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Design and Implementation of Mobile-Based Application for Malang City Public Transportation Route Search

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Abstract

Public transportation in Malang City, East Java – Indonesia becomes an important supporting factor of its population mobilization. Angkutan Kota (Angkot) is one of public transportation which provided by Malang City Government. There are 25 routes of Angkot which able to connect inter-terminal and any potential locations in 5 districts. The amount of Angkot routes and the typical of Angkot Routes system causing difficulties to choose the Angkot route that appropriate to be used by the user. In some case, the user has to transfer or using several Angkot routes when a direct route is unavailable. A mobile-based application is necessary to increase the effectiveness and simplify of Angkot routes search. This paper deal with the design and implementation of Mobile-Based Application for Malang City public transportation route search. Then, how it can be applied to solve the problems. Based on the experiment, have been obtained 40 of 40 test case or 100% routes found by the application. However, the application resulted in 34 of 40 test case, or 85%, are identic and valid when a comparison with manual Angkot route search that have been conducted. The result showed that the proposed design method was able to always found the Angkot routes in Malang city with correctness accuracy level was 85%.

Keywords: *Public Transportation, Route Search, Mobile Application, Path Planning.*

1 Introduction

Malang City, East Java - Indonesia, are 110,06 km^2 wide area city and 883.810 of the population [1]. The Malang City's density is 8000/km^2 and keep growing up based on the fact that Malang is a tourism and education destination. It can be seen in 4 state universities in Malang City. Furthermore, the average of foreign and domestic tourist is 180.000 tourist per year [2].

Public transportation in Malang becomes an important supporting factor of its population mobilization. Angkutan Kota (Angkot) is one of public transportation which provided by Malang City Government to fulfill the population needs. There are 25 routes of Angkot which able to connect inter-terminal and any potential locations in 5 districts [3].

Each Angkot route was designed to be integrated to connect every side of Malang. It makes a possibility which a single street passed by several Angkot route. It is a problem for the user to choose a suitable Angkot route for their need. In some case, the user has to transfer when a direct route is unavailable which bring out a new problem linked to the exact location of the transfer point and choosing the suitable Angkot route for the next. That problems becomes a complicated problem, especially for a tourist or a newcomer in Malang City.

Based on the fact, a media of information for Malang City people about Angkot routes is a needed. Nowadays, Malang City Government provides media, a website, as an information center which provides the information of Angkot routes in a Mediacenter website [4]. Based on the functional feature, Mediacenter website was not good enough to facilitate the people for searching Angkot route. The media center website just and only provides general information Angkot routes. To increase the effectiveness and simplification of Angkot routes information access, a mobile-based application is a necessity. The application provides Angkot route information and Angkot route utilization recommendation, based on the current user location (origin) and destination location with a minimum transfer. This paper proposes mobile-based Angkot routes search design application by using Modified-Path Planning and Haversine method. Some previous research has been proposed methods of path planning and routing on public transportation [5-11]. Nevertheless, it is necessary to modify the algorithm to adjust with the real case.

This paper is organized as follows: The first section explains the background and motivation of the research. The proposed method and the implementation will be explained in second and third. The fourth section consists experiment process and discuss the result. The last section explains the conclusion of the research.

2 Proposed Method

The implementation outcome of this research is Android mobile application. The application searches the Angkot routes according to the inputted origin location and destination location by the user. The result of the Angkot Malang city routes searching was a route name which able to be used by the user. The route described according to the street, intersection, or the traffic roundabout which passed by the Angkot routes. Figure 1 shows the user block diagram in utilizing the application.

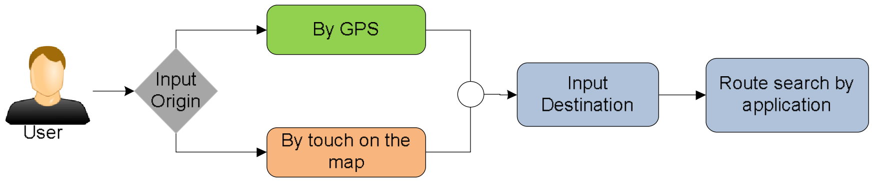

Fig. 1: User block diagram

The mobile application which has been build was a Location-Based Service by utilized the mobile device GPS service to got the location or longitude and latitude user beginning position. Based on the user beginning position location, Haversine formula has been used to found the location of nearest potential point as user departure beginning point (origin) and user last destination (destination). Therefore, the algorithm of modified path planning used to found the Angkot routes. The algorithm of Modified path planning did not limit the amount of transfer. There were complicated cases. The user must transfer the Angkot route several times, not only once or twice. It is the main reason why a method design which does not limit the route transfer amount is urgent. The purpose of the Haversine combination formula is to find the result of Angkot search constantly. A High–Level Flowchart of the proposed method is shown in Figure 2.

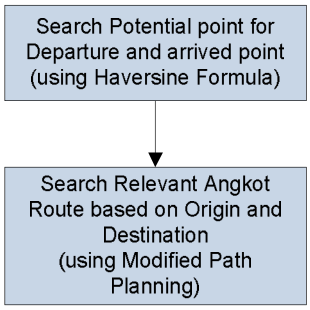

Fig. 2: High–Level Flowchart of proposed method.

2.1 Data

Data which used in this research are real data that divided into 3, which are: Angkot Routes; Streets; and Potential Point. Table 1 shows 2 of 25 Angkot routes data and the streets which passed by.

- Angkot Routes
  This data consists of the list of all Angkot routes in Malang City, included with the streets which be passed by the Angkot. The data acquired for the Malang City Mediacenter. There are 25 Angkot routes.
- Streets
  This data is a depiction of Angkot routes. There were 243 streets which used in this research. The data acquired by utilized API of Google Maps.
- Potential Point
  Potential point data is a list of places which considered as a potential point of transit and Angkot transfer if more than one Angkot route is needed to reach the destination location. This data consists of terminal, crossroads, bus stop, traditional market, and so forth. The amount of potential places were 257 places.

Table 1: Sample of Angkot routes data

Angkot Routes Name	Origin	Destination	Routes	
			Start	Return
AL	Arjosari Terminal	Landungsari Terminal	Arjosari Terminal - Raden Panji Suroso St. - Laksamana Adi Sucipto St. - Tenaga Utara St. - Karya Timur St. - Industri Timur St. - Asahan St. - Batanghari St. - Mahakam St. - Wage Rudolf Supratman St. - Panglima Sudirman St. - Patimura St. - Trunojoyo St. - Kertanegara St. - Tugu St. - Kahuripan St. - Semeru St. - Ijen St. - Retawu St. - Bondowoso St. - Jombang St. - Surabaya St. - Jakarta St. - Bogor St. - Veteran St. - Sumbersari St. - Gajayana St. - Mayjen MT. Haryono - Landungsari Terminal	Landungsari Terminal - Raya Tlogomas St. - Mayjen MT. Haryono St. - Gajayana St. - Sumbersari St. - Veteran St. - Bandung St. - Ijen St. - Semeru St. - Kahuripan St. - Tugu St. - Kertanegara St. - Trunojoyo St. - Patimura St. - Panglima Sudirman St. - Wage Rudolf Supratman St. - Mahakam St. - Batanghari St. - Asahan St. - Industri Timur St. - Karya Timur St. - Tenaga Utara St. - Laksamana Adi Sucipto St. - Raden Panji Suroso - Arjosari Terminal

AG	Arjosari Terminal	Gadang Terminal	Terminal Arjosari - Simpang Raden Panji Suroso St. - Raden Intan St. - Jenderal Ahmad Yani St. - Letjen S. Parman St. - Letjen Sutoyo St. - Jaksa Agung Suprapto St. - Jenderal Basuki Rahmat St. - Merdeka Utara St. - Merdeka Timur St. - Sukarjo Wiryopranoto St. - Pasar Besar St. - Sersan Harun St. - Prof. Moh. Yamin St. - Sartono SH St. - Kolonel Sugiono - Terminal Gadang	Terminal Gadang - Kolonel Sugiono St. - Sartono SH St. - Irian Jaya St. - Tanimbar St. - Sulawesi St. - Yulius Usman St. - Syarif Al Qodri St. - Kauman St. - KH. Hasyim Asy'ari St. - Arief Rahman Hakim St. - Jenderal Basuki Rahmat St. - Jaksa Agung Suprapto St. - Letjen Sutoyo St. - Letjen S. Parman St. - Jenderal Ahmad Yani St. - Raden Intan - Terminal Arjosari

2.2 Haversine Formula

Haversine Formula was used to found nearest potential place point with the beginning point position and destination point. The Haversine formula is an equation giving great-circle distances between two points on a sphere from their longitudes and latitudes [12]. The distance (d) between two given latitudes and longitudes are computed using Haversine formula as shown below [12]:

$$d = 2R\, sin^{-1}\left(\sqrt{(sin\left(\frac{lat_2 - lat_1}{2}\right))^2 + cos(lat_1)\, cos(lat_2)(sin\left(\frac{lon_2 - lon_1}{2}\right))^2}\right)$$

Where R is the radius of Earth or 6372.797560856 in kilometers.

The distance between every potential point, the user origin point, and the destination point were calculated. The nearest potential point with the user beginning position assumed as departure point which the user must utilize the Angkot. The nearest potential point with the user destination location assumed as an ending point which the user must stop utilizing the Angkot.

2.3 Modified Path Planning

In this research, path planning method used as Angkot Malang routes search by adjusting the matrix value which assumed as an Angkot route. The basic idea of the method which used in this paper is matrix adjacency utilization as a basic connectedness inter-destination. If the standard matrix adjacency used value 0 and 1 as connectedness indicator, which 0 indicated no connectedness between 2 destinations and vice versa. Based on the typical, the core utilization of matrix adjacency was suitable for Malang public transportation which connectedness between A to B is not the same as B to A. The modification was a fulfillment on the matrix if value 1 or connected. We changed value 1 with routes based on the route which passed by. The reason was based on the fact which a street or a point was able to pass by different Angkot route. Based on the typical of Angkot which there is no cost difference whether it takes short or long miles, furthermore, the algorithm determination was based on the least amount of transfer. It caused the application recommendation produced the lowest cost route. Illustrated in Figure 3, a place point {A,B,C,D,E} connected with the Angkot route {x,y,z}.

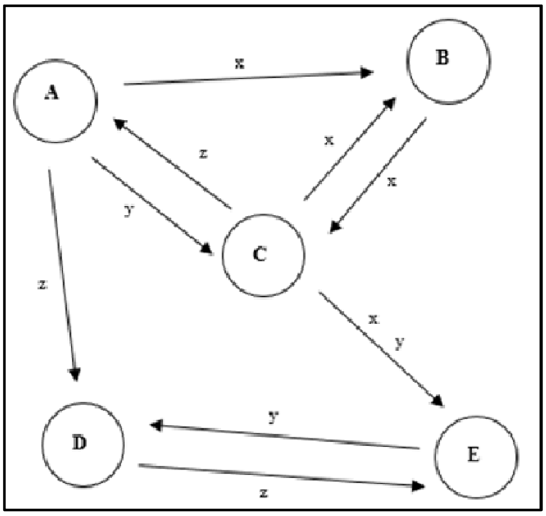

Fig. 3: Public Transportation Route Illustration.

Based on the path in Figure 3, it translated in a connectedness table or adjacency matrix like on Table 2. The table observed the connection between the beginning point and destination point. When both points were not connected by any Angkot route, the value of both points was 0. Nevertheless, when both points were connected, the value of both points consisted the Angkot route which connected both points. The adjacency matrix was guidance on the Angkot routes search.

Table 2: Connectedness Table.

		DESTINATION				
		A	**B**	**C**	**D**	**E**
ORIGIN	**A**	0	{x}	{y}	{z}	0
	B	0	0	{x}	0	0
	C	{z}	{x}	0	0	{x, y}
	D	0	0	0	0	{z}
	E	0	0	0	{y}	0

For example, the Angkot route search conducted with point B, T_0={B} as the beginning point and point E, T_z={E} as the destination point. It was conducted with a backward process which observed from the destination point to the beginning point.

Step 1: Searching any points with E as the destination point. In this case, the points were C and D. This condition has been notated as T(E)={C, D}.

Step 2: Searching any Angkot route which connected the points N(C,E)={x, y}; N(D,E)={z}.

Step 3: Conducted the same step (step 1-2) for component points which have been found, until obtained the similar component point with the beginning point $T_{(x,y)}= T_0$.

Step 4: Displayed the list of Angkot routes. In this case, it was Angkot route which connected point B to point E. N(B,C)={x} , N(C,E)={x, y} → N(B,E)={x}

Based on all steps which have been conducted, route X was the only Angkot route which from point B, as the beginning point, to point E as the destination point. For more details, observe Figure 4.

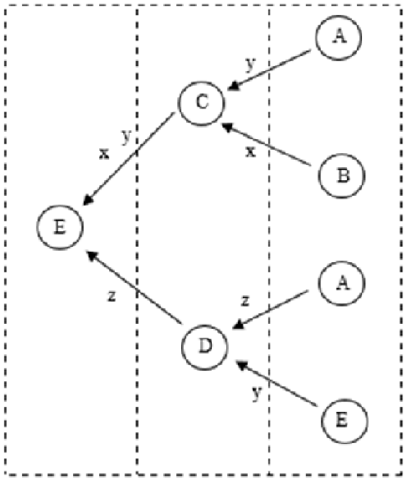

Fig. 4: Public Transportation Route Illustration to E point.

3 Implementation

There is an Android platform application that has been developed which named *Angkot Malang Apps.* The screenshot of *Angkot Malang Apps* shown in Figure 5. *Angkot Malang Apps* has been published and distributed in Google Play store (https://play.google.com/store/apps/details?id=com.orion.Angkotmalang&hl=en).

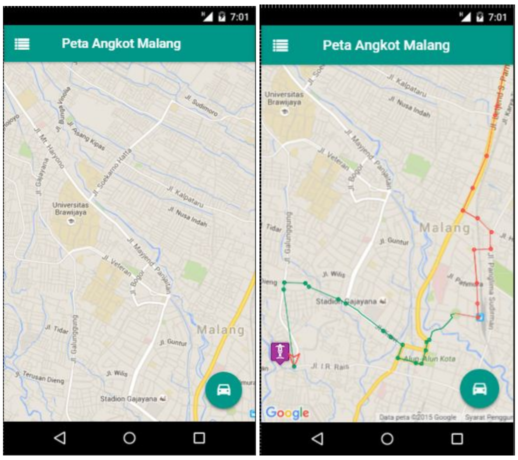

Fig. 5: Angkot Malang Apps Screenshot.

Angkot Malang used Google Map API to load the map interface. The adjacency matrix or Connectedness table that derived from Angkot Routes, Streets, and potential point data, was included into the application as asset. It was to prevent the application for wasting time just for create the connectedness table. If the computation was not done quick enough, or lag, it would effect to the Application User Interface process and frustrated the user automatically.

The user input the beginning location or the user location at that time and the destination location. Automatically, the application shows a recommendation of Angkot route and transit point or route point or Angkot transfer if necessary. The recommendation is generated from the proposed method.

4 Experiment and Discussion

The experiment has been conducted after the design have been made and implemented into an application. The purpose of the experiment was to observe the accuracy of the proposed method. The experiment has been done by comparing application Angkot route search result with manual search result. The output of the manual search was gathered from the drivers or the users which regularly use the route. 40 real data have been used as a test case for experiment purpose. The test case consisted of scenario direct route and transfer route (1-3 transfer). Table 3 shows 6 of 40 conducted test.

Table 3: Test Result Sample Data

Number	Departure	Destination	Result from Application	Result from User Experience	Result
1	Arjuno St.	Ade Irma Suryani St.	LDG	LDG	True
2	Ade Irma Suryani St.	Bendungan Sigura-gura St.	LDG - GML	LDG - GML	True
3	Bandung	Barito St.	ASD	ASD	True

	St.				
4	Bendungan Sengguruh St.	Bale Arjosari St.	LG - JPK	LG - JPK	True
5	Arief Rahman Hakim St.	Batubara St.	GA - ASD	GA - ASD	True
6	Akordion St.	Aris Munandar St.	AJG	JPK – LDG - AJG	False

Based on the experiment, have been obtained 40 of 40 test case or 100% routes found by the application. It can be stated that our proposed method was always able to found the Angkot routes based on origin and destination point. However, the application resulted in 34 of 40 test case, or 85% are similar and valid when a comparison with manual Angkot route search have been conducted. Some errors occurred because of mistakes on the Angkot routes data and wrong assumption of the departure (origin) point, potential transfer point, and destination point. For example, there are point A and point B which included in the data, but in reality, there is point M or the transfer point / potential point M which not included in the data. It makes the Angkot route on the point M is not included on the proposed method calculation. It can be seen in Figure 6. It is a necessity to improve the potential points data or transfer points.

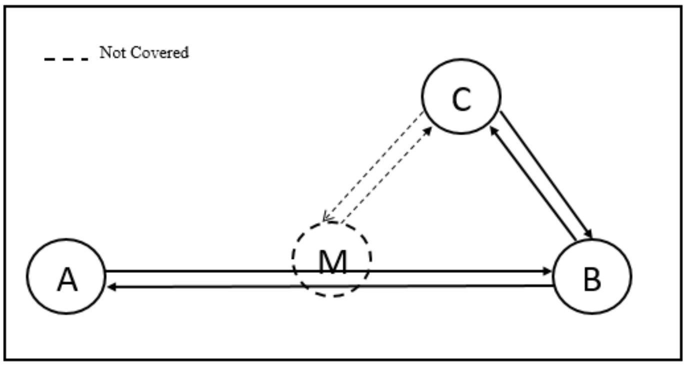

Fig.6: Uncovered potential point.

5 Conclusion

Based on the experiment result, the conclusion has been made. The combination of Haversine and Modified-Path Planning Method are suitable for mobile-based application to search the Malang City Angkot routes. Based on the experiment, the proposed method was 100% succeed to found Angkot routes. The proposed method always provides Angkot routes recommendation regardless the amount of the transfer. When the application compared with the manual search, the application was able to produce 85% similarity. In the future, it is necessary to improve the places data for the potential places determination. It is also a necessity to observe the distance from one point to another

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