.2] + C2, 3)) \\
&= \min(\infty, (1+1)) \\
&= \min(\infty, 2) \\
&= 2 \\
M[2.4] &= \min(M[1.4], (M[1.2] + C2, 4)) \\
&= \min(\infty, (1+6)) \\
&= \min(\infty, 7) \\
&= 7
\end{aligned}
$$

From the second iteration process, the minimum values are obtained from the destination point of point 3 and point 4, namely 2 minutes and 7 minutes. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 3

$$
\begin{aligned}
M[3.4] &= \min(M[2.4], (M[2.3] + C3, 4)) \\
&= \min(7, (2+9)) \\
&= \min(7, 11) \\
&= 7 \\
M[3.9] &= \min(M[2.9], (M[2.3] + C3, 9)) \\
&= \min(\infty, (2+2)) \\
&= \min(\infty, 4) \\
&= 4 \\
M[3.5] &= \min(M[2.5], (M[2.4] + C4, 5)) \\
&= \min(\infty, (7+1)) \\
&= \min(\infty, 8) \\
&= 8
\end{aligned}
$$

From the third iteration process, the minimum value of the destination points 4, 9 and 5 is obtained, namely 7 minutes, 4 minutes and 8 minutes. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iterasi 4

$$\begin{aligned} M[4.10] &= \min(M[3.10], (M[3.9] + C9, 10)) \\ &= \min(\infty, (4+8)) \\ &= \min(\infty, 12) \\ &= 12 \\ M[4.5] &= \min(M[3.5], (M[3.4] + C4, 5)) \\ &= \min(8, (7+1)) \\ &= \min(8, 8) \\ &= 8 \\ M[4.6] &= \min(M[3.6], (M[3.5] + C5, 6)) \\ &= \min(\infty, (8+2)) \\ &= \min(\infty, 10) \\ &= 10 \end{aligned}$$

From the fourth iteration process, the minimum value of the destination points 10, 5 and 6 is obtained, namely 12 minutes, 8 minutes and 10 minutes. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 5

$$\begin{aligned} M[5.11] &= \min(M[4.11], (M[4.10] + C10, 11)) \\ &= \min(\infty, (12+4)) \\ &= \min(\infty, 16) \\ &= 16 \\ M[5.12] &= \min(M[4.12], (M[4.10] + C10, 12)) \\ &= \min(\infty, (12+4)) \\ &= \min(\infty, 16) \\ &= 16 \\ M[5.6] &= \min(M[4.6], (M[4.5] + C5, 6)) \\ &= \min(10, (8+2)) \\ &= \min(10, 10) \\ &= 10 \\ M[5.7] &= \min(M[4.7], (M[4.6] + C6, 7)) \\ &= \min(\infty, (10+6)) \\ &= \min(\infty, 16) \\ &= 16 \end{aligned}$$

From the fifth iteration process, the minimum values obtained from the destination points of points 11, 12, 6, and 7, namely 16 minutes, 16 minutes, 10 minutes, and 16 minutes. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 6

$$\begin{aligned} M[6.14] &= \min(M[5.14], (M[5.11] + C11, 14)) \\ &= \min(\infty, (16+5)) \\ &= \min(\infty, 21) \\ &= 21 \\ M[6.13] &= \min(M[5.13], (M[5.12] + C12, 13)) \\ &= \min(\infty, (16+1)) \\ &= \min(\infty, 17) \\ &= 17 \\ M[6.7] &= \min(M[5.7], (M[5.6] + C6, 7)) \\ &= \min(16, (10+6)) \\ &= \min(16, 16) \\ &= 16 \\ M[6.8] &= \min(M[5.8], (M[5.7] + C7, 8)) \\ &= \min(\infty, (16+6)) \\ &= \min(\infty, 22) \\ &= 22 \end{aligned}$$

From the sixth iteration process, the minimum values obtained from the destination points of points 14, 13, 7, and 8, namely 21 minutes, 17 minutes, 16 minutes, and 22 minutes. While the others still remain ∞. Because the value of the nearest neighboring point is still worth ∞, the next iteration calculation is continued.

Iteration 7

$$\begin{aligned} M[7.7] &= \min(M[6.7], (M[6.13] + C13, 7)) \\ &= \min(16, (17+4)) \\ &= \min(16, 21) \\ &= 16 \\ M[7.8] &= \min(M[6.8], (M[6.7] + C7, 8)) \\ &= \min(22, (16+6)) \\ &= \min(22, 22) \\ &= 22 \\ M[7.14] &= \min(M[6.14], (M[6.8] + C8, 14)) \\ &= \min(21, (22+2)) \\ &= \min(21, 24) \\ &= 21 \end{aligned}$$

$$\begin{aligned} M[7.15] &= \min(M[6.15], (M[6.14] + C14, 15)) \\ &= \min(\infty, (21+1)) \\ &= \min(\infty, 22) \\ &= 22 \end{aligned}$$

From the seventh iteration process, the minimum values obtained from the destination points of points 7, 8, 14, and 15, namely 16 minutes, 22 minutes, 21 minutes, and 22 minutes.

Table 2. Bellman-Ford Algorithm Iteration Calculation Results.

Iterasi	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
1	0	1	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
2	0	1	2	7	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
3	0	1	2	7	8	∞	∞	∞	4	∞	∞	∞	∞	∞	∞
4	0	1	2	7	8	10	∞	∞	4	12	∞	∞	∞	∞	∞
5	0	1	2	7	8	10	16	∞	4	12	16	16	∞	∞	∞
6	0	1	2	7	8	10	16	22	4	12	16	16	17	21	∞
7	0	1	2	7	8	10	16	22	4	12	16	16	17	21	22

From the results of the 7th iteration, it is already known that the final value of the entire calculation of point 1 to point 15 is 22 minutes. Some of the paths shown in figure 2 include (1-2-3-9-10-12-13-7-8- 14-15), (1-2-4-5-6-7-8-14-15), (1-2-3-4- 5-6-7-8-14-15), and (1-2-3-9-10-11-14- 15). And based on table 1 of the optimal path to pass from the starting point (point 1) of Otanaha Hospital to the destination point (point 15) of Prof.Dr.H.Aloe Saboe Hospital, namely 1-2-3-9-10-11-14-15. Which starts from Jl.Rambutan Jl.Beringin - Jl.Raja Eyato Jl.Sultan Botutihe - Jl.Prof.Dr.H.Aloe Saboe.

Based on the results of the search for the optimal route from the starting point to all points using the Bellman-Ford algorithm, on the search for the optimal route with the starting point of otanaha hospital and the destination point of Prof.Dr.H Hospital. Aloe Saboe there are 7 iteration processes, namely as follows:

First Iteration: The first iteration starts from the point corresponding to the starting point i.e. point 1 to point 2. in the first iteration the weight of point 2 is filled with the minimum value of the weight of point 1 plus the distance from point 1 to point 2 is obtained by 0.04 km.

Second iteration: The second iteration starts from the corresponding point i.e. Point 2 to point 3 and point 2 to point 4. in the second iteration the weight of point 3 is filled with the minimum value of the weight of point 2 plus the distance from point 2 to point 3 is obtained by 0.22 km. the weight of point 4 is filled with the minimum value from the weight of point 2 plus the distance from point 2 to point 4 is obtained by 2.54 km.

Third iteration :
The third iteration starts from the corresponding points, namely point 3 to point 4, point 3 to point 9, and point 4 to point 5. in the third iteration the weight of point 4 is filled with the minimum value of the weight of point 3 plus the distance from point 3 to point 4 is obtained by 2.54 km, the weight of point 9 is filled with the minimum value from the weight of point 3 plus the distance from point 3 to point 9 is obtained by 0.77 km, and the weight of point 5 is filled with the minimum value from the weight of point 4 plus the distance from point 4 to point 5 is obtained by 2.89 km.

Fourth iteration :
The fourth iteration starts from the corresponding point which is point 9 to point 10, point 4 to point 5, and point 5 to point 6. in the fourth iteration the weight of point 10 is filled with the minimum value from the weight of point 9 plus the distance between point 9 to point 10 is obtained by 4.17 km, the weight of point 5 is filled with the minimum value from the weight of point 4 plus the distance from point 4 to point 5 is obtained by 2.89 km, and the weight of point 6 is filled with the minimum value from the weight of point 5 plus the distance from point 5 to point 6 is obtained by 3.74 km.

Fifth iteration :
The fifth iteration starts from the corresponding point i.e. point 10 to point 11, point 10 to point 12, point 5 to point 6, and point 6 to point 7. in the fifth iteration the weight of point 11 is filled with the minimum value of the weight of point 10 plus the distance between point 10 to point 11 is obtained by 5.97 km, the weight of point 12 is filled with the minimum value from the weight of point 10 plus the distance from point 10 to point 12 is obtained by 5.87 km, the weight of point 6 is filled with the minimum value from the weight of point 5 plus the distance of point 5 to point 6 is obtained by 3.74 km, and the weight of point 7 is filled with the minimum value from the weight of point 6 plus the distance from point 6 to point 7 is obtained by 6.44 km

Sixth iteration :
The sixth iteration starts from the corresponding points, namely point 11 to point 14, point 12 to point 13, point 6 to point 7, and point 7 to point 8. in the sixth iteration the weight of point 14 is filled with the minimum value of the weight of point 11 plus the distance between point 11 to point 14 is obtained by 7.97 km, the weight of point 13 is filled with the minimum value from the weight of point 12 plus the distance from point 12 to point 13 is obtained by 5.96 km, the weight of point 7 is filled with the minimum value from the weight of point 6 plus the distance of point 6 to point 7 is obtained by 6.44 km, and the weight of point 8 is filled with the minimum value from the weight of point 7 plus the distance from point 7 to point 8 is obtained by 8.74 km.

Seventh iteration :
The seventh iteration starts from the corresponding points, namely point 13 to point 7, point 7 to point 8, point 8 to point 14, and point 14 to point 15. in the seventh iteration

the weight of point 7 is filled with the minimum value of the weight of point 13 coupled with the distance between point 13 to point 7 is obtained by 6.44 km, the weight of point 8 is filled with the minimum value from the weight of point 7 plus the distance from point 7 to point 8 is obtained by 8.74 km, the weight of point 14 is filled with the minimum value from the weight of point 8 plus the distance of point 8 to point 14 is obtained by 7.97 km, and the weight of point 15 is filled with the minimum value from the weight of point 14 plus the distance from point 14 to point 15 is obtained by 8.17 km.

By the seventh iteration all points had been passed and there were no longer routes with a more minimum distance. then the iteration process is complete and all routes contained in the seventh iteration are the minimum routes. Some of the paths obtained include (1-2-3- 9-10-12-13-7-8-14-15), (1-2-4-5-6-7-8- 14-15), (1-2-3-4-5-6-7-8-14-15), and (1- 2-3-9-10-11-14-15). The optimal path to go from the starting point (point 1) of Otanaha Hospital to the destination point (point 15) of Prof.Dr.H.Aloe Saboe Hospital is 1-2-3-9-10-11-14-15. Which starts from Jl.Rambutan - Jl.Beringin - Jl.Raja Eyato - Jl.Sultan Botutihe - Jl.Prof.Dr.H.Aloe Saboe.

4 Conclusions

Based on the results of the study, it can be concluded that in this study the search for the optimal route using the Bellman-Ford algorithm can be carried out in several stages, namely registering the starting point and the destination point which is then marked 0 and not until. And further carry out the process of iterating the calculation of distance and time starting from the starting point until all points are passed. From the iteration process carried out, there are two optimal routes that are used as samples from several hospitals and health centers in the city of Gorontalo. The minimum route with the starting point of Otanaha hospital and the destination point of Prof.Dr.H.Aloe Saboe Hospital is 1-2-3-9-10-11-14-15. Which starts from Jl.Rambutan - Jl.Beringin - Jl.Raja Eyato - Jl.Sultan Botutihe - Jl.Prof.Dr.H.Aloe Saboe., and the route with the starting point of the South City health center and the destination point of Prof.Dr.H.Aloe Saboe Hospital is 1-3-4-10- 11-12. Which starts from Jl.Moh Yamin - Jl.Raja Eyato - Jl.Sultan Botutihe - Jl.Prof.Dr.H.Aloe Saboe.

In this study, the determination of the optimal route using the Bellman-Ford Algorithm was discussed. Suggestions on later studies can be to try or compare 2 or more algorithms. In the next research, it is also expected to be able to develop this algorithm or use other algorithms in the search for optimal routes.

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