SJIF Impact Factor: 6.093 Volume: 4 | Issue: 7 | July | 2019 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Peer Reviewed Journal

MODIFICATION OF ANT COLONY OPTIMIZATION IN SHORTEST PATH FINDING ALGORYTHM

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ABSTRACT

This study aims to solve the shortest route optimization problem by combining the decision support system (DSS) by inserting the Simple Multi Attribute Rating Technique (SMART) algorithm into the route calculation between points in the ACO Algorithm. The method used in this study is research and development. The author performs a test by making a combination of decision support systems and testing the algorithmic modification results by making a table of parameter values randomly on several paths and then giving weight. Simple Multi Attribute Rating Technique (SMART) is used to determine the best value of the weight specified in the criteria of each parameter.

KEYWORDS: *Ant Colony Optimization (ACO), Decision Support System (DSS), Simple Multi Attribute Rating Technique (SMART)*

1. INTRODUCTION

The virtue of ACO algorithm is widely used to solve various Non Polynomial (NP) problems (Dorigo et al., 2004), such as quadratic assignment problems, traveling salesman problems (TSP), packet packet routing, vehicular routing, edge detection and so on. In this study the ACO algorithm is used to find the shortest route

To optimize the movement of ants is to consider several criteria such as road conditions, roads, congestion levels or priority destinations to be passed. In this study, each path will be given several criteria as the weight used to determine the route of the ant. Ants will prioritize the best weight as a reference path to be passed. This method is expected to be used to optimize path discovery.

Objectives of the Study

How to optimize the shortest path by combining Decision Support System (DSS) and the Simple Multi Attribute Rating Technique (SMART) algorithm into the route calculation between points in the ACO Algorithm.

2. METHODOLOGY

This research begins with making artificial data, by randomly placing a graph. Then each distance will be calculated by euclidean distance method. To test the algortima modification, the author also makes a table of parameter values randomly on several paths and then gives the weight value. So that in addition to distance weights, there are other weights that are parameters in decision making. The author uses the Simple Multi Attribute Rating Technique (SMART) method to determine the best value of the weight determined by each parameter so that the data tested will be analyzed as a whole. The method used in this study is research and development.

3. LITERATURE REVIEW

Graf theory

A graph is a discrete structure consisting of a set of interconnected vertices and edges. A weighted graph is a graph that has values or weights on each side (edge). The term labeled graph is another designation for weighted graphs (Syaifudin, Deasy Sandhya Elya Ikawati, & Cahya Rahmad, 2018).

The application of graphs to computers requires a way to translate so that the values on a graph can be read and recognized by the computer. The matrix written in a computer can be done in several ways, including: adjacency matrix, incidency matrix

Ant Colony Optimization

The Ant Colony Opmization algorithm is a metaheuristic algorithm that is used to search with ants as the main object forming an algortima. Ant colony is an algortima inspired by the behavior of ant colonies in finding food to go down to the nest. Dorigo et al. (2002) stated that "Ant Colony Optimization (ACO) is a method proposed to solve combinatorial optimization problems with a metaheuristic approach"

The initial stages of completion with the ACO algorithm are by initializing the algorithm parameters.

1. The intensity of ant trace between cities and their changes (τij).
2. The number of cities (n) includes coordinates (x, y) or distance between cities (dij) and the city departing and the destination city.
3. The cyclic setting (Q).
4. Set the controlling intensity of the ant trace (α), the value of $\alpha \geq 0$.
5. The visibility control constant (β), the value of $\beta \geq 0$.
6. Visibility of ant trace ηij = 1 / dij.
7. Number of ants (m).
8. Regarding the evaporation of the ant trace (ρ), the value of ρ must be> 0 and <1 to prevent infinite pheromone traces.
9. The maximum number of cycles (NCmax) is fixed as long as the algorithm is executed, while τij will always be updated in value in each cycle starting from the first cycle (NC = 1) until the maximum number of cycles is reached (NC = NCmax).

Simple Multi Attribute Rating Technique (SMART)

Simple Multi Attribute Rating Technique (SMART) is a method of decision making using many criteria. The SMART method was developed by Edward in 1977. The technique using the SMART method is based on the theory that each alternative consists of a number of criteria that have weighted values that describe the level of importance with other criteria. Weighting is done aiming to assess each criterion in order to obtain the best alternative when the decision is taken.

SMART method is used for comprehensive decision making that is quantitative and qualitative. Decision making with the SMART method can be said to be quite simple, but the results are still good and transparent. The analysis provided is also able to provide a high understanding of the problem and can be accepted by decision makers. SMART has several advantages compared to other decision-making methods such as allowing alternative additions / subtractions, simple, transparent, multi-criteria, flexible weighting

Several studies related to determining the shortest route using Modification of the Ant Colony Optimization Algorithm, as follows:

Xiong & Wu (2017) who conducted a study entitled "An Improved Routing Optimization Algorithm Based on Traveling Salesman Problem for Social Networks", modified the probability of ants in selecting nodes. With the modification of the probability of ants, the simulation results show an increase in the speed of convergence and the ability to search algorithms, and achieve more accurate goals and the best results.

Peker & Kumru (2013) conducted research by optimizing additional parameters using Taguchi method. With the additional method for calculating the best parameters, the ant algebra will be more in accordance with the actual conditions. However, the taguchi method does not weigh the importance of the input parameters.

Ambarsari (2017) conducted a study by modifying the ant algorithm to optimize node selection probability in determining the shortest path by inserting the Fuzzy C-Means Algorithm into the probability of selecting the node of the Ants Algorithm so that the path chosen during the cycle runs continuously, so that iterations what is done in calculating the shortest path is not too long because it is faster to find the convergence of path values.

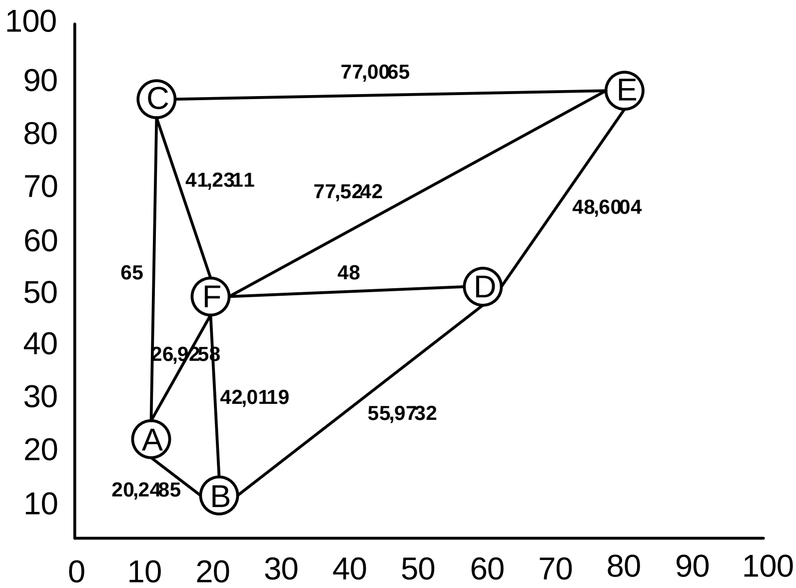
4. ANALYSIS AND RESULTS

To determine the distance between edges is calculated using the Euclidean method, then the distance between edges by adding 2 pieces of weight as additional criteria to be tested using the Ant Algorithm. The data generated is as in Table 1.

Table 1. Distance between Nodes

	A	B	C	D	E	F
A	-	20,2485	65,0000	54,1202	100,1249	26,9258
B	20,2485	-	82,7345	55,9732	104,4844	42,0119
C	65,0000	82,7345	-	62,4820	77,0065	41,2311
D	54,1202	55,9732	62,4820	-	48,6004	38,0000
E	100,1249	104,4844	77,0065	48,6004	-	77,5242
F	26,9258	42,0119	41,2311	38,0000	77,5242	-

In table 1 shows a distance between nodes seen in the graph so we can see the point to be passed in short path finding. The data in the table above shows the value of the distance etween edges calculated using X and Y coordinate.



Gambar 1. **Graf Dengan Enam Vertex**

Classical ACO Algorithm Test.

In this discussion the simulation results will be described in the process of shortest path finding using the mathlab program before adding the ACO algorithm weight to the path that is passed. Each trip starts from point 1 and the next route is selected with the algorithm.

Test with 5 Iterations

The test is carried out using 6 vertices and 5 iterations to see the route taken only considering the distance as the weight calculated using the euclidean distance. The test results can be seen in Table 10.

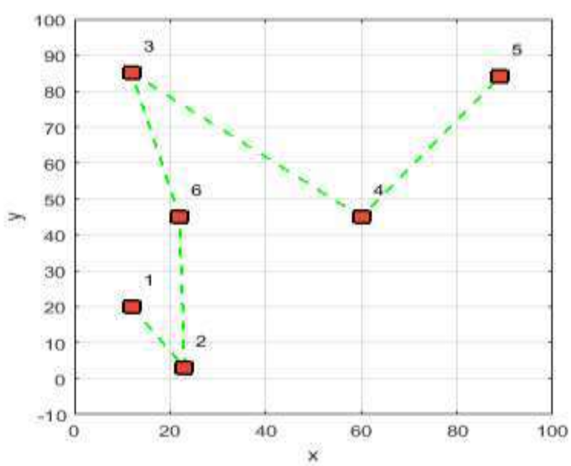


Figure 2. The route taken by 5 iterations on classic ACO

In Figure 2 shows that the route selected based on the results of the classic ACO calculation of 5 iterations produces route 1-2-6-3-4-5 (A-B-F-C-D-E). if calculated manually based on table 1 is the best route. The chosen route is the best value based on the distance between points to other points. The computational process uses classic ACO algorithms based on the best comparison of values and iterations can be seen in Figure 3.

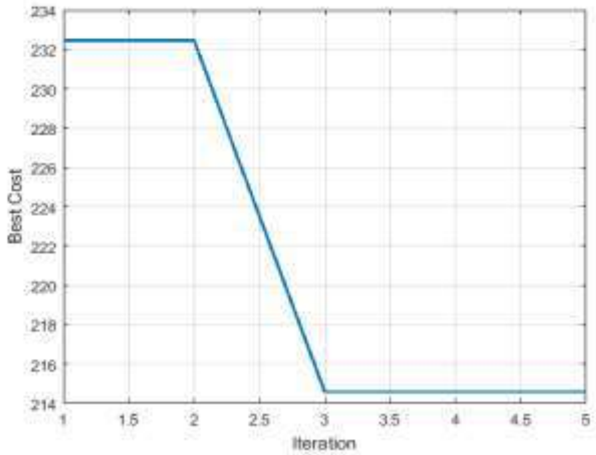


Figure 3. Graph Calculation of 5 iterations in classic ACO

From Figure 2 it can be seen that the selected result is:
Route : 1 -> 2 -> 6 -> 3 -> 4 -> 5.
Best Cost : 214,5738
Time Proses : 0,434537 detik.
Based on Figure 3. The Best Cost has been seen in the 3rd iteration.

Testing for 10 Iterations

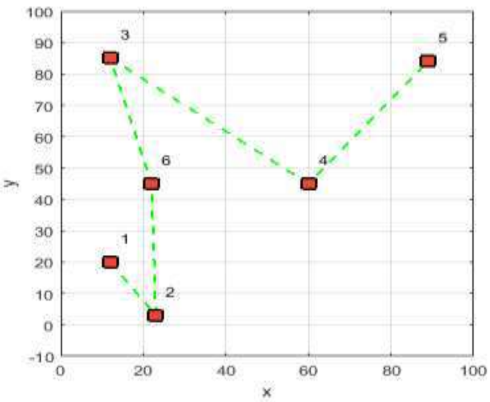


Figure 4. Route taken by 10 iterations on classic ACO

After testing the classic ACO algorithm for 10 iterations. The chosen route is 1-2-6-3-4-5 (A-B-F-C-D-E). The route results can be seen in Figure 4. The best route is 1-2-6-3-4-5 (A-B-F-C-D-E), the path passed does not change or equals the test for the number of iterations. However, the computational process of 10 iterations in the classic ACO algorithm based on the best comparison of values and iterations in Figure 5 shows that the best route is generated in the 8th iteration.

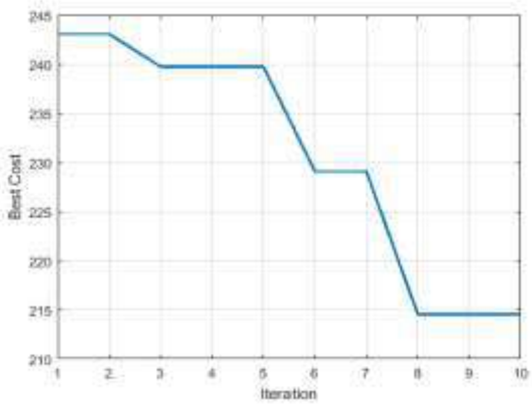


Figure 5. Graph Calculation of 10 iterations in classic ACO

From Figure 4. it can be seen that the results chosen are:
Route : 1 -> 2 -> 6 -> 3 -> 4 -> 5.
Best Cost : 214,5738
Time Proses : 0,663602 detik.
Based on Figure 5. The Best Cost has been seen in the 8th iteration.

Testing for 15 Iterations

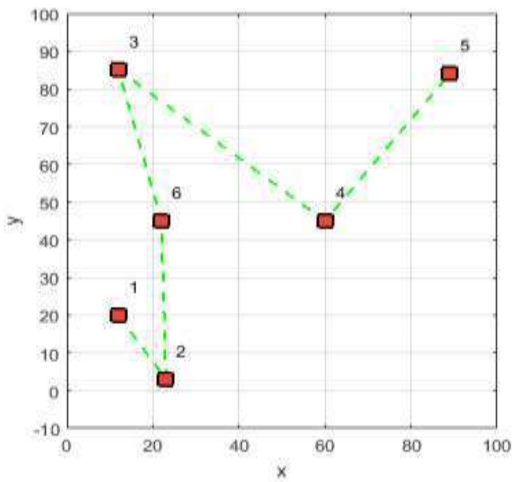
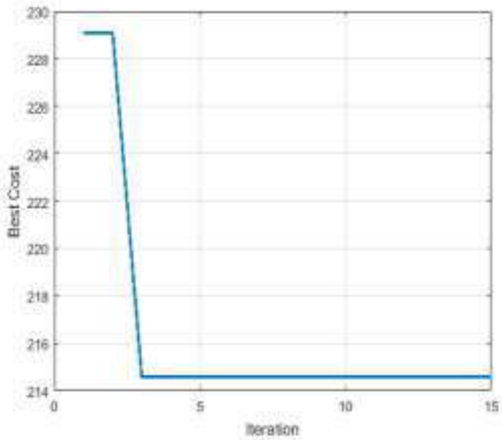


Figure 6. The route taken by 15 iterations on classic ACO

In Figure 6, the results of the classic ACO algorithm are 15 iterations. The chosen route is 1-2-6-3-4-5 (A-B-F-C-D-E). From the testing of 5 iterations, 10 iterations and 15 iterations showed that the ACO Classic algorithm chose lines 1-2-6-3-4-5 (A-B-F-C-D-E) as the best path. This is because the algorithm only considers the distance weights at the time of selecting the path. Algorima ACO is the best algorithm that is able to solve combinatorial problem optimization and is able to produce the best solution in finding the shortest path.



Gambar 7. **Grafik Perhitungan 15 iterasi pada ACO klasik**

From Figure 6, it can be seen that the selected results are:
Route : 1 -> 2 -> 6 -> 3 -> 4 -> 5.
Best Cost : 214,5738
Time Proces : 0,907388 detik.
Based on Figure 7. The Best Cost has been seen in the 3rd iteration.

In Figure 6. the results of the classic ACO algorithm are 15 iterations. The chosen route is 1-2-6-3-4-5 (A-B-F-C-D-E). From the testing of 5 iterations, 10 iterations and 15 iterations showed that the ACO Classic algorithm chose lines 1-2-6-3-4-5 (A-B-F-C-D-E) as the best path. This is due to the fact that the algorithm only considers the distance weights at the time of selecting the path. Algorima ACO is the best algorithm that is able to solve combinatorial problem optimization and is able to produce the best solution in finding the shortest route.

Testing using the ACO Modification Algorithm.

The modified ACO algorithm will be used to determine the fastest route by considering the complexity and weight entered. Modification of the ACO algorithm is done by adding value parameters to each path that will be taken. So it's different from the previous ACO algorithm. In the classic ACO algorithm only consider the value of distance between points (nodes). The modified ACO algorithm provides 2 additional criteria (road conditions and density) then given weights as the level of importance on the criteria passed. The additional parameter values are found in Table 8 and Table 9.

Table 8. Value of Road Path Density

	A	B	C	D	E	F
A	-	1,0000	1,0000	1,0000	1,0000	1,0000
B	1,0000	-	1,0000	1,0000	1,0000	1,0000
C	1,0000	1,0000	-	1,0000	1,0000	1,0000
D	1,0000	1,0000	1,0000	-	78,0000	1,0000
E	1,0000	1,0000	1,0000	78,0000	-	1,0000
F	1,0000	1,0000	1,0000	1,0000	1,0000	-

In Table 8. The value entered for the path density level on Route D-E is 78. The weight of the criteria for line density is 50.

Table 9. Value of Road Conditions for Each Path

	A	B	C	D	E	F
A	-	90,0000	1,0000	4,0000	1,0000	1,0000
B	90,0000	-	1,0000	8,0000	1,0000	85,0000
C	1,0000	1,0000	-	1,0000	1,0000	6,0000
D	4,0000	8,0000	1,0000	-	1,0000	1,0000
E	1,0000	1,0000	1,0000	1,0000	-	1,0000
F	1,0000	85,0000	6,0000	1,0000	1,0000	-

In Table 9. The value entered for the value of the road condition lies in Route A-B = 90, B-D = 8, B-F = 85, C-F = 6, D-A = 4. The weight given for the path condition criteria is 70. Then the above values are calculated to get the best value with the SMART Method.

Table 10. Results of Determining the Best Value

	A	B	C	D	E	F
A	-	39,8494	26,6000	23,2981	40,6500	11,3703
B	39,8494	-	33,6938	25,4393	42,3938	46,8048
C	26,6000	33,6938	-	25,5928	31,4026	18,8424
D	23,2981	25,4393	25,5928	-	39,2902	15,8000
E	40,6500	42,3938	31,4026	39,2902	-	31,6097
F	11,3703	46,8048	18,8424	15,8000	31,6097	-

The results of calculations using the SMART method can be seen in table 10. The values found in table 10 will be used as parameters to determine the path that will be calculated using the ACO algorithm. To see the ACO modification, a test was performed on the iterations 5, 10 and 15.

Testing with 5 Iterations

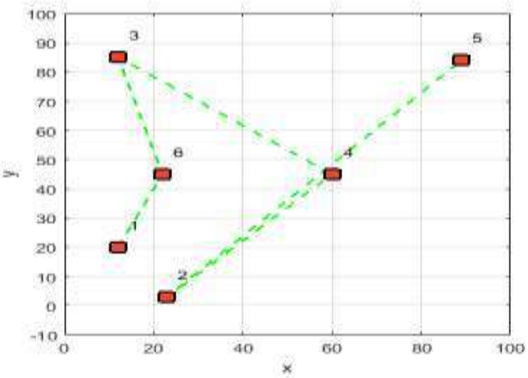


Figure 8. Route taken by 5 iterations on ACO Modification

The route data in Figure 8 shows that the route chosen is based on the calculation of the modified ACO starting from 1-6 (A-F). This shows that the best value does not start from 1-2 (A-B). The route calculation chosen by considering criteria and the added weight causes changes in the value of the path that can be seen in the data below:

Before

1-2 (AB) = 20,2485.

1-6 (A-F) = 26,9258.

After

1-2 (AB) = 39,8494.

1-6 (A-F) = 11,3703.

If you look at the data changes above, the values of lines 1-2 (AB) are greater, and the values from lines 1-6 (A-F) are smaller. This is due to the addition of values due to the very large road conditions on lines 1-2 (AB).

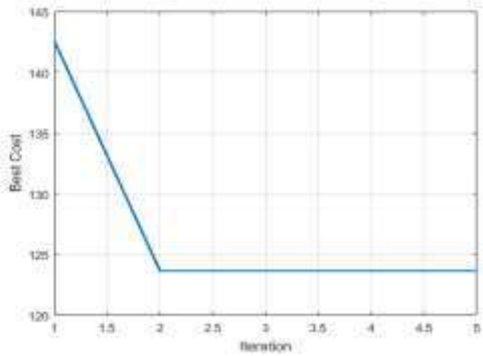


***Figure 9.* Computational Graph 5 iterations in ACO Modification**

From Figure 8 it can be seen that the results chosen are
Route : 1 -> 6 -> 3 -> 4 -> 2 -> 5.
Best Cost : 123,6386
Time Proces : 0,401649 detik.
Based on Figure 9. The Best Cost has been seen in the 2nd iteration.

Test with 10 Iterations

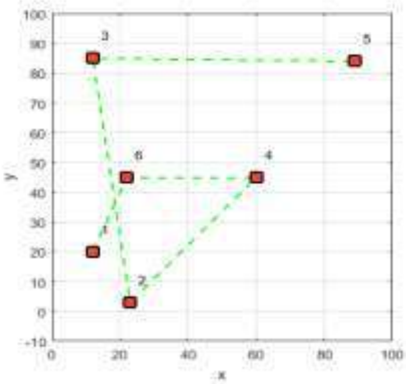


Figure 10. Route taken by 10 iterations to ACO Modification

After taking10 iterations in the calculation using ACO modification, although the chosen path changes, but the path chosen is not 1-2 (A-B) or 4-5 (D-E).

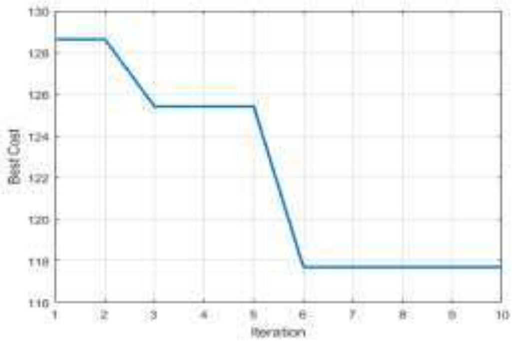


Figure 11. Computational Graph of 10 iterations in ACO Modification

Figure 10 shows that the results chosen are:Route : 1 -> 6 -> 4 -> 2 -> 3 -> 5.
Best Cost : 117,706
Time Proces : 0,68473 detik.
Based on Figure 11.The Best Cost has been seen in the 6th iteration.

Testing with 15 Iterations

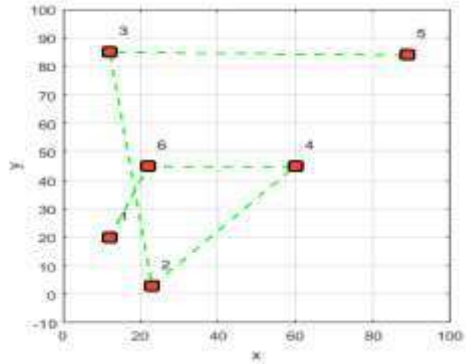


Figure 12. Route taken by 15 iterations in ACO Modification

In figure 12 is the result of the modified ACO process with 15 iterations, but the results show that it still does not pass path 1-2 (A-B) and 4-5 (D-E).

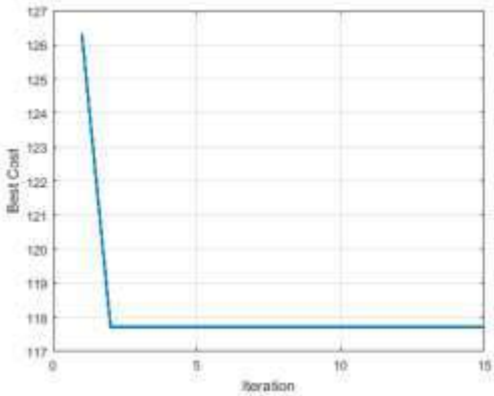


Figure 13. Computational Graph of 10 iterations in ACO Modification

From Figure 12 it can be seen that the selected results are:
Route : 1 -> 6 -> 4 -> 2 -> 3 -> 5.
Best Cost : 117,706
Time Proces : 0,925067 detik.
Based on Figure 13. Best Cost can be seen in the 2nd iteration.

5. DISCUSSIONS

From testing using the Classical ACO algorithm and the modified ACO Algorithm shows the relationship between the determination of the route taken. In the classic ACO algorithm route determination is done by considering the distance weights so that the route taken depends on the distance between points (nodes). But in the ACO modification algorithm uses several criteria and additional weights to determine the path to be passed. Then after being given a value on the criteria and weight, the route selection that will be passed is done using the Decision Support System (DSS) methodology for decision making by considering these criteria and weights. Then taking the route is no longer based on distance weights but other criteria are also calculated with the SMART Method to get the best value for the criteria given. Testing of ACO Algebra is done by using a graph of 6 vertices with the number of iterations 5,10,15. The test results can be seen in Table 11.

Table 11. Test Results Using Classical ACO Algorithms, and Modified ACO Algorithms

	Iteration 5			Iteration 10			Iteration 15		
	Distance	**Route**	**Time**	**Distance**	**Route**	**Time**	**Distance**	**Route**	**Time**
Algorithm ACO Classic	214,6	1-> 2-> 6-> 3-> 4-> 5	0,435	214,6	1-> 2-> 6-> 3-> 4-> 5	0,664	214,6	1-> 2-> 6-> 3-> 4-> 5	0,907
Algorithm ACO Modification	305,5	1-> 6-> 3-> 4-> 2-> 5	0,402	311,4	1-> 6-> 4-> 2-> 3-> 5	0,685	311,4	1-> 6-> 4-> 2-> 3-> 5	0,925

Based on Table 11 it can be seen that in general the addition of parameters on the path does not affect the performance of ACO algorithm, which is shown in the value of Time Process based on the results of computational calculations. But the solution produced by the modified ACO algorithm is able to provide an alternative solution to the path taken by considering several criteria and the weight given by the user as a consideration for the selection of paths. In Table 11, Classical ACO Algorithm always chooses route 2 as the next destination, this is due to the fact that there are no criteria and additional weight on a path to be traversed but only distance weights. However, in ACO algorithm that has been modified, ant always chooses route no 6 as the next route, because on route 1-2 (AB) even though the distance is shorter but the additional weight values are given, congestion and road conditions, the best path is the path 1-6 (AF). Likewise on paths 4-5 (D-E), ants prefer other routes because the parameters of road conditions cause paths 4-5 (D-E) not the best solution.

The process of inserting SMART method on ACO algorithm based on the research conducted is able to provide alternative solutions to decision making on each path also more flexible. Based on the research conducted, the number of iterations used has a significant influence, the more number of iterations the more optimal the solution. The number of iterations needed for the best results does not correlate positively with the number of points completed, but depends on the time needed to achieve the best tour results. The results show that the classic ACO and ACO modification algorithms do not always produce the same solution for each calculation. But the solution remains optimal, with the heuristic method of course the process will be faster in producing solutions.

6. CONCLUSION

1. Hasil modifikasi algortima ACO dapat menunjukan route yang harus dilalui dengan mempertimbangan kriteria dan bobot tiap-tiap route yang akan dilewati.
2. Kriteria setiap jalur diberi bobot oleh pengguna, sehingga dilakukan perhitungan dengan Metode Simple Multi Attribute Rating (SMART) mampu menghasilkan route terbaik.

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