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ANT COLONY OPTIMIZATION TO DETERMINE THE SHORTEST ROUTE OF TOURIST DESTINATIONS IN BALI : A CASE STUDY

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Abstract

Bali is one of the popular tourist destinations in Indonesia. As technology develops, the tourism sector also gets support in the process. The problem we address in this research is to determine the closest distance to travel in Bali. The purpose of this study is to assist users in deciding which route is better to visit first so that it is more effective in terms of energy, gasoline usage, and time. We proposed a shortest route system using ant colony optimization (ACO). ACO then compared with other optimization method such as Genetic Algorithm (GA) and min max method. ACO produces a great result with the optimal distance and reasonable amount of search time. ACO reached only 4.8560 in distance when every nodes visited. GA and min max produces worse result with consecutively 8.5594 and 5.0413. However, in processing time ACO produces a slightly similar results with min max method.

Key words: shortest route, optimization, ant colony optimization, Bali, tourism.

INTRODUCTION

COVID-19 pandemic seems to change human ways of life. People need to wear masks, use hand sanitizer, and keep their clean. Tourism is one of the most affected areas in this pandemic. People limiting their mobility to curb the virus. This is not only happening locally but also on a global scale [1]. Many countries close their entrances and exits when cases arise.

The decline in foreign tourist arrivals is a bad thing, one of which is for Bali [2]. The Central Statistics Agency (BPS) of Bali Province recorded that foreign tourist arrivals in January 2021 fell by 93.33 percent in January 2021. The pandemic has caused people to avoid traveling long distances and in groups [3]. Local tourists, solo travelers, and backpackers are Bali's hope to revive the tourism in Bali.

Research on technology that supports tourism in Bali has been widely carried out. One of the researches is on the selection of tourism objects using AHP (Analytic Hierarchy Process) and Copeland Score Model [4]. Research that has been done, tourist objects are clustered using k-means and x-means [5]. Another research, there is a tourist recommendation system using Topsis and Greedy [6].

The tourists usually have a schedule and tourist destinations they want to visit. The problem faced by tourists is that they have to determine the route they will take manually. In this paper, we propose to find the closest distance to the tourist area. Finding the shortest route is one of the optimization problem. Stateand Post-Enrollment Course Timetabling (PE-CTT) are a problem that needed optimization in education fields. PE-CTT problem can be solved with a hyper-heuristics approach using self-adaptive and simulated annealing (SASA) algorithm [7]. The hybridization of the SASA algorithm produced competitive results. Thesis Examination Timetabling which input data are room availability, lecturer schedules, lecturer's functionality qualification, examiner numbers, examiner's specialty, the number of students tested by the lecturer solved using a Genetic Algorithm [8]. Another optimization problem in manufacturing field using Particle Swarm Optimization (PSO) to solve [9][10][11]. SA, GA, and PSO are heuristics.

Another optimization problem is finding the shortest route. Shortest path are the minimum distance to get to a destination. In optimization, usually referred to Vehicle Routing Problem (VRP). Research on the shortest route and VRP has been done and still interesting to discuss.

Djikstra algorithm is one of the popular method to solve shortest path [12][13]. The goal of the research are minimizing cost such as distance, time, and search time. Genetic Algorithm (GA) and Simulated Annealing (SA) also used to study about shortest driving time [14][15].

Another popular algorithm is Ant Colony Optimization (ACO). ACO can solve feature selection of the microarray datasets [16], shortest route problem [17][18], logistic route planning [19], Airtravel Itinerary [20], 'one-day tour' traffic line [21], multi-depot vehicle routing problem [22].

The problem that is currently being faced in Indonesia due to COVID-19 is the problem of tourism. In this paper, we propose ACO algorithm to deal with tourism problems during covid by providing the best route in Bali. ACO is chosen because it can provide satisfactory results on the VRP.

MATERIAL AND METHODS

In this paper, we will examine the shortest route of tourism in Bali with ACO. Methodology to solve this problem is shown in Fig 1.

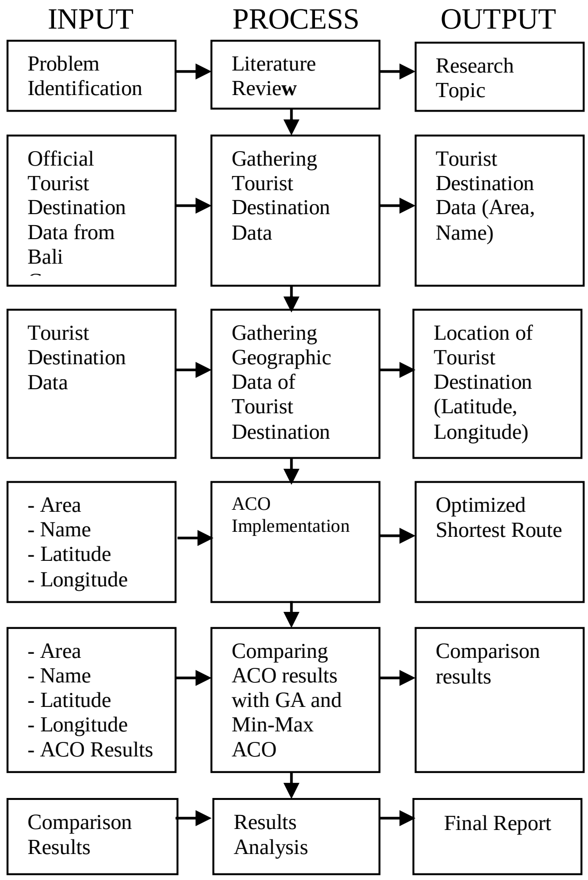

Fig 1. Research methodology.

Literature Review

Problem identification as an input in literature review step. We conducted a literature review concerning shortest route, shortest path, or VRP and the algorithm to solve the problem. Previous researchs and document needed collected in this step..

Gathering tourist destination data from Bali Government Tourism Office

The data collected is differentiated by tourism area in Bali. There are 3 types of tourist destinations, namely natural, artificial, and cultural. The natural destination is natural attractions such as gardens, beaches, mountains, or waterfalls. Artificial tourism is tourist attractions that are made by humans so that visitors can enjoy, such as safari parks and zoos. Cultural tourism, namely tourist attractions related to culture such as temples, tourist villages, museums. Samples are taken from officially provided data.

Gathering geographic data from the sample

After the data sample of Bali tourist destinations is collected, geographic data from each tourist destination is collected. Latitude and longitude of each tourist destinations is recorded. Both data can be found on Google Maps. Tourism data is categorized according to the tourism area determined by Bali Government Tourism Office. The tourism areas are Tabanan, Badung, Klungkung, Bangli, Karangasem, Buleleng, Jembrana, Gianyar, Denpasar. The destination will be presented as a node in VRP. Data source as shown in Table 1.

Table 1. Data node

Destination Area	Tourist Destination's Name	Latitude	Longitude
Badung	Kawasan Luar Pura Uluwatu	-8.82903	115.0851
Badung	Pantai Nusa Dua	-8.79492	115.2329
Badung	Bumi Perkemahan Blahkiuh	-8.5101	115.206
Bangli	Museum Gunung Api Batur	-8.27612	115.5064
Denpasar	Museum Le Mayeur	-8.67448	115.2798
Denpasar	Pantai Sanur	-8.70769	115.2674
Gianyar	Bali Zoo	-8.58995	115.266
Karangasem	Lingkungan Pura Besakih	-8.37432	115.4562
Klungkung	Monumen Puputan Klungkung	-8.53459	115.4042
Klungkung	Pantai Kusamba	-8.56319	115.4519
Tabanan	Puri Gede Kerambitan	-8.54635	115.081
Tabanan	Bedugul	-8.28387	115.1723

Optimizing the data with ACO

After the tourist destinations, locations, and area tours are collected, routes can be optimized. Route optimization is done by the ACO algorithm. ACO is inspired by natural occurance by ant behaviour. The unique thing about ant behavior is the use of Pheromone. Pheromone is a way to communicate between ants. The more often the pheromone is used, the slower the pheromone's attracting effect evaporates. On the other hand, if the pheromone is rarely used, the attractive effect of the pheromone will evaporate more quickly. An overview of the nature-inspired algorithm can be seen in Fig 2.

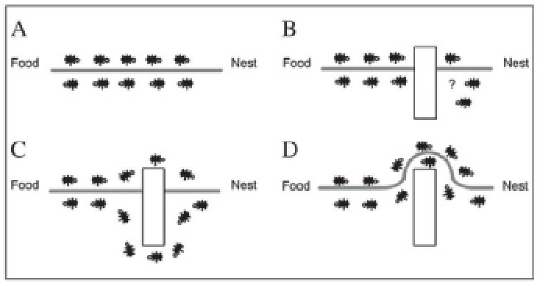

Fig 2. Nature-inspired algorithm, ACO

The mathematical operation for ACO reaching to a destination is shown in (1).

$$D_{ij^h}(s) = \frac{[\tau_{ij}(s)]^{\alpha}.n_{ij}{}^{\beta}}{\sum l\epsilon N_i^h[\tau il(s)]^{\alpha}.[n_{il}{}^{\beta}} \quad (1)$$

τ_{ij} is the pheromone. S is step or tour. h is the ant.

Mathematical operation for updating pheromone (2).

$$\tau_{ij}(s+1) = (1-\rho).\tau_{ij}(s) + \sum_{h=1}^{m} \Delta ij^h \quad (2)$$

ρ is a coefficient for pheromone decay. The value of the coefficient is in range 0-1.

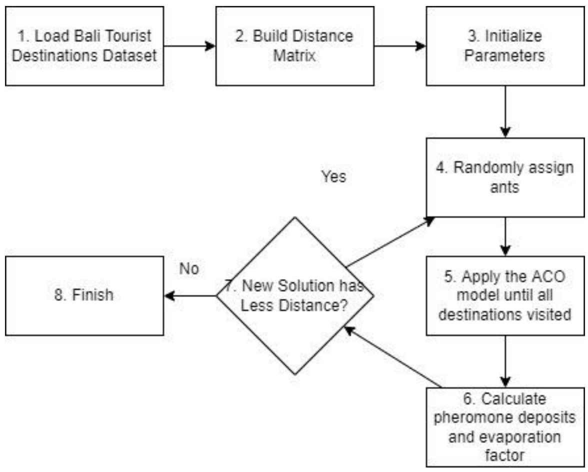

Fig 3. ACO method

Comparing with Genetic Algorithm (GA) and min-max ACO

In addition to route optimization with ACO, a comparison of the GA and min-max ACO algorithm was also carried out. GA is a popular heuristics algorithm. Min-max is a modified ACO algorithm.

Results Analysis

After the experiment and comparison are completed, the last step is results analysis. The better algorithm should be the more optimal. The minimum distance with the minimum search time is the desirable result.

RESULT AND DISCUSSION

All destinations before optimization is shown in Fig 3. There is no visible pattern in the route.

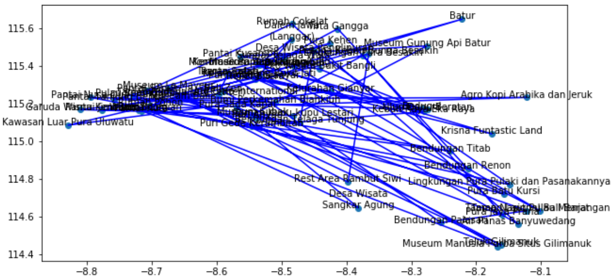

Fig 4. Destination tour in Bali before optimization

All destinations after optimization is shown in Fig 5.

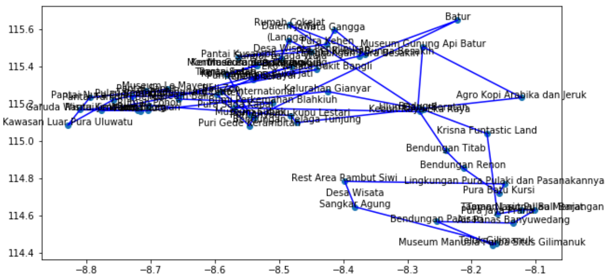

Fig 5. Destination tour after optimization

Algorithm implementation shown in table II. The table contains original distance, distance after ACO implementation, distance after GA implementation, and distance after Max-Min implementation. The ACO, GA, and Max-Min algorithm gives almost similar results on routes grouped in destination area. However, if all destinations are included, ACO algorithm gives the optimal results. Minimum distance produced by ACO algorithm is 4.8560 while the distance produced by GA and Max-Min is 8.5594 and 5.0413 respectively.

Table 2. Distance optimization results

	Original distance	ACO	GA	Max – Min
Badung	1.3	0.8172	0.8089	0.8089
Bangli	1.55	1.2927	1.2927	1.2927
Buleleng	1.35	1.0310	1.0310	1.0310
Denpasar	0.20	0.2036	0.2036	0.2036
Gianyar	0.48	0.4815	0.4815	0.4815
Jembrana	1.12	0.8529	0.8529	0.8529
Karangasem	1.45	1.1605	1.1605	1.1605
Klungkung	0.11	0.1127	0.1127	0.1127
Tabanan	0.66	0.622	0.622	0.622
ALL	11.67	4.8560	8.5594	5.0413
Random	3.14	1.8459	1.8459	1.8459

Algorithm search time shown in table III. Search time required for ACO, GA and Max-Min varies. The longest search time is required for GA. Optimizing the all destinations using GA need 29.27. ACO and Max-Min spend less search time. Most of the routes, Max-Min gives better search time than ACO. In random destinations, ACO algorithm gives better search time than Max-Min.

Table 3. Search time

	ACO Search Time	GA Search Time	Max – Min Search Time
Badung	0.09	19.66	0.088
Bangli	0.048	18.37	0.044
Buleleng	0.092	20.22	0.083
Denpasar	0.027	17.86	0.026
Gianyar	0.062	18.83	0.069
Jembrana	0.037	18.88	0.030
Karangasem	0.046	18.72	0.044
Klungkung	0.023	28.45	0.017
Tabanan	0.066	17.88	0.057
ALL	4.213	29.27	4.165
Random	0.186	21.39	0.323

Tabanan route shows in Fig 6. The route is Taman Kupu-kupu Lestari - Museum Subak - Puri Anyar - Puri Gede Kerambitan - Bendungan Telaga Tunjung - Kebun Raya Eka Raya - Ulun Danu Beratan – Bedugul.

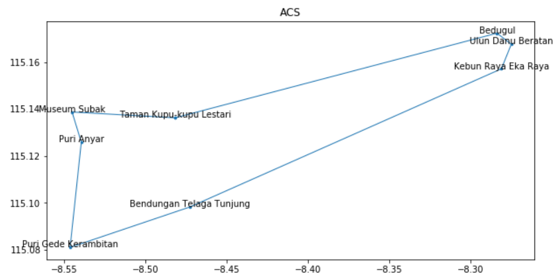

Fig 6. Tabanan route

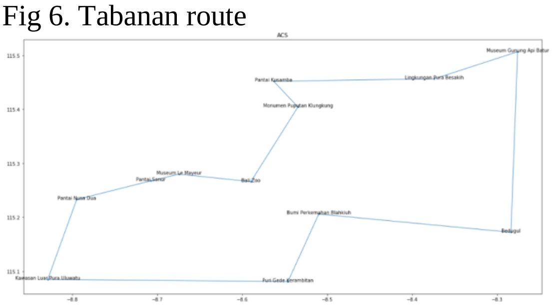

Fig 7. Random route

Random route shows in Fig 7. Kawasan Luar Pura Uluwatu - Pantai Nusa Dua - Pantai Sanur - Museum Le Mayeur - Bali Zoo - Monumen Puputan Klungkung - Pantai Kusamba - Lingkungan Pura Besakih - Museum Gunung Api Batur - Bedugul - Bumi Perkemahan Blahkiuh - Puri Gede Kerambitan.

CONCLUSION

ACO algorithm gives the most optimal result with all destinations. The optimal result is the shortest distance 4.8560. ACO algorithm also has the less search time in random and Gianyar destinations. GA gives a well enough distance but longest search time. Max-Min gives better search time than ACO in most routes. This result shows that ACO algorithm produced a competitive result.

Future work for this research is adding more constraint such as travelling time. Also adding recommendations tours so we can prioritize which destination to visit.

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