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Search Application of Alternative Road for Tourism Location in Jember Regency – East Java by Using Ant Colony System (ACS)

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ABSTRACT
Everyone needs a tourist attraction to add knowledge and experience. Jember city is one of the city that has many tourist attractions. The tourists who are going to the attractions need a lot of paths to take, so it takes a method to choose the shortest path. There are some solutions to solve the shortest path search which has been done a lot. However, the solution has not provided satisfactory success, so various improvement efforts need to be done. In this research, the shortest path search is using Ant Colony System (ACS) method. The ACS method is one of the heuristic methods that can provide the optimal solution to find the shortest path on the way from the nest to the food source or destination. The performance process of the ACS is to move from one node to the next with high pheromone evaporation to choose the best and optimal solution based on the compilation of the visit path from each ant to each city. Ant colony travels continuously until all the cities one by one which is visited or have occupied the tabu list. This method uses tabu list to store a set of recently evaluated solutions, and the results will be adjusted first with the contents of the taboo list to see if the solution has been achieved or not. When the solution is reached then the solution will not be evaluated again in the next iteration. Various trials are underway to prevent the retrieval process in the available traced solution space. The results show that ACS method developed in this research is able to find the determination in determining the journey with the shortest path from and to the tourist object in Jember so that it can be considered in decision making to show the path that will be passed and the efficiency of time, cost and energy. The quality of success is obtained using parameters q0 = 0.1, $\alpha = 0.2$, $\beta = 2$, $\rho = 0.2$ with the number of ants and many cycles.
Keywords: Tourist Attraction, Ant Colony System, Taboo List, Shortest Path Search

I. INTRODUCTION

Tourist attraction is a place that contains elements of cultural values, history, education, recreation and so forth. Therefore, everyone is in need of a tourist attraction to gain knowledge and experience [1]. Potential tourist attraction in East Java province is very diverse and spread in districts or cities in East Java. The existence of a tourist attraction in Jember Regency is highly dependent on the tourists. Nature tourism becomes the main attraction, based on the data of the number of tourists visiting the many tourist attractions in East Java is Jember. When the tourists usually go to the attractions by following the common path or the usual path becomes less efficient in terms of time, energy and cost, then the shortest path search when traveling is expected [2]. In general, tourists use maps to find the path of travel from one place to another. The use of the map itself has grown from a physical to a map service that can be accessed online. Provider sites that are famous and commonly can accessed is Google Maps [3]. Google Maps has covered maps of most regions of the world including in Indonesia. Lack of Google Maps is incomplete data areas that are still remote and steep roads. Therefore, in this research to find the shortest path required an optimization method.

There are several search methods for solving optimization problems. One of the optimization methods that is developed today is the method of Ant Colony System (ACS). ACS is one of the heuristic methods that can provide the optimal solution to find the shortest path in the journey from the nest to the source of food or destination [4]. The performance process of the ACS is to move from one node to the next with high pheromone evaporation to choose the best and optimal solution based on the compilation of each ant pathway to each city. Ant colonies can find the shortest route between the nest and the source of food based on the footprints on the trajectory that has been traversed. The more ants that pass through a path, the trajectory will be more visible footprints. This case will cause the passage passed by the ant in the number of slightly longer will decrease the density of ants that pass through it, or even will not be skipped at all and the opposite [5]. Given the principle of an algorithm based on the behavior of the ant colony in finding the shortest travel distance, the Al Ants algorithm is very appropriate to be applied in solving the optimization problem, one of which is to determine the shortest path.

II. METODOLOGY

Basically, the tourists who travel from one place to another always consider efficiency, time and cost, so it takes a precision in determining the shortest path between cities with one another. The shortest path is a network used as a directed route where the hint will enter the initial city and the destination city. Then, the system will determine the shortest path between the two cities, based on some alternative paths available, where the destination point is only one [6]; it can be seen in Figure 1. The input data in this research is in the form of tourism object in Jember, East Java, Indonesia (such as: Papuma beach and Watu Ulo, Puger Sea, Patemon Natural Bathing, Waterfall Tancak, Rembangan Bath, Agung Garden Bath, Bedadung Hill and Waterfall Slopes Roar). Jember has 98 highways and an average road with a distance of 3.5 km which can be seen in Table 1. The results of determining the shortest path will be a consideration in decision making to indicate the path to be skipped.

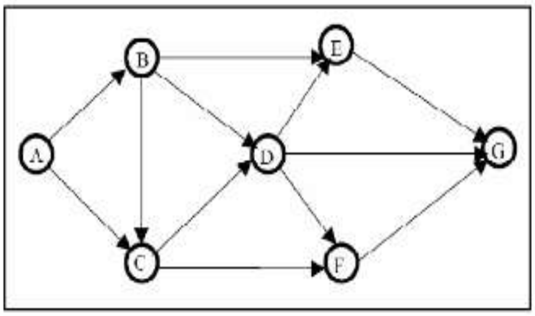

Figure 1. *Graph of Shortest Path.*

Table 1. Street names in Jember

Node	**Street Name**	***Node***	**Street Name**
1	Jatiroto	50	Mawar A
2	Jatiroto	51	Mawar B
3	Yosorati	52	Cempedak
4	Kaliglagah	53	Pemandian krembangan
5	Pringgowirawa n	54	Cempedak A
6	Tanggul	55	dr Subandi
7	patemon	56	Arjasa
8	Klatakan	57	Jelbuk
9	Pecoro	58	Jelbuk A
10	Curahmalang	59	Bondowoso
11	Sukorejo	60	Sbr Wringin
12	Besuki	61	Sbr Kalong
13	Semboro	62	Sbr Kalong 2
14	Gumukmas	63	Kalisat
15	Umbulsari	64	Pakusari
16	Balung	65	Pakusari 2
17	Puger	66	Kalisat 2
18	Laut Puger	67	Borobudur
19	Kasiyan	68	Sbr Pinang
20	Jatisari	69	Kaliurang
21	Kencong	70	MT Haryono
22	Padomasan	71	MT Haryono 2
23	Rowotengah	72	Mayang
24	Ampel	73	Seputih
25	Wuluhan	74	Kedawung
26	Gemuling	75	Mumbulsari
27	Air terjun Tancak	76	Tamanan
28	Ambulu	77	Sbr Wringin 2
29	Jenggawah	78	Sumberjambe
30	Ajung	79	Pringgondo
31	Terminal	80	Cumedak
32	Hayam Wuruk	81	Sukosari
33	Rambipuji	82	Sukowono
34	Sidodadi	83	Kalisat
35	Banjar Agung	84	Prambanan
36	Tempurejo	85	Air terjun lereng raung
37	Pemandian kebon agung	86	Kr Pajlon
38	Wirowongso	87	Lembengan
39	Panti	88	Suren
40	Air terjun Tancak	89	Sempolan
41	Sukorambi	90	Banyuwangi
42	Gajah Mada	91	Sbr Salak
43	Melati	92	Sbr Bulus
44	Mawar	93	Sempolan 2
45	Panjaitan	94	Silo
46	Panjaitan A	95	Karangharjo
47	Bedadung hill	96	Curahmanis
48	S Parman	97	Babon
49	Kalimantan	98	Banyuwangi 2

In general, solving the problem of finding the shortest path can be done using two methods, they are the conventional algorithm method and heuristic method. Conventional methods are easier to understand than Heuristic methods. But if compared, the result of Heuristic method is more varied and the time required is shorter. The Heuristic Method consists of various methods. One of them is the Ant Colony System (ACS) method. ACS is a method taken from the behavior of ant colonies in finding the shortest path between the nest and the source of food. ACS is adopted from the behavior of ant colonies known as the Ants system [7]. Naturally ant colonies are able to find the shortest path in the journey from the nest to the food sources in each random initial city, can be seen in Figure 2. Then each ant visits other cities that have not been visited until all the cities are visited. Each ant has a list of city visits it has passed, this list of visits is called tabu list. Selection of cities that have never been visited is based on a rule called state transition rule. This rule takes into account visibility (inverse distance from one city to another) and the number of pheromones on each segment connects one city to another. Colonies of ants can find the shortest path between the nest and the source of food based on footprints on the trajectory that has been passed. The more ants that pass through a path, the more visible the footprints are. This will cause the passage of the ants to pass in small quantities, which the longer it will decrease the density of the ants that pass through it, or even will not be skipped at all. And conversely, the path that ants pass in large quantities, the longer the density will increase.

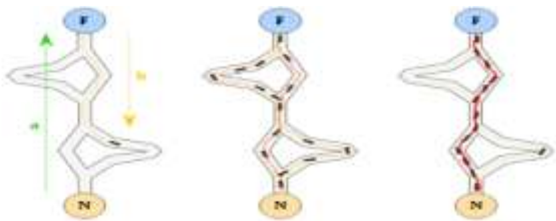

Figure 2. *The Ant Trip Goes To The Food Source*[8]

Steps of ACS method to find the shortest path at tourist location in Jember district, including (1) Initialization of ACS parameters and initialization of first city of each ant. ACS parameters initialized include: inter-city ant trace intensity (τ_{ij}), many cities (n) including x and y (coordinates) or dij (distance between cities), determination of departing city and destination city, ant-cycle constant (Q), Ant trace intensity control constant (α), the visibility control constant (β), Inter-city visibility = $1/d_{ij}$ (η_{ij}) , the number of ants (m) , the ant trap evaporation constant (ρ), the maximum number of cycles (NC_{max}) is fixed As long as the algorithm is executed, whereas τ_{ij} will always be updated on every cycle of the algorithm from the first cycle ($NC=1$) until the maximum cycle number ($NC=NC_{max}$) or until convergence is reached. (2) Filling the first city into a taboo list. The initialization of the first ant city in step 1 should be loaded as the first element of the taboo list. The result of this step is to fill the first element of the taboo list of each ant with the first city index. (3) Arranging the path of each ant's visit to each city. Ant colonies that have been distributed to the first city will begin to travel from the first city as the home town and one of the other cities as the destination city. An ant placed in city r chooses to go to city s by applying the rule shown by equation (1). Then from the second city, each ant colony will continue its journey by choosing one of the cities that is not found in the $tabu_k$ as the next destination city. Ant colony trips continue to reach the city that has been determined. If s denotes the index of the order of visits, the originated city is declared as $tabu_k(s)$ and the other cities are denoted as {N-$tabu_k$}, then to determine the destination city the city's probability equation to visit is defined in equation (2).

$$v = \text{arg.max} \{[\tau(r,u)] . [\eta(r,u)]^{\beta}\} \quad (1)$$

$$p_{ij}^{k} = \frac{[\tau_{ij}^{\alpha} . \eta_{ij}^{\beta}]}{\sum \tau_{ik}^{\alpha} . \eta_{ik}^{\beta}} \text{ for } j \in \{N - tabu_k\} \quad (2)$$

$$k \in \{N - tabu_k\}$$

$$p_{ij}^{k} = 0 \; for \; j \; others$$

with i as the original city index and j as the destination city index. (4) The calculation of the path length of each L_k ant is done after one cycle is completed by all ants. The calculations are performed on the basis of each $tabu_k$ with equation (3). After L_k each ant is calculated, the minimum price of the total closed path for each cycle or L_{minNC} and the minimum price of the total closed path length is L_{min}. Colonies of ants will leave footprints on the inter-city passage it passes. The existence of evaporation and differences in the number of ants passing, causing the possibility of changes in the price of ant footprint intensity between cities with Equation (4).

$$L_k = d_{tabu_k,(n),\; tabu_{k(1)}} + \sum_{s=1}^{n-1} d_{tabu_k,(n),\; tabu_{k(s+1)}} \quad (3)$$

with d_{ij} is the distance between city i to city j calculated by equation (5).

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (4)$$

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \quad (5)$$

with $\Delta\tau_{ij}$ is the price change of the ant footprint intensity between cities each ant that is calculated based on equation (6).

$$\Delta\tau_{ij}^{k} = \frac{Q}{L_k} \quad (6)$$

to $(i,j) \in$ city of origin and city of destination within $tabu_k$. And $\Delta\tau_{ij} = 0$, for (i,j) others. (5) Calculation of the price of ant footprint intensity between cities for the next cycle. The intensity of inter-city ant footprints on all inter-city tracks is likely to change due to evaporation and the difference in the number of ants passing through. For the next cycle, the ant that will pass through the trajectory of its intensity price has changed. The intensity of the ant footprints between cities for the next cycle is calculated by

Equation (7). For subsequent cycles the price change of the ant trace intensity between cities needs to be reset to have a value equal to zero. (6) Discharge the taboo list, and repeat step two if necessary. Taboo lists need to be emptied to be filled again with the new city order in the next cycle, if the maximum number of cycles has not been reached or has not converged yet. The algorithm is repeated from step two with the price of the ant footprint intensity parameters between cities that have been updated.

$$\tau_{ij} = \rho . \tau_{ij} + \Delta\tau_{ij} \quad (7)$$

III. RESULT AND DISCUSSIONS

Given the limitations of information possessed by Google Maps, where incomplete data of remote areas and steep paths is in this study to find the shortest path using the ACS method. While the ACS method itself to find the shortest path requires parameter nisialisasi as the first step ant in crossing each city, can be seen in Figure 3. For example, the initial city allocated to the Puger area, which is at node 17 and headed to the city Petemon bath at node 7. After initialization, the next step is to find the value of η*(r,s)* shown in table 2 which is *(distance from r to s)$^{-1}$* of each *node* connection, can be seen in Figure 4. Then the ants move by renewing the value The intensity of ant footprints between cities until the ants form a shortest path corresponding to a particular N. From what has been exemplified the shortest path is on route such as node of 17,19,14,15,12,8,6,7 that is by route from Puger - Kasiyan - Gumukmas -Umbulsari - Besuki - klatakan - embankment - Patemon Bath with distance is 25 km, can Seen in Table 3 and interface map view can be seen in Figure 5.

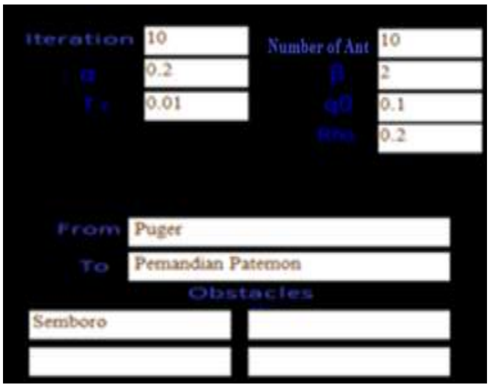

Figure 3. *Implementation of the initialization process of ACS parameters and the first city of each ant*

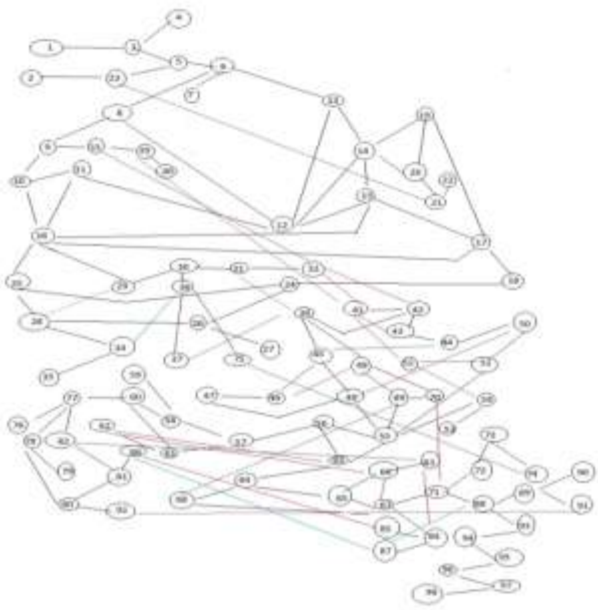

Figure 4. *Implementation of connections per nodes*

Table 2. *Calculation process η(r,s)*

conecting *node* 17	17	15	16	18	19
τ(r,s)	0.01	0.01	0.01	0.01	0.01
d(r,s)	0	6.8	6.25	5.35	3.29
d^{-1}(r,s)	0	0.147	0.16	0.1869	0.3076
Temporary	0	0.0002	0.00025	0.0003	0.0009
probability (r,s)	0	0.1223	0.1447	0.197	0.5353
Cumulative Probability	0	0.1223	0.267	0.464	1

Table 3. *Renewal of the intensity of ant footprints between cities*

Node	17	19	14	15
τ(r,s)	0.01	0.030	0.054	0.028
Node	12	8	6	7
τ(r,s)	0.060	0.028	0.02	0.02

(a) *(b)*

Figure 5. Implementation of the shortest trajectory result using ACS (a) Passing the route without obstacles, (b) Passing the route with obstacles in the city of semboro

Table 4. *The Test Results from Node 17 to Node 7*

No	From	To	Distance	Parameter of ACS						Result (km)	
				α	β	ρ	q0	m	N	Not Obstacle	Obstacle
1	Puger	Patemon	Dekat	0.2	2	0.2	0.9	2	1	25	0
2	Puger	Patemon	Dekat	0.2	2	0.2	0.9	10	10	25	28
3	Puger	Patemon	Dekat	0.2	2	0.2	0.9	1	10	25	Uncertain
4	Puger	Patemon	Dekat	0.2	2	0.2	0.9	10	1	25	Uncertain
5	Puger	Patemon	Dekat	0.2	2	0.2	0.9	10	20	25	25
6	Puger	Patemon	Dekat	0.2	2	0.2	0.9	20	20	25	25
7	Puger	Patemon	Dekat	0.2	2	0.2	0.5	2	1	25	0
8	Puger	Patemon	Dekat	0.2	2	0.2	0.5	10	10	25	0
9	Puger	Patemon	Dekat	0.2	2	0.2	0.5	1	10	25	0
10	Puger	Patemon	Dekat	0.2	2	0.2	0.5	10	1	25	0
11	Puger	Patemon	Dekat	0.2	2	0.2	0.5	10	20	25	25
12	Puger	Patemon	Dekat	0.2	2	0.2	0.5	20	20	25	25
13	Puger	Patemon	Dekat	0.2	2	0.2	0.1	2	1	Uncertain	0
14	Puger	Patemon	Dekat	0.2	2	0.2	0.1	10	10	20	25
15	Puger	Patemon	Dekat	0.2	2	0.2	0.1	1	10	NA	0

IV. CONCLUSION

ACS method is able to find the determination in determining the journey with the shortest path from and to the tourist attraction in Jember, shown from the testing results with

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