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Recommendation of Scheduling Tourism Routes using Tabu Search Method (Case Study Bandung)

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Abstract

In 2019, the Indonesian Ministry of Tourism is in the process of improving the Go Digital program for the industrial era 4.0, where the internet has become one of the ways to determine travel destinations. However, currently, tourists still have difficulties obtaining detailed and complete information about tourist destinations, when visiting several destinations in one trip. Tourists are still having trouble estimating the distance and time needed for tourism independently, without having to depend on travel agents. These problems are often referred to as Traveling Salesman Problems (TSP). Therefore, we provide a solution to solve this TSP problem in the form of a system scheduling and searching route tourist using the tabu search method which enables tourists to find the optimal solution based on travel time, operational hours of tourist attraction, and the time limit of visits per day. Calculations in the tabu search method are combined with the concept of MAUT (Multi-Attribute Utility Theory) to determine the optimal tour based on several criteria: popularity, cost, and the number of attractions to be visited. Then, the test results of the tabu search method are compared with the firefly method. The result shows that the tabu search method is better than the firefly method, where there is an increase in accuracy of 48% in the calculation of fitness values, 47% in running time average, and 27% in the number of tours to be visited during 3 days of tour visits.

Keywords: Tourist; Tourist Route; TSP; Tabu Search; MAUT;

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1. Introduction

According to Law the Republic of Indonesian number 10 in 2009 about tourism, people who travel are called tourists. Tourists are interested in visiting tourist attractions that have a unique tourist attraction. This case study is limited in Bandung area only. European Travel Commission (ETC) states that, the internet is the main source of information for tourists to search for tourist attractions they want to visit [1]. However, information obtained from the internet is not complete and detail. Usually, tourists find it difficult to find tourist attractions that they have never visited. In addition, tourists find it difficult to estimate distance and travel time when visiting several tourist attractions at one time. Tourists will start a tour from the hotel where they stay.

Some of the problems faced by tourists are part of traveling salesman problem (TSP). Traveling salesman problem (TSP) is a problem where a person travels between cities but must start from the city of origin and return to the city of origin, with minimum total distance and minimum cost. Until now, there have been many studies that have developed optimization methods to determine optimal tourism visit routes. The Ant Colony Hyper-Heuristics (ACO HH) method is one method to determine the optimal tourist route, where this method is a development of the Ant Colony algorithm by replacing several heuristic values and evaluation function values [2]. In another research, there is a combination of Genetic Algorithms and Ant System. This method is combined to solve TSP problems with large-scale data, namely the KroA200 dataset [3]. We have conducted research on the itinerary recommendation system using the ant-colony approach. Based on this research, the Ant Colony approach was combined with the MAUT concept to handle multi-criteria based travel plans [4]. We have also conducted research comparing the Ant Colony method with Simulated Annealing for a search of tourist routes. Based on this research the Ant Colony algorithm is better than Simulated Annealing in calculating the number of tourist attraction to be visited. While Simulated Annealing is better than Ant Colony in calculating the average of travel time [5]. In addition to comparing the Ant Colony and Simulated Annealing method, there also research that compares multi-level GA method with brute force method, where the results of this research prove a multi-level GA method is better than brute force method in determining the time of tour travel [6]. In another research entitled "A Hybrid Tabu Search Algorithm for Simultaneous Pickup and Delivery and Maximum Tour Time Length Vehicle Routing Problems", stated that the tabu search method was able to improve the initial solution until it found a global optimum value of 88% [7] and better than genetic algorithm [8]. Lastly, there is a research that combines the firefly algorithm and the tabu search algorithm (FATS) to solve traveling salesman problems. The combination of FA and TS is done because the FA has the disadvantage to obtain optimization values from large scale data, while TS is a proven effective method for solving large scale data optimization problems [9].

Based on some research results, we use the tabu search method for scheduling and searching tourist routes, because this method can produce optimum tourist routes. The tabu search method is a single - solution based metaheuristic, which has the advantage of finding optimal solutions by storing candidate solutions that have been visited [10]. In this paper, the tabu search method will be combined with the concept of MAUT (Multi Attribute Utility Theory). MAUT calculations are based on popularity criteria, costs and number of tours to be visited. In this test, we compare the test result of tabu search method and firefly method with a limit of 3 days of tour visits. We compare the tabu search method and firefly method because based on the results of research in the Firefly and Tabu search Implementation papers for TSP", that shows good fitness results if firefly and tabu search are combined [9] but in this paper we want to show that traveling salesman problems are better solved by using tabu search method rather than firefly method. This test is carried out using the same data, by choosing 1 hotel and 125 tourist attractions to be scheduled within 3 days of tourist visits.

2. Related Work

The literature review is an explanation of the theories and methods used in this research. This research uses a tabu search method to solve TSP problems, and uses the concept of MAUT to determine the optimal tour based on the criteria of cost, popularity and number of tour that tourists want to visit.

2.1. Tabu Search

In 1986, Fred Glover discovered a method for resolving local search optimization problems. This Optimization Method, commonly referred to as tabu search [10]. The basic concept of the tabu search method is to direct each process to produce the optimal solution, without being trapped in the initial solution found during the continuous process. The tabu search method's goals is to find ways to prevent repetition and find the same solution in an iteration. Some parameters contained in the tabu search method is:

a. Local Search Procedure: The local search procedure consists of insertion and swap. Insertion is the process of randomly selecting one part of the structure to move to another part. Meanwhile, swap is the process of exchanging positions randomly between two parts of the structure.
b. Neighbourhood Structure: Neighbourhood structures are functions that are used to identify any other solutions is obtained by exchange of two nodes in a solution. Hotels and tourist attractions are considered as a nodes.
c. Tabu Condition: Tabu conditions are conditions that prohibit using solutions that have been found before.
d. Aspiration Condition: The aspiration condition is a condition of ignoring tabu status. Aspiration conditions occur when the process of exchanging nodes in an iteration [11].
e. Termination Criteria: The tabu search algorithm is stopped based on the number of user-specified iterations and the number of consecutive iterations without increasing the value of the best objective function.

2.2. Tabu Search in Travelling Salesman Problem

Tabu search can be used to solve TSP by moving through two point exchanges [10]. The process that determines the scheduling and searching of tourist routes using the tabu search method will be explained through a flowchart. Figure 1 is a flowchart from the tabu search method for solving TSP.

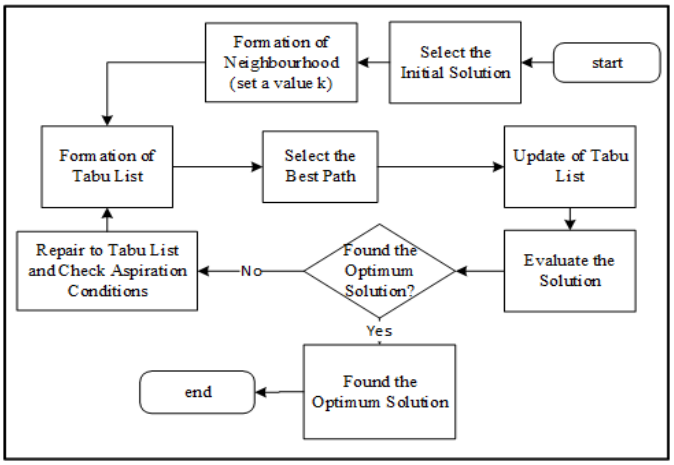


Fig. 1. Flowchart of Tabu Search in TSP

2.3. . Multi Attribute Utility Theory (MAUT)

Multi Attribute Utility Theory or MAUT is an evaluation scheme that is used to assess products and has many assessment attributes. Schafer states that MAUT is a product assessment based on its attributes and dimensions [12]. Therefore, the Multi Attribute Utility Theory can be used to make decisions from research objects related to scheduling and searching for tourist routes. Equation 1 is a function for MAUT calculation.

$$v(x) = \sum_{i=0}^{n} w_i x_i(x) \quad (1)$$

The description of equation 1 is the function $v(x)$ as an evaluation function, the function w_i as the weight value for each attribute and function x_i as the value of an attribute [13].

3. Methodology of Tabu Search

This system design flow applies the stages that are used in the tabu search method. The process of scheduling and route search will use the Bandung Raya case study. Figure 2 is a description of the flow of the design of a tourist route scheduling and search system using the tabu search method and MAUT calculation.

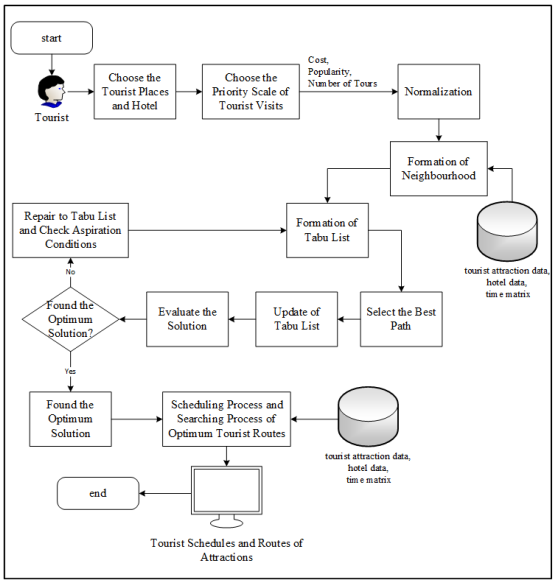


Fig. 2. System Design Flow in Tabu Search

The explanation of each step in Figure 2 is as follows:

3.1. Selection of Tourist Places and Hotels

The first stage, tourists will choose hotels and tourists attractions that they want to visit. The hotel is used as the starting point of departure and end point in searching routes in the tabu search method. However, in this paper we try to include all tourist attractions contained in the dataset.

3.2. Determination of Optimal tours (Cost, Popularity, and Number of Tours)

The second stage, tourists will choose the priority scale of tourist visits based on the criteria of cost, popularity and number of tours. Values 0 - 1 are used as weight values for each attribute. Calculation at this stage uses the concept of multi attribute utility theory (MAUT). MAUT calculation aims to obtain a suitable value that will be used in the tabu list formation process.

3.3. Normalization

The results of the calculation of fitness values are obtained from the results of normalization. Normalization data is a form of data transformation to group different ranges of values into the same value scale [14]. There are several normalization methods that can be used, but in this case study we use the min – max normalization method. Min –

max Normalization is a linear transformation process in the original data [15]. Equation 2 is the formula of min – max normalization.

$$X_{norm} = \frac{X - Xmin}{X_{max} - X_{min}} \quad (2)$$

The results of normalization calculation in formula 2 are a range of values from 0 to 1 [16]. Normalization aims to connect the value of two or more variables that have different values range. Examples of normalization searches in travel time calculations (see eq 3). The travel time to tour X is 3600 seconds. In travel time, the minimum value used is 0 and the maximum value is 36000 seconds (total travel time).

$$X_{norm(t)} = \frac{3600-0}{36000-0} = 0.10 \quad (3)$$

We do normalization calculations based on the criteria of cost, popularity and number of tours visited. Based on equation 1 and equation 2, we use equation 4 to find the best fitness value in the tabu search method.

$$fitness = \frac{D_R.R'}{\frac{(D_t - T') + (D_c - C')}{2}} \quad (4)$$

Fitness value is an optimization value from the calculation of 3 criteria. The D_R function is the weight value of the rating attribute and the R' function is the value of the rating attribute that has been normalized. The rating function is used on the popularity criteria. The D_t function is the weight value of the travel time attribute and the T' function is the normalized travel time attribute value (see equation 3). The travel time function is used on the criteria for number of tours that tourists want to visit. The D_c function is the weight value of the tourism cost attribute and the function C' is the normalized tourism cost attribute value.

3.4. Formation of Neighbourhood

Formation of neighbourhood is the process of determining the parameters to be used and checking each solution that is feasible to be included in the tabu list. Table 1 is the parameters we use in the scheduling system and optimum route search.

Table 1. Parameter of Test Data

Parameter	Value
Total Tour Time	3 days
Tour Start Time	08:00
Tour End Time	18:00
Tour Duration	The Minimum Value
Tourism Costs	The Minimum Value
Time of Open and Close Tourist Attractions	08:00 – 17:00

3.5. Formation of Tabu List

Tabu list is the process of storing a list of solutions obtained from search results in each iteration. The tabu list process aims to find the best solution. In this paper, we give a simple example of the tabu list formation process.

For example to the manual calculation of the tabu list formation process, we choosing 5 tourist attractions and 1 hotel. The hotel is used as a starting point and ending point in the tabu search process. In the process of formatting tabu lists, tourist attractions and hotel that have been selected will be likened to nodes. The initial iteration in the tabu list process can use the random search or use the greedy concept [17]. Table 2 is a number of variables that will be

normalized and included in the MAUT calculation to get optimal fitness value and find the best tourist routes. Some of the variables needed are a node of destination data, the travel time data for each node that will be visited, rating, and ticket price of the tourist attraction.

Table 2 Tourist Attractions Data

Node	Hotel/ Tourist Attractions	Rating	Ticket Price	Travel Time between Tourist Attraction					
				0	1	2	3	4	5
				t	t	t	t	t	t
0	Hotel Reddoorx Natuna	0	0	0	5144	2732	2886	2936	2536
1	Tangkuban Perahu	3.5	20000	5246	0	2812	6395	3020	2752
2	Maribaya Hot Springs	4	35000	2651	2816	0	4367	1705	596
3	Situ Cuburuy	3	20000	2524	6536	4157	0	3908	3964
4	Observatorium Bosscha	4	15000	2900	3126	1757	4109	0	1125
5	Taman Begonia	4	10000	2468	2604	633	4186	1109	0

The temporary optimal route is obtained from the results of greedy calculations. Greedy calculations aim to sum the minimum travel time passed by each node. Therefore, the optimal route while all nodes in table 2 is 0 – 5 – 2 – 4 – 1 – 3 – 0

Minimum travel time addition result: 2468 + 596 + 1757 + 3020 + 6536 + 2886 = 17263

Based on the greedy calculations we have done, we save the optimum route temporarily in the tabu list. After that, we do a search for solutions again using several iterations.

3.6. Select the Best Solution and Update Tabu List

The tabu list update process is a process of finding solutions using several iterations. Based on the optimum temporary route (0 - 5 - 2 - 4 - 1 - 3 - 0), we do 10 iterations with swapping of node [18]. Table 3 is the tabu list update process with 10 iterations [19].

Table 3. Update of Tabu List

No	Swapping	Travel Route	Total time
1	Swap 5,2	0 – 2 – 5 – 4 – 1 – 3 – 0	16851
2	Swap 5,4	0 – 4 – 2 – 5 – 1 – 3 – 0	18727
3	Swap 5,1	0 – 1 – 2 – 4 – 5 – 3 – 0	17778
4	Swap 5,3	0 – 3 – 2 – 4 – 1 – 5 – 0	18177
5	Swap 2,4	0 – 5 – 4 – 2 – 1 – 3 – 0	17532
6	Swap 2,1	0 – 5 – 1 – 4 – 2 – 3 – 0	17094
7	Swap 2,3	0 – 5 – 3 – 4 – 1 – 2 – 0	19109
8	Swap 4,1	0 – 5 – 2 – 1 – 4 – 3 – 0	15796
9	Swap 4,3	0 – 5 – 2 – 3 – 1 – 4 – 0	19678
10	Swap 1,3	0 – 5 – 2 – 4 – 3 – 1 – 0	20268

Based on the results of the iteration experiment in table 3, we obtain the optimum temporary route with the node:

0 – 5 – 2 – 1 – 4 – 3 – 0

In addition, the minimum number of time based on the optimum optimum route is:

2468 + 596 + 2812 + 3126 + 3908 + 2886 = 15796

3.7. Evaluate the Solution to find the Optimum Solution

The evaluation process is the process of combining the results of MAUT calculations and tabu list formation that has been done. The process of evaluating solutions is useful for finding optimum solutions and fitness values. If the solution found is not optimum, then you can repeat the tabu list formation process again by determining the number of iterations to be used.

3.8. Scheduling Process and Searching Process of Optimum Tourist Routes

The route search process is the last process to find the optimum search results using the MAUT calculation results and tabu list formation. Based on the search results for these routes, we will recommend travel itinerary. In addition, we will show the results of running time, the number of tours that can be visited in 3 days and the results of fitness calculations based on the cost budget, the popularity and number of tours visited.

4. Experiment and Implementation

This research uses tourist data as a data set. We conducted a test by comparing the results of the tabu search method and the firefly method. In this paper, we optimize tour scheduling for 3 days of tour visits. The parameters used in this research are the number of iterations, number of hotels and number of tours destination.

4.1. Test Result of Tabu Search Method and Firefly Method

Tests are carried out by choosing 1 hotel and 125 same tourist attractions between the tabu search method and the firefly method. We use several iterations to get optimal test results. The test produces a fitness value, running time, and node. Fitness values are obtained from MAUT calculations in 3 optimum tour criteria. Running time is the average time in finding the optimal solution. Meanwhile, the node is the average number of tours to be visited in 3 days of tour visits. We conduct testing in 5 times for each line. Table 4 is data from the test results from the tabu search method and the data from the firefly method.

Table 4. The Result Data On Tabu Search Method

Iteration	#Destination	Tabu Search			Firefly		
		Fitness	Running Time	Node	Fitness	Running Time	Node
10	125	0.34	28.10	21.80	0.31	72.40	17.40
15	125	0.32	34.60	18.50	0.26	54.50	16.50
50	125	0.37	141.10	17.20	0.26	170.40	17.80
75	125	0.36	130.60	20.30	0.28	262.20	15.40
100	125	0.35	216.40	16.50	0.14	476.20	11.20
150	125	0.29	324.20	17.00	0.11	366.40	12.20
250	125	0.26	616.40	14.00	0.10	801.60	11.40
500	125	0.28	1704.40	20.00	0.08	2401.30	12.20
750	125	0.29	1719.70	15.00	0.07	3859.20	11.80
Average		**0.31**	**546.17**	**17.81**	**0.16**	**940.47**	**13.99**

From table 4, the average of fitness value in the tabu search method is 0.31 and the average of fitness value in the firefly method is 0.16. So, according to these results the fitness value in the tabu search method is better than the firefly method. The average of running time in the tabu search method is 546.17 second, however in the firefly method it is 940.47 second. When we look from the average running time, the tabu search method is faster than the firefly method. In addition, the average of total node in the tabu search method is 17.81, whereas in the firefly method it is 13.99. So based on these test results, indicates the total nodes in the tabu search method is better than the firefly method.

4.2. The Result Comparison of Tabu Search Method and Firefly Method

Table 5 is a result to comparison of fitness values, running time, and nodes in tabu search method and firefly method. We use mathematical formulas regarding the percentage increase to calculate the percentage increase of accuracy value between the results a comparison of two methods on table 5 [20].

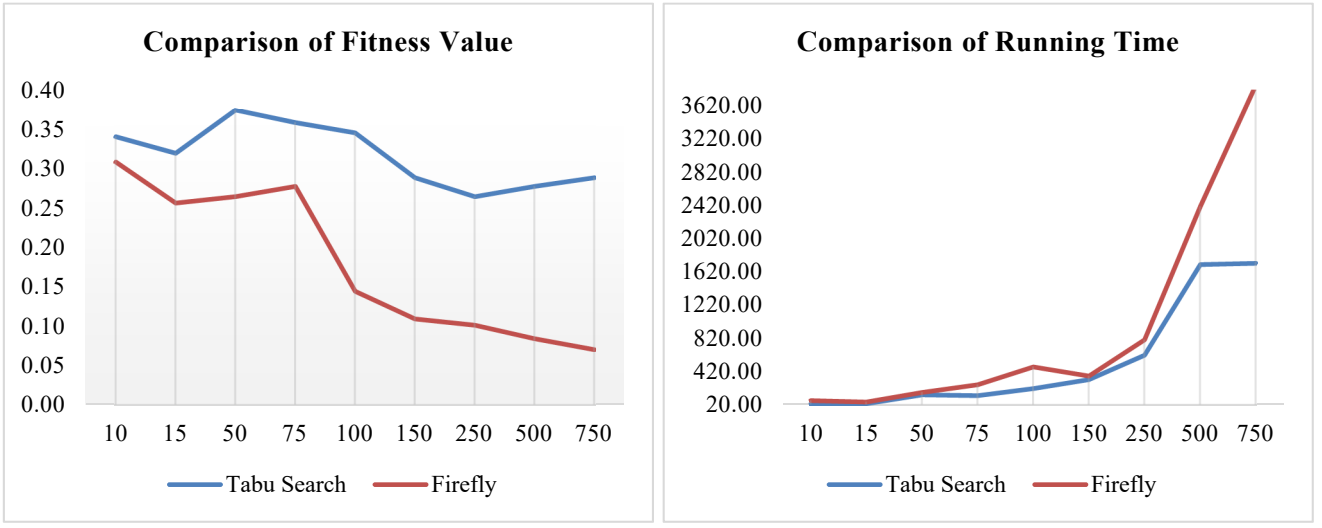
Table 5. The Result Comparison of Two Methods

Data	Result of Tabu Search	Result of Firefly	Increased Accuracy
Fitness Value	0.31	0.16	48%
Running Time	546.20	940.50	42%
Node	17.81	13.99	27%

Based on table 5, the tabu search method is better than the firefly method to solve traveling salesman problems. The results of fitness values in the tabu search method increased 48% better than using the firefly method. The speed of time in determining the best tourist routes in the tabu search method increased 42% better than the firefly method. In addition, the average value of the number of tourist places visited during the 3 days of tour visits was better to use the tabu search method because the accuracy increased by 27%.

4.3. Comparison of Fitness Value and Running Time

Figure 3(a) is a comparison graph fitness values between the tabu search method and the firefly method, while figure 3(b) is a graph of the comparison of average a time to scheduling and searching for tourist routes between tabu search method and firefly method.



(a) (b)

Fig. 3. (a) Comparison of Fitnes Value; (b) Comparison of Running Time

Figure 3(a) is a comparison chart of fitness values from the calculation of priority scale in the form of costs (1), popularity (1), and the number of tours to be visited (1). The results of this calculation have been normalized and entered into the MAUT concept. We used 1 hotel and 125 tours in this testing process. Based on the production line from figure 3, the production lines of tabu search and firefly method look different on the average of fitness value. The average fitness value obtained in the tabu search method is better than the firefly method. When the number of iterations is above 75, in the taboo search method the value of fitness decreases but not below the average of 0.25. Whereas in the firefly method, the average fitness value decreases drastically to an average of 0.5.

Figure 3(b) is a comparison chart of running time. The research average result of scheduling and searching of

tourist routes using tabu search method and firefly method is different. In tabu search method and firefly method, the fewer the number of iterations, the faster the time of scheduling and route searching. However, if the number of iterations is increasing, then the scheduling process and route searching time will be longer. In addition, the increase in search time for tourist routes in the firefly method is greater than in the tabu search method. So, figure 3(b) shows that the average time of scheduling and searching for tourist routes in tabu search method is better then firefly method.

4.4. Comparison of Node

Figure 4 is the average comparison graph of total tourist attraction visited during 3 days tour visit between tabu search method and firefly method.

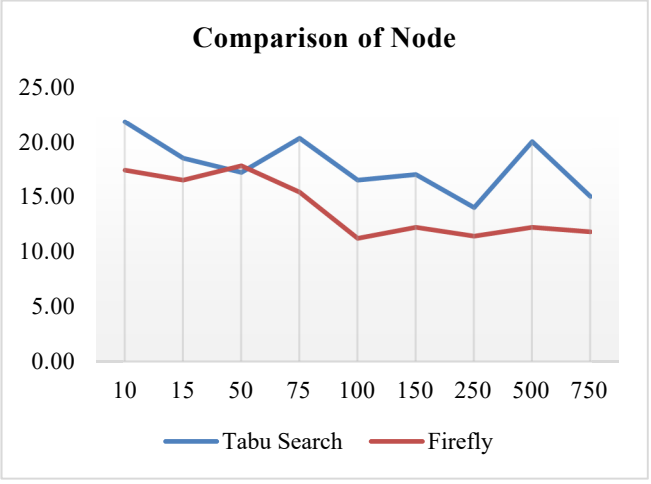


Fig. 4. Comparison of Node

In this research, we compare the average total tourist attractions to be visited by tourists. Node is an initialization for hotel names and tourist attractions visited by tourists. In this research, the number of iterations does not affect the results of the average total node. However, figure 4 shows that the average total node in the tabu search method is more stable than the firefly method.

5. Conclusions

In this research, We use combining the tabu search method and the concept of MAUT calculation to solve the traveling salesman problem. The tabu search method acts as a determinant to find the best route based on the MAUT calculation results that have been done so that we can obtain optimal values. We recommend one hotel to stay and scheduling tourist routes for maximum tourist visits for 3 days.

This research produces 3 optimization values that can be compared between tabu search method and firefly method. First optimization values is a fitness value obtained in tabu search method is 0.31 and firefly method is 0.16, so tabu search method is 48% better than firefly method.

Second, average time results of scheduling and searching tourist routes using the tabu search method amounted to 546.17 seconds and firefly method was 940.47 seconds. Based on the average time results of scheduling and searching tour route, the tabu search method is 42% faster than the firefly method.

Third, the average number of tours to be visited in tabu search research is more than the firefly research. The average number of tours visited by tourists with the tabu search method is 17.81 and the firefly method is 13.99, so tabu search method is 27% better than firefly method. Based on the results of this study, it can be concluded that the tabu search method applies to completing traveling salesman problem. In addition, the tabu search method obtains better optimization values than the firefly method.

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