Tourism Route Planning Route Based on Tourist Category using Orienteering Problem with Time Windows

Indri Hapsari, Hazrul Iswadi, Yosvaldo Ongko Cahyadi
Departement of Industrial Engineering, University of Surabaya

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ABSTRACT

Indonesia has a large number of favorable tourism destinations, for example like Besuki in East Java that has some potential tourist attractions. The complexity to plan a tourism travel routes for particular tourist category become a problem. Hence, travel recommendations for tourists are required. To solve this problem, the first step is accumulating data from questionnaires, Google Map, TripAdvisor, and website of the Tourism Office in Besuki. The questionnaires were distributed to respondents with dominant age between 15-24 years (60%) and most of them were students (44%). Most respondents were single (74%) and traveling with their family (52%). Using LINGO, model Orienteering Problem with Time Windows (OPTW) with objective function is maximizing scores and having restrictions in opening and closing hours of each tourist attractions. The database that required are opening and closing hours, the distance between tourist attractions, and maximum tourist's hours per day. Score for each tourist attraction and service time will be taken from each tourist category. There are 3 tourists' categories such as Simplicity Searchers (42%), Cultural Purists (34%), and Reward Hunters (24%). Eventhough there is no significant difference among service time for all categories, the median service time will give different results in total score and routes.

SARIPATI

Indonesia memiliki sejumlah besar tujuan wisata yang menguntungkan, misalnya Besuki di Jawa Timur yang memiliki beberapa tempat wisata potensial. Kompleksitas merencanakan rute perjalanan wisata untuk kategori wisata tertentu menjadi masalah. Oleh karena itu, rekomendasi perjalanan untuk wisatawan diperlukan. Untuk mengatasi masalah ini, langkah pertama adalah mengumpulkan data dari kuesioner, Google Map, TripAdvisor, dan situs web Kantor Pariwisata di Besuki. Kuesioner dibagikan kepada responden dengan usia dominan antara 15-24 tahun (60%) dan sebagian besar adalah siswa (44%). Sebagian besar responden adalah lajang (74%) dan bepergian dengan keluarga mereka (52%). Menggunakan LINGO, model Orienteering Problem with Time Windows (OPTW) dengan fungsi objektif memaksimalkan nilai dan memiliki batasan dalam membuka dan menutup jam di setiap tempat wisata. Database yang diperlukan adalah jam buka dan tutup, jarak antara tempat-tempat wisata, dan jam wisata maksimum per hari. Skor untuk setiap daya tarik wisata dan waktu layanan akan diambil dari setiap kategori wisata. Ada 3 kategori wisatawan seperti Pencari Kesederhanaan (42%), Puritan Budaya (34%), dan Pemburu Hadiah (24%). Meskipun tidak ada perbedaan yang signifikan antara waktu layanan untuk semua kategori, waktu layanan median akan memberikan hasil yang berbeda dalam skor total dan rute.

Corresponding Author:

Email: indri@staff.ubaya.ac.id

INTRODUCTION

Indonesia is a country that has many natural resources for tourist attractions. One area with good tourist attractions is Besuki Residency which covers the districts of Banyuwangi, Jember, Situbondo, and Bondowoso. Banyuwangi Regency, for example, received an achievement as The Winner of Re-inventing Government in Tourism in the category of Innovation in Public Policy Governance at the United Nations World Tourism Organization (UNWTO) Awards in 2016. Another example is Ijen Crater which consists of two mountain craters that illuminate a unique blue color. Besuki also has Plengkung Beach or G-Land which is good for surfing for foreign tourists because of the 6 meters waves.

The problem that occurs in tourism in Indonesia is the lack of information media for tourists, either a location description or travel routes. The official website of the tourism department already exists for each district, such as www.banyuwangitourism.com, is handled by Banyuwangi Regency Tourism Office. However, tourists must arrange their own routes for their journey because of the lack of supporting tools. This study will develop a model that can arrange tourism travel routes for each tourist so they can travel easily from one location to others. Therefore, number of tourists who visit Besuki will increase.

There are several types of tourists according to Amadeus (2015) based on tourists who prioritize the smoothness of tourism travel, learn culture, show off on social media, experience new experiences, travel without planning, and protect the environment of tourism destinations. There are 6 types of tourists, namely Simplicity Searchers, Cultural Purists, Reward Hunters, Social Capital Seekers, Obligation Meeters, and Ethical Travelers. This classification is based on the behavior and needs of tourists. For the purposes of this study the first three are used because they are in accordance with the characteristics of domestic tourists. Each type of tourist is predicted have different visit time or service time even though they visit the same destination. Almost all destinations have operating hours or time windows. This research will arrange tourism route planning with time windows based on the type of tourists.

The first type is Simplicity Searchers, the type of tourists who have planned most of their journey before the tourism trip begins. Simplicity Searchers prefer to avoid things that increase travel time such as transit and transportation changes. Simplicity Searchers tend to choose shorter trips and look for lodging as close as possible to the destination. This type of tourist considers things that make tourism trips more comfortable and smooth. Simplicity Searchers are not so enthusiastic in learning the culture around or getting different experiences on tourism travel. In traveling, this type of tourist aims to relieve fatigue but with the best possible level of comfort. This type of tourist is willing to accept advice from many people for the places visited and the length of time to visit for the smooth and comfortable travel of tourism, but this type of tourist also has the opportunity to choose the tourist attractions visited and the length of time to visit the tourist attractions. This type of tourist will have a different personal visit time compared to other types of tourists because they will decide for themselves the allocated service time.

The second type of tourist is Cultural Purists, which is the type of tourist who prefers new things. These types of tourists tend to like different tourism trips compared to tourism trips in general, both in terms of tourist attractions and experiences during tourism trips. Type of Cultural Purists will take a tour of tourism in order to escape the daily routine that is monotonous. This type of tourist is more interested in visiting tourist attractions that are

usually visited by local residents, compared to visiting tourist attractions that are usually visited by tourists in general. Cultural Purists tourists prefer to make their own decisions about the tourist attractions visited and when to visit them. This type of tourist is a type of tourist that is different from the type of tourists in general because it prioritizes a different experience so that the time of this type of visit at a tourist destinations will also be different compared to other types of tourists.

The third type of tourist is the Reward Hunter, which is the type of tourist who tends to enjoy tourism trips without doing detailed planning. This type of tourist travel planning is left to other parties both partners in tourism travel and tourism agents. This type of Hunter Reward tourist wants to provide extra costs to get an exclusive tourism travel experience. Hunter Reward type of tourists want to get something positive from the tourism trip carried out as improving the mentality or physical condition. As a result of handing over tourism travel planning to a travel partner or tourism agent, this type of tourist will visit a tourist destination that has been suggested by a travel partner or tourism agent. For the length of time a visit at a tourist spot can be different depending on travel partners or tourism agents.

The preparation of tourism travel routes usually uses the Traveling Salesman Problem model as the basis for making the model. For planning tourism routes in the Besuki Residency it is more suitable to use Orienteering Problem because every tourist has their own favorite tourist spots and not all of them can be visited due to time constraints. Because the destination has operating hours, the model to be used is Orienteering Problem with Time Windows.

The type of traveler described above will affect the model of the trip route that will be created. Gavalas (2013) states that Orienteering Problem (OP) aims to arrange travel routes with maximum total benefits and minimal travel costs. Vansteenwegen (2011) states the name OP comes from one of the game sports. Sports games are played by individuals who compete by starting the game at a certain point and try to visit as many checkpoints as possible and return to a certain point given a certain time. Each checkpoint will give a certain score. The aim of the game is to get as many scores as possible. Not all points must be traversed on the OP so determining the shortest path between the selected points will help to visit as many points as possible at the time available. Orienteering Problems with Time Windows (OPTW) are different from standard Orienteering Problems (OP). For example, there are problems that are usually solved using OPTW which cannot be solved efficiently with standard OP. Changing the order of trips can also be hampered because of the time window.

Vansteenwegen, Souffriau, & Sörensen (2009) explain about the TOPTW model which is generally like OP with m-route. For the TOP *m*-route, a number of m routes must be determined and each trip starts from point 1 and ends at point *n* which maximizes the total team value or for the entire route. Each point has a S_{id} value from the first route and the total time obtained from visits to each point on the route *m* that cannot exceed the specified time or T_{max}.

$$\text{Max} \sum_{d=1}^{m} \sum_{i=2}^{n-1} S_i y_{id} \quad (1)$$

s.t.

$$\sum_{d=1}^{m}\sum_{j=2}^{n-1} x_{1jd} = \sum_{d=1}^{m}\sum_{i=2}^{n-1} x_{ind} = m \quad (2)$$

$$\sum_{i=1}^{n-1} x_{ikd} = \sum_{j=2}^{n-1} x_{kjd} = y_{kd}; k = 2, \dots, n-1, d = 1, \dots, m \quad (3)$$

$$s_{id} + T_i + c_{ij} - s_{jd} \leq M(1 - x_{ijd}); i,j = 1, \dots, n; d = 1, \dots, m \quad (4)$$

$$\sum_{d=1}^{m} y_{dk} \leq 1; k = 2, \dots, n-1 \quad (5)$$

$$\sum_{i=1}^{n-1}\left(T_i y_{id} + \sum_{j=2}^{n} c_{ij} x_{ijd}\right) \leq T_{max}; d = 1, \dots, m \quad (6)$$

$$O_i \leq s_{id}; i = 1, \dots, n; d = 1, \dots, m \quad (7)$$

$$s_{id} \leq C_i; i = 1, \dots, n; d = 1, \dots, m \quad (8)$$

$$x_{ijd} y_{id} \in \{0,1\}; i = 1, \dots, n, \quad d = 1, \dots, m \quad (9)$$

y_{id} is 1 if location i is visited in route d, if not $y_{id} = 0$; x_{ijd} is worth 1 if there is a trip from location i to location j on route d and value 0 if vice versa. The objective function (1) maximizes the total value obtained. Limitation (2) guarantees that routes starting at location 1 will end at location n. Limits (3) and (4) determine the relationship and sequence of each route. s_{id} is the time of arrival at location i on route d, T_i is the time of visit at location i, c_{ij} is the travel time from location i to location j. Limits (5) guarantee that each location is visited at most once and boundary (6) guarantees that each route is completed within a specified time limit. Limits (7) and (8) guarantee arrival time is still in operational time $[O_i, C_i]$. Limitation (9) prevents the same route planning.

The research is expected to study the types of tourists who travel for tourism in the Besuki Residency. Then can analyze the relationship between types of tourists with service time on domestic tourists in Besuki. Finally is the design of a recommended route for tourists who travel in the Besuki Residency by considering the type of tourist.

METHODS

Primary data was collected by distributing questionnaires to domestic tourists in Besuki Residency. The questionnaire contains questions about the habits of the respondents in making a tourism journey so the behavior of respondents can be determined by the type of tourist. The number of respondents is 100 people. Secondary data was collected from report, journal and internet sources. There is algorithm development from basic OPTW algorithm which will be modified to be more relevant with the condition in Besuki. The study will use 3 types of service time based on type of tourists. Another data collection is the rating of tourist attractions from www.tripadvisor.com.

There are 3 types of tourists analyzed: Simplicity Searchers, Cultural Purists, and Reward Hunter. Simplicity Searchers tourists are the types of tourists who have planned most of their tourism trips before the tour begins. Respondents who answered prioritizing the comfortability during the tour included in this type of tourist. The second type of tourist is called Cultural Purists, which is they prefer new things. Respondents who answered prioritizing different experiences in tourism travel included in this type of tourist. Hunter Reward is the type of tourists who tend to enjoy a tourism trip without doing detailed

planning. Respondents who answered not to participate in planning a tourism trip included in this type of tourist.

RESULTS AND DISCUSSION

From 100% of respondents there are types of tourists with a proportion of 42% Simplicity Searchers, 34% Cultural Purists, and 24% Hunter Rewards. Average service time is known from each tourist destination for each type of tourist. The searching of average service time has done first before the searching of coefficient variation. Most of the data service time has a coefficient of variation is large enough, above 20%. Thus, the average value of service time cannot represent the existing raw data. We will use the median of service time to represent the existing raw data.

This initial model was run using optimation software LINGO. Based on the questionnaire respondents set a max of 14 hours with a start time at 7 AM and a finish time at 9 PM. The starting point and end point of the route follow the respondent's answer being tested. Respondents answered starting and ending points the same is in Yudomulyo Hamlet, Ringintelu Village, and Bangorejo District. Travel time between the starting point and end point with each tourist spot is obtained from Google Maps. After input data was completed, the next step is to use LINGO to determine the best route with the main goal is maximizing the score. The results of LINGO can be seen in Figure 1 and Figure 2.

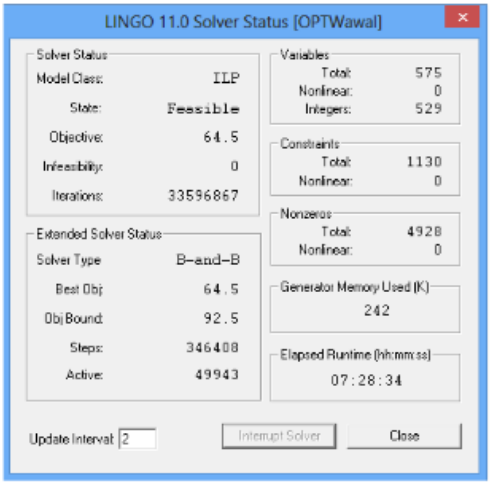

Figure 1. Lingo Result for Existing Model

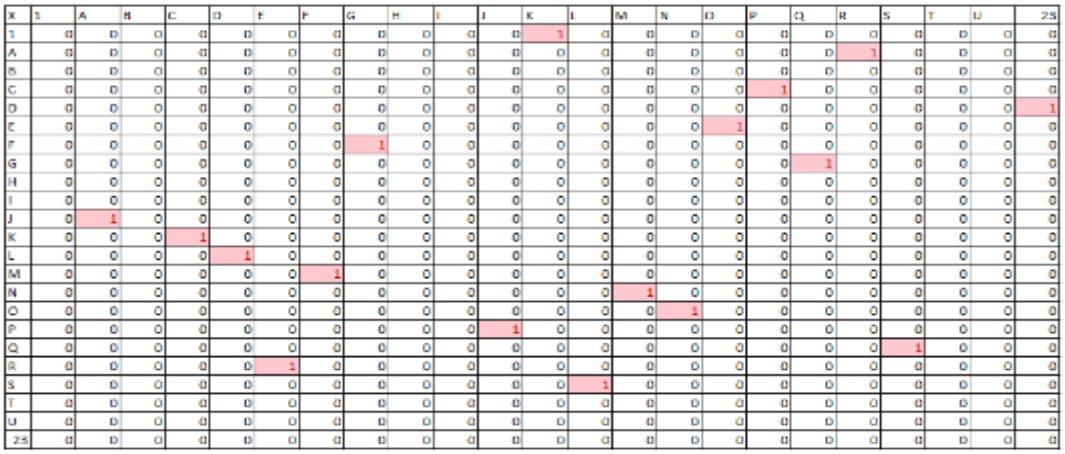

Figure 2. Route Development

There was an interruption while running the software because it has been more than 7 hours and global optimal has not emerged yet. Thus, the result was considered feasible and the total score achieved was 64.5. The route is 1 - K - C - P - J - A - R - E - O - N - M - F - G - Q - S - L - D - 23. Code 1 is a point the beginning and 23 are the end points. The letters A - U represent 21 tourist attractions in the Besuki Residency in sequence, so the route will be Starting Point – Green Bay - Meru Betiri National Park - Wedi Ireng Beach - Red Island - Alas Purwo National Park - Bedul Mangrove - Plengkung Beach - Putri Wulan - Grajagan Beach - Watu Dodol Beach - Tabuhan Island - Bangsring Underwater - Boom Beach - Jagir Waterfall - Wurung Crater - Ijen Crater - Final Point.

The initial model cannot be directly used for existing problems because it needs more adaptation to the real condition. The development of the initial model into the proposed model is focused on objective function, where the score is initially multiplied by whether or not the tourist attractions are visited, become a score multiplied by the ratio obtained from the ranking of respondents multiplied by whether or not the tourist attractions are visited. The limits in the initial model do not take into account service time as a condition for uninterrupted routes needs to be changed by adding service time to the left hand side. The next restriction on the initial model limits the start time service time at the location must be less than or equal to time close location is changed to start time service time at location plus the service time at the location must be less than or equal to the closing time of the location. For data that includes the opening and closing time of the location, the distance between the start and end points of the tourist site and the distance between one tourist place and another will influence the maximum time.

MANAGERIAL IMPLICATION

Examples of using the model on the first traveler are as follows in Table 1.

Table 1. Example of Score and Service Time

Destinations	Rank	Ratio	Score	Service Time (min)
Green Bay	1	½	2.25	120
Papuma Cape	2	1/3	1.5	90
Pasir Putih Beach	3	¼	0.875	60
Ijen Crater	4	1/5	0.9	120
Baluran National Park	5	1/6	0.667	180

It can be seen in Table 1 that the new score is smaller than the old score. Thus, it is certain that the objective function of the first tourist category trial will be smaller when compared to the objective function of the initial model. Scores from tourist attractions are taken from the existing tourist category while service time uses data from one respondent from each traveler category. Service time data is taken from respondents who are being tested. After the data is complete, the first tourist category trial is run with LINGO and the results can be seen in Figure 3.

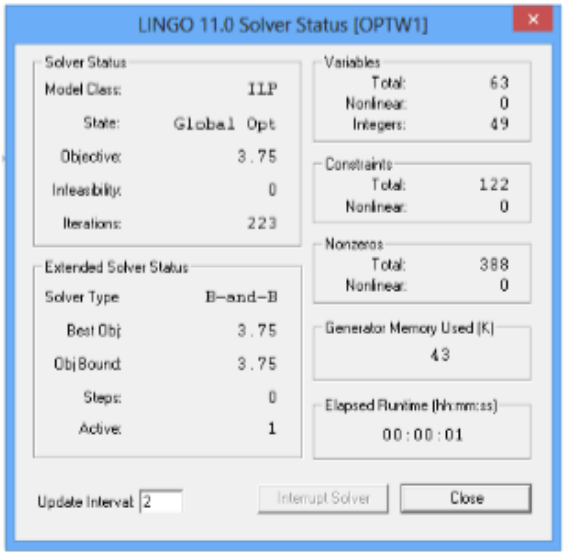

Figure 3. Lingo Result for Proposed Model

It can be seen in the results of the first tourist category trials in Figure 3 that the run time required to achieve optimal global results is 1 second. This is far different from the initial model which in more than 7 hours has not reached optimal results yet. However, the objective function is obtained to only 3.75, this happens because the formula to get the objective function is changed. The change made is multiplying the old objective function with a ratio according to Table 1. Changing objective function and restrictions makes the possibility of fewer routes so that the optimation software run time is reduced. The route obtained by the first tourist category trial is 1 - A - B - 23 or if it is called based on the location's name being the Starting Point – Green Bay – Papuma Cape - End Point. From this route it can be seen a reduction in tourist attractions visited from 16 tourist attractions to 2 tourist attractions. This condition happens because maximum time no longer has to be more than the same as the total travel time, but now maximum time must be more than equal of the total travel time plus the total service time.

CONCLUSION

The initial model used in this study is Orienteering Problem with Time Windows (OPTW). The model of OPTW was developed in the form of replacement of objective functions and 3 constraints. The results show that when changing the service time and score of tourist attractions, the results of the destination and route will also change. Based on the analysis of the relationship between types of tourists with service time on domestic tourists, a coefficient of variation of more than 20% is obtained so that statistical tests cannot be performed to determine the difference in average service time of each type of tourist.

By looking at the fact that the existing service time data for each type of tourist cannot be tested statistically, it would be better if further research explore more service time data. Another suggestion for this problem is to ask the reason of the respondent in determining service time, maybe it is not entirely based on the type of tourist. The reason could be waiting for a travel companion, or a respondent is in a rush to leave tourist attractions.

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