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***Research paper***



# A Web Application for TSP Travel Route System Methodology: An Experimental

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**Abstract**

The shortest route in tourism application has been developed by some researchers. Generally, the focus of research in comparison some method in obtaining the shortest route between two locations. All these research is useful to find the optimal route between two locations that contains one origin place and one destination place. But when the number of destination places is bigger than one, all these research become un-useful. In tourism, TSP travel route is important for the traveler of the group especially when they want to visit some destination travel locations in a one-day trip. The optimal TSP travel route can make the traveler of a group plan their traveling optimally. Google as a big company in web service has provided well environment to develop TSP travel route efficiently. In this research, we want to test the feasibility of TSP travel route application that developed by using google service. The TSP travel route that was produced by using google service then compared with TSP solution by manual computation. The experiment result shows that TSP travel route application based on google service can give similar travel route recommendation as manual computation based on shortest distance. This application is feasible but only in small scale. In large scale, development of system including real map and streets, special computation function for distance matrix and TSP solution have to built by our self.

***Keywords***: *Travelling Salesman Problem (TSP), many destinations, Google service, travel route*

## 1. Introduction

The TSP travel route is TSP implementation in tourism wherein nodes in the graph TSP states travel locations. In experiments in the laboratory, the number of nodes in the TSP can be quite large, reach thousands of nodes or more. In TSP tour travel case, the number of nodes in the TSP is not a lot and adapted to the real requirement of the traveler in a day traveling.

Presence travel applications are certainly very helpful for the tourists in choosing travel destinations as they wish. Various travel applications have a variety of menus that generally can be classified into several groups, namely descriptions of travel location, hotel information, travel tips, car rental information, event, location map, travel packages, travel tickets and travel shop. In a variety of travel applications, a recommendation of certain travel locations is based on a review of previous travelers.

The Travel route application development today has been done by some researchers (Belalawe et al. 2012; Andriani 2014; Varita & Setyawati 2013). Belalawe et. al. used Forward Chaining method(Belalawe et al. 2012), Anik used Floyd-Warshall algorithm(Andriani 2014), while Ivana et. al. used Tabu Search algorithm (Varita & Setyawati 2013) to determine the most optimal travel route. Studies in travel route field of these research are only performed for a single destination travel locations based on the particular user location. The development of web application to solve TSP is also conducted by (Helshani 2015). In his/her research, a genetic algorithm is used to solve the TSP. TSP which solved in that study is general, not specific to a particular field. The development of TSP web-application in a specific domain like tourism will be interested.

In reality, the need for a travel route that contains some travel destinations is very needed and there are researchers have conducted in this area (Adelfio 2014; Ave & Floor 2013). Travel route Recommendations that have developed usually is restricted to certain user's route (Kiseleva et al. 2015; Kurashima et al. 2010; Lu et al. 2010). Some of route recommendation is generated from photographer behavior model (Ave & Floor 2013; Kurashima et al. 2010; Lu et al. 2010) while others recommendation is generated from based on behaviors of users and their peers (Kiseleva et al. 2015; Adelfio 2014; Zhang et al. 2015). All these researchers only give route recommendation based on existing route and can't give new route recommendation.

Many destinations in one day trip are one of the example route problem that contains new route. Travelers in this category usually is a group of people who come from a homogeneous community as community groups of schoolmates, community groups of office mates or community group of specific activities. Travelers of groups who come from different regions or provinces, generally have different characteristics than other travelers group. In this group, they usually want to visit several travel locations in a single day trip. The needs of optimal travel route in this cases become important. By having the optimal travel route, travelers can plan their tour optimally.

In this study, the recommendation system of TSP travel route is proposed. This system will provide TSP travel route recommendations with the shortest distance from an initial place to several selected travel locations, then returned to origin place. The optimal search algorithm is not a primary aim of this study, by considering that the amount of travel location is not a lot. The tour route computing time will be quite fast even conducted by using the simplest search algorithm such as exhaustive search algorithm.

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## 2. Traveling salesman problem

TSP is a case in a graph problem and can be modeled as a closed weighted graph. The graph's vertices are cities, the graph's edges are paths and the edge's length is a path's distance. TSP can be modeled as a set of cities and for each pair of distinct cities, we will have a distance: .TSP is a minimization problem starting and finishing at a specified city after having visited each other city exactly once. The goal is to find an ordering k of the cities that minimizes the quantity (1) (Johnson & McGeoch 1997).

$$\sum_{i=1}^{N-1} d\left(c\left(k_{(i)}\right), c\left(k_{(i+1)}\right)\right) + d\left(c\left(k_{(N)}\right), c\left(k_{(1)}\right)\right) \quad (1)$$

TSP also can be modeled as is a complete graph where if no path exists between two cities, path's distance will be set with an arbitrarily long edge and it will complete the graph without affecting the optimal tour. Illustration of TSP as from un-complete graph to complete graph can be seen in Figure 1(A) and Figure 1(B). Two TSP in that figure has a same optimal solution.

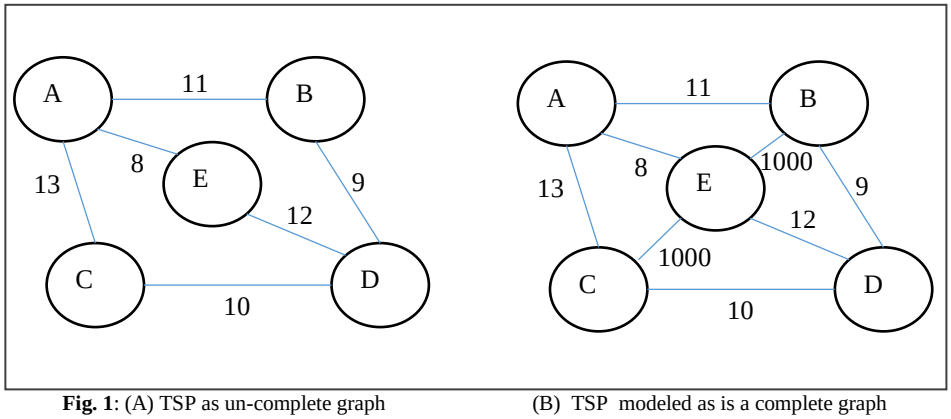



**Fig. 1**: (A) TSP as un-complete graph (B) TSP modeled as is a complete graph

TSP is divided into two categories namely asymmetric TSP and symmetric TSP. In symmetric TSP, the distance between two cities namely from A to B is the same as the distance from B to A. Symmetric TSP form an undirected graph. In asymmetric TSP, paths between two cities may not exist in both directions or paths from A to B might be different with B to A. Asymmetric TSP will form a directed graph. Examples of asymmetric TSP are Traffic collisions, one-way streets, and airfares for cities with different departure and arrival fees.
TSP solution is classified as a combinatorial optimization problem. There are a lot of possible solutions when the number of cities is huge. The number of possible round-trip routes for TSP is equal to (n – 1)!/2, where n is the number of cities (MacGregor & Chu 2011).

## 3. TSP travel route

### 3.1. Travel category

Travelers usually choose a destination location based on the needs of tourism travel. The traveler's group of students will prefer to choose educational travel locations, while travelers of religious groups prefer to choose religious travel locations. But it is possible too they choice heterogeneous travel category, for the example, they want to visit educational travel location, religious travel location, entertainment travel location and others simultaneously in a one-day trip. In this application, several tourism categories are developed which can be seen in Table 1. Each travel location can have only one tourism category or have more than one tourism category.

**Table** 1: Travel Category

| Number | Tourism Category |
|---|---|
| 1 | Nature |
| 2 | Education |
| 3 | City |
| 4 | Entertainment |
| 5 | Agro |
| 6 | Culture |
| 7 | Culinary |

### 3.2. Travel route recommendation

Travel route that recommended by the system is the TSP travel route, which starts from the initial user location and then to several tourism sites were chosen and back again to the initial user location. Users can choose 1 up to 5 different tourism sites contained in the list menu. A number of maximum tourism sites that can be selected by the user are five locations with the consideration that in one-day traveling, the maximum locations that traveler can visit is only five locations. The TSP Travel Route recommendation is developed by using structured based approach.

### 3.3. TSP travel route algorithm

Travel route recommendation process starts by selecting several tourism sites by the user and determining the initial location of the user. Based on input several tourism sites and the initial location of the user, the system will convert these input into Latitude and Longitude values. The Latitude and Longitude values of tourism sites and the user's position will be used for the establishment of a distance matrix that will be used for the calculation of the shortest TSP route. The computation process of Latitude, Longitude distance matrix, and TSP solution is using by google service (google Maps API). Detailed Process in TSP travel route algorithm can be seen in Fig. 2.

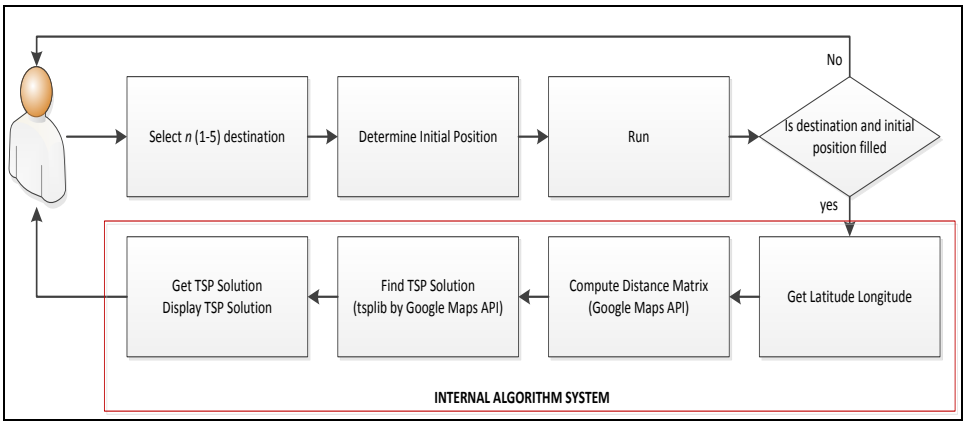



**Fig. 2**: Diagram of TSP Travel Route Algorithm

### 3.4. Google maps Directions API

Directions between two locations in a web application can calculate by using the DirectionsService object in google maps API(Google Developers 2016). The DirectionsService object communicates with the Google Maps API Directions Service which receives direction requests and returns computed results. The Directions service can return multi-part directions using a series of waypoints. Directions are displayed as a polyline drawing the route on a map, or additionally as a series of textual description within a  element (Google Developers 2016).
Directions Requests covered some parameters like the location of origin and destination, waypoints, travel Mode, transit option etc. Location of origin and destination contain information about Latitude and Longitude where this information can be obtained by using LatLng function in google Maps API. The use of the Directions service has limitation. In standard plan, we only can obtain 2,500 free requests per day, up to 8 waypoints per request, and 50 requests per second, calculated as the sum of client-side and server-side queries (Google Developers 2016). When we need more quota than those, we can use Directions service with the Premium Plan.

Travel modes currently supported in google Maps API are(Google Developers 2016):
- DRIVING (Default) indicates standard driving directions using the road network.
- BICYCLING requests bicycling directions via bicycle paths & preferred streets.
- TRANSIT requests directions via public transit routes.
- WALKING requests walking directions via pedestrian paths & sidewalks.

The result of directions request can be handled by our self or we can use the DirectionsRenderer object to render these results. To display the result of the directions query using DirectionsRenderer, we simply need to do the following (Google Developers 2016):
- Create a DirectionsRenderer object.
- Call setMap() on the renderer to bind it to the passed map.
- Call setDirections() on the renderer, passing it the DirectionsResult as noted above. Because the renderer is an MVCObject, it will automatically detect any changes to its properties and update the map when its associated directions have changed

### 3.5 Solve tsp by using google maps api

To solve TSP, we can use waypoints to calculate routes through additional locations, in which case the returned route includes stopovers at each of the given waypoints. Waypoints are one of the parameters in directions request. To obtain the most optimal TSP route, we may pass optimize: true as the first argument within the waypoints parameter to allow the Directions service to optimize the provided route. Travel time is the primary factor which is optimized, but other factors such as distance, the number of turns and much more may be taken into account when deciding which route is the most efficient (Developers 2016).

## 4. The implemented system and testing

Implementation of the system is measured by the success of the system in running TSP travel route application. Our system is written in Bahasa Indonesia. Scenario testing is done by selecting some tourism destinations (3 and 4) and comparing the recommendations result with TSP travel route by manual solutions. TSP travel route provided by the system is ideally equal to manual calculation. In manual computation, determination of the distance between tourism sites is using by Google Maps application where the distance between two locations is obtained by choosing the closest distance (Google Inc. n.d.).

### 4.1. Testing of TSP travel route recommendation for 3 destination

Initial Location : X.Pasar Baru
Destination : Y1. Kawah putih Ciwidey, Y2. Trans Studio, Y3. Danau Situ Patenggang

TSP travel route recommendation from our system can be seen in Fig. 3. The recommended route is given by ordered alphabetical.

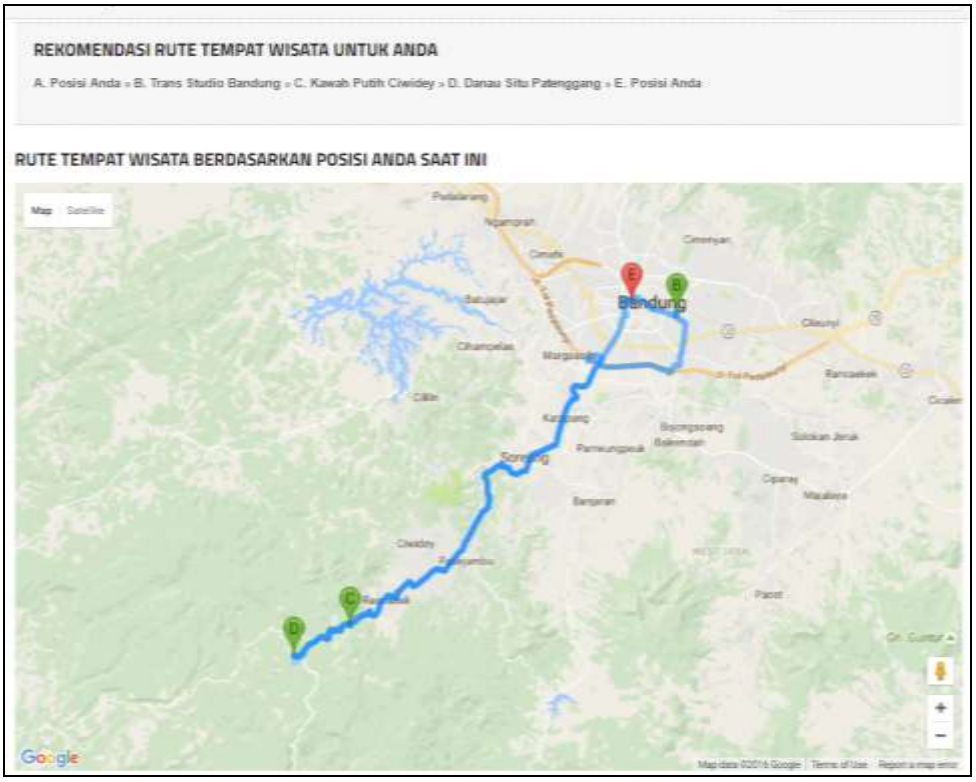



**Fig. 3:** Result of TSP travel route recommendation for 3 destinations

Manual computation of TSP travel route is started by building a distance matrix from Google maps. On the next step, the computation of TSP travel route distance is conducted for all TSP travel route combinations. In this case, the number of route combination is 6. The distance matrix for 3 destinations can be seen in Table 2, while the distance of all TSP route combination can be seen in Table 3.

**Table 2:** Distance Matrix of 3 Destinations (in km)

| Location | X | Y1 | Y2 | Y3 |
|---|---|---|---|---|
| X | 0 | 47,7 | 48,9 | 7,7 |
| Y1 | 47,9 | 0 | 13,8 | 56,3 |
| Y2 | 50,8 | 14,0 | 0 | 59,0 |
| Y3 | 5,6 | 50,4 | 53,1 | 0 |

**Table 3:** Result of Route Computation Manually for 3 Destinations

| Number | Route | Distance |
|---|---|---|
| 1 | X-Y1-Y2-Y3-X | 207.7 |
| 2 | X-Y1-Y3-Y2-X | 126.1 |
| 3 | **X-Y2-Y1-Y3-X** | **122.8** |
| 4 | **X-Y2-Y3-Y1-X** | **122.8** |
| 5 | X-Y3-Y1-Y2-X | 126.1 |
| 6 | X-Y3-Y2-Y1-X | 207.7 |

Manual TSP Travel route calculations produce **X-Y2-Y1-Y3-X** or **X-Y2-Y3-Y1-X** as the optimal route. The distance of this route is 122.8 km. It's mean the optimal TSP route given by our system are

- User →Trans Studio → Kawah Putih Ciwidey → Danau Situ Patenggang → User
- User →Trans Studio → Danau Situ Patenggang → Kawah Putih Ciwidey → User

The TSP travel route manually is equal when compared with TSP travel route recommendation by the system.

### 4.2. Testing of TSP Travel Route Recommendation for 4 Destination

Initial Location : X. Pasar Baru
Destination : Y1. Kawah Putih Ciwidey Y2. Trans Studio Bandung Y3. Danau Situ Patenggang, Y4. Kampung Gajah Wonderland

TSP travel route recommendation from our system can be seen in Fig. 4

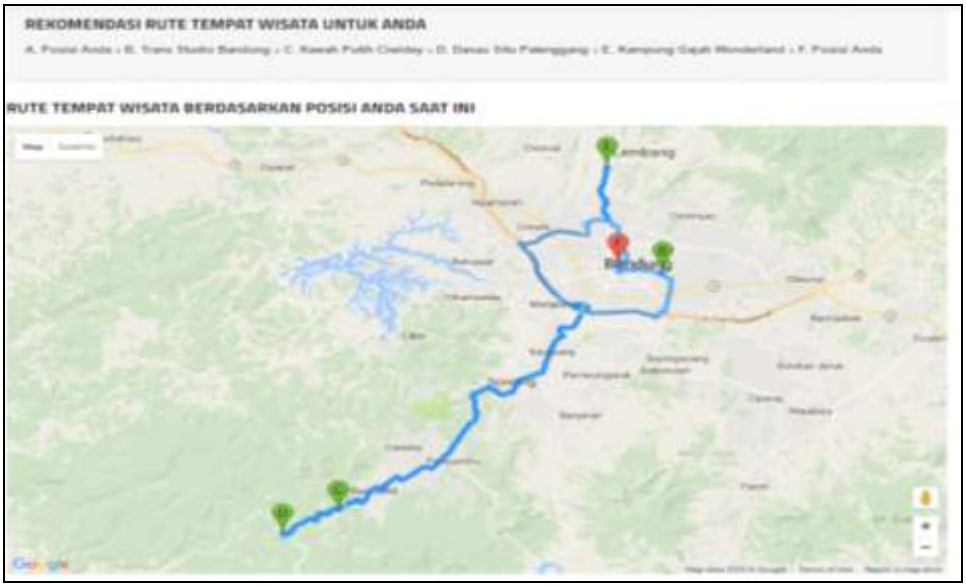



**Fig. 4:** Result of TSP travel route recommendation for 4 destinations

Manual computation of TSP travel route is conducted for all TSP travel route combinations. In this case, the number of route combination is 24. The distance matrix for 4 destinations can be seen in Table 4, while the distance of all TSP route combination can be seen in Table 5.

**Table 4:** Distance matrix of 4 Destinations (in km)

| Location | X | Y1 | Y2 | Y3 | Y4 |
|---|---|---|---|---|---|
| X | 0 | 47,7 | 48,9 | 7,7 | 12,2 |
| Y1 | 47,9 | 0 | 13,8 | 56,3 | 61,0 |
| Y2 | 50,8 | 14,0 | 0 | 59,0 | 15,4 |
| Y3 | 5,6 | 50,4 | 53,1 | 0 | 64,0 |
| Y4 | 11,8 | 62,1 | 18,1 | 64,8 | 0 |

**Table 5:** Result of Route Computation Manually for 4 Destinations

| Nb. | Route | Distance | Nb. | | |
|---|---|---|---|---|---|
| 1 | X-Y1-Y2-Y3-Y4-X | 232.7 | 13 | X-Y3-Y2-Y1-Y4-X | 232.6 |
| 2 | X-Y1-Y2-Y4-Y3-X | 234.8 | 14 | X-Y3-Y2-Y4-Y1-X | 234.8 |
| 3 | X-Y1-Y3-Y2-Y4-X | 147.7 | 15 | X-Y3-Y1-Y2-Y4-X | 147.7 |
| 4 | X-Y1-Y3-Y4-Y2-X | 149.2 | 16 | X-Y3-Y1-Y4-Y2-X | 149.1 |
| 5 | X-Y1-Y4-Y2-Y3-X | 230.7 | 17 | X-Y3-Y4-Y2-Y1-X | 230.8 |
| 6 | X-Y1-Y4-Y3-Y2-X | 238.1 | 18 | X-Y3-Y4-Y1-Y2-X | 238.2 |
| **7** | **X-Y2-Y1-Y3-Y4-X** | **147.8** | **19** | **X-Y4-Y2-Y3-Y1-X** | **145.3** |
| 8 | X-Y2-Y1-Y4-Y3-X | 234.8 | **20** | **X-Y4-Y2-Y1-Y3-X** | **145.3** |
| 9 | X-Y2-Y3-Y1-Y4-X | 147.7 | 21 | X-Y4-Y3-Y2-Y1X | 234.3 |
| 10 | X-Y2-Y3-Y4-Y1-X | 234.9 | 22 | X-Y4-Y3-Y1-Y2X | 152.7 |
| 11 | X-Y2-Y4-Y1-Y3-X | 149.9 | 23 | X-Y4-Y1-Y2-Y3X | 234.3 |
| 12 | X-Y2-Y4-Y3-Y1-X | 149.9 | 24 | X-Y4-Y1-Y3-Y2X | 152.7 |

Manual TSP Travel route calculations produce **X-Y4-Y2-Y3-Y1-X** or **X-Y4-Y2-Y1-Y3-X** as the optimal route. The distance of this route is 145.3 km. It's mean the optimal TSP route given by our system are

- User's location →Kampung Gajah→Trans Studio → Danau Situ Patenggang → Kawah Putih Ciwidey→ User's location
- User's location →Kampung Gajah→Trans Studio → Kawah Putih Ciwidey→ Danau Situ Patenggang→ User's location

The TSP travel route by the system gives the little different result. The optimal TSP route by the system is X-**Y2-Y1-Y3-Y4-X** which give a distance of route is 147.7. The difference TSP route distance from our system and manual computation are very small, less than 2%. It can be understood by considering that the optimal TSP route is given by google service in our system also **used traffic time**. In this research, we only make comparison TSP travel route by our system with TSP route based on short distance. The huge infrastructure is needed to make comparison TSP travel route by our system with TSP route based on traffic time. However, our system can give TSP route recommendation based on **traffic condition** but the accuracy very depends on google Maps service.

## 5. Conclusions

Web application for TSP travel route based on Google service can provide an optimal TSP travel route recommendations based on the shortest distance. This result is not compared with another research because the route problem that handled in this research is new. This application can be added to existing travel applications that usually also contains information such as descriptions of tourism sites, hotels,

car rental, events calendar and others. For a small scale, this TSP travel route application is very feasible to use. For large-scale, additional costs are required to still use this google service. This is due to google gives certain limitations related to the number of destinations and the number of user requests in one day.

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