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Recommendations for Tourism Sites Using the Mamdani Fuzzy Logic Method and Floyd Warshall Algorithm (Case Study in Yogyakarta)

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***Abstract*—Tourism is one of the activities carried out for recreation or leisure in a place with a variety of purposes and objectives. In Indonesia, many cities provide attractive tourism places, and one of them is the city of Yogyakarta. Because it has interesting and diverse tourism places, Yogyakarta is in great demand by local and foreign tourists. Thus to be able to maximize the visits of tourists who come to Yogyakarta, we need a system that is able to provide information on tourist attractions to tourists precisely in accordance with what the tourists want. The proposed system uses the Fuzzy Logic method and Floyd Warshall Algorithm which are combined, so as to obtain results in the form of recommendations for tourist attractions based on the costs of tourists, the length of time and distance needed to reach the tourist attractions.**

Keywords—Tourism, Fuzzy Logic, Floyd Warshall, Yogyakarta.

I. INTRODUCTION

Yogyakarta is one of the provinces in Indonesia known as the city of Education. In addition, Yogyakarta is also one of the most popular tourist attractions. Tourism in Yogyakarta is one of the main contributors to the economy in the Yogyakarta area. Yogyakarta has a variety of tourism places ranging from religious tourism, historical tourism, museums, beaches, and many others. Based on Yogyakarta tourism statistics [1] annual tourist arrivals continue to increase. Tourists visiting the city of Yogyakarta come from various regions in Indonesia and from various countries. With a high tourist attraction, the development of a tourism recommendation system will greatly help tourists to provide information and maximize tourist visits in the city of Yogyakarta. For tourists, information about tourism objects, costs that will be incurred when traveling, the length of time that will be spent, and the distance between tourist attractions is very necessary to be a parameter of tourists. With the rapid development of technology today, the tourism recommendation system can be used to provide tourism information to tourists appropriately.

One of the most frequently used recommendation algorithms is fuzzy logic. Fuzzy method is a powerful method to solve the problem of the representation of uncertainty knowledge. The advantages of Fuzzy methods that are used are methods that have been widely applied in research, by producing satisfactory results in accuracy so that it is expected to have high accuracy in producing information.

Mamdani Fuzzy Logic is a suitable method for recommendations on tourist attractions. Mamdani Fuzzy Logic is used because of its simple structure. Mamdani Fuzzy Logic uses the min-max or max-product operation with a set of predetermined rules, namely IF ... AND ... THEN before. In addition, the algorithm used is the Floyd Warshal algorithm which is useful for solving route search problems. This algorithm can also be applied to a road route search application that is closest from one area to another, with this method the results can be optimized.

The purpose of the proposed system is to provide recommendations for tourism places in Yogyakarta by using the Mamdani Fuzzy Logic method and recommendations for travel routes using the Floyd Warshall algorithm so that it is expected to have high accuracy in producing information. This paper is organized as follows. Section 2 outlines some studies related to the use of algorithms in this study. Section 3 describes in depth our proposed approach. Section 4 presents the results of the analysis and experiments in the proposed system. Section 5 discusses related work. Finally, we conclude with some future works

II. RELATED WORK

The tourism industry is growing from year to year. With the existence of social media, many tourism places are published so that tourists want to visit, both domestic and foreign tourists. For tourists, information about tourist attractions in a country is very important so that they are not wrong in determining their tourist destination with the cost and distance they want.

To make it easier for tourists to determine tourist attractions that will be their destination, a system is built using the Fuzzy method which in this system accommodates tourism object recommendation information. Some previous studies also used Fuzzy methods in tourism systems, there are several methods used, among others, Fuzzy Rule Based method [2], Fuzzy Set and Dominance-Based Rough Set [3], Neuro-Fuzzy Model method [4], and others. With the existence of a tourism recommendation system, it is very beneficial for tourists because they can provide advice or recommendations on tourist attractions [5] which is right for the user's needs

According to [3] based on the tourism systems approach, risk factors are divided into two dimensions, namely internal

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risk, and external risk and seven criteria namely political, economic, cultural-social, technological, environmental health, functional, and safe security. Another paper discusses a comprehensive multimodel approach to developing a conscious context recommendation system in the field of tourism information support [6]. In addition, it can use several methods and approaches to develop the tourism system. According to [7] the use of SWOT (Strength, Weakness, Opportunity, and Threat) approaches and Fuzzy logic methods are used for sustainable tourism development strategies. The SWOT analysis is a tool commonly used to analyze external and internal environments [8] simultaneously to obtain a systematic approach and support for decision situations. Data or information about attractions can be taken from the history of visitors, from the amount of digital data increasing rapidly. One example is the development of concepts in the field of historical tourism applications using a multi-agent, event-oriented design method with a central information center [9].

Some studies also use Mamdani Fuzzy Logic to obtain better accuracy results [10] [11] [12]. To facilitate route planning [13] of tourism, the Floyd Warshall algorithm is used [14]. Where Floyd Warshall's algorithm can reduce the complexity of calculations to simplify the method of finding the shortest path [15] and is very suitable for use in mapping-based applications [16]. The system to be designed consists of two concepts, namely a combination of Mamdani Fuzzy logic methods and Floyd Warshall algorithm. Fuzzy logic used will be applied as a method in the system inference engine part [17] [18] [19]. Input from the system will be processed using Fuzzy logic and the Floyd Warshall algorithm is used to determine the route [20] which is in accordance with user input.

Based on previous research, the study wanted to combine Mamdani Fuzzy Logic and Floyd Warshall algorithm for recommendations on tourist sites in Yogyakarta. Actually in this study also uses Location Based Services (LBS) to support the Floyd Warshall algorithm.

III. ARCHITECTURE DESIGN

This section will display the architectural design of the system that will be created and explain the fuzzification process in depth. Figure 1 illustrates the initial and final stages of the system to be made. From the system to be designed, it is divided into two stages. The first stage is the Fuzzy method that will determine the recommendations of tourist objects, after that, the second stage is the selection of routes based on the results of recommendations using the Floyd Warshall algorithm (see figure 1).

In Figure 1, the first process carried out is that the user enters three parameters, namely price, distance and vacation time. From the parameters specified each membership function is created. To help the process of making membership functions, the process of fuzzyfication is done by converting non-fuzzy variables into fuzzy variables. After generating a number of recommendations about tourist places with distances measured from the user's point when accessing the system, then the system will search for the best route using the Floyd Warshall algorithm and display the results of these routes to the system for use by users so that they can be utilized.

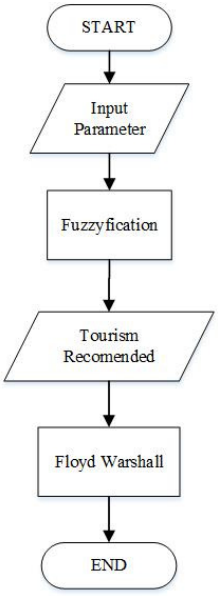

Fig. 1. System Architecture Design

A. *The Function of membership and Fuzzification*

From the three input parameters specified, each membership function is created from the fuzzy variables that have been made as in the table below. The first variable is the price that has a cheap, medium and expensive fuzzy set. Previously lower prices were 15,000 lower, medium prices from 10,000 to 55,000 and expensive prices greater than 50,000. For cheap and expensive sets using the trapezium membership function and the set is using the triangle membership function as shown in Figure 2.

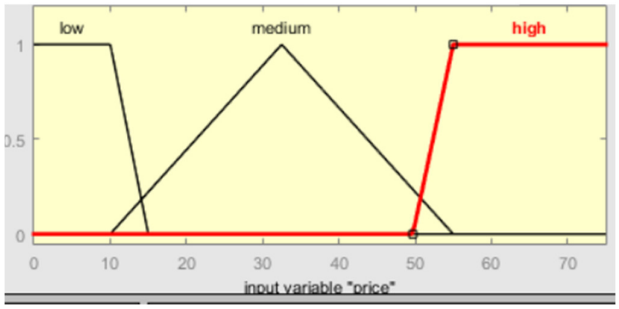

Fig. 2. Price Membership Function

In Figure 2 uses a scale 10^4 on the x axis. From the membership function the price can be formulated as follows:

$$\mu\, Low\ Price\ (x) = \begin{cases} 1\,; & x < 10.000 \\ \frac{15.000 - x}{15.000 - 10.000}; & 10.000 \le x \le 15000 \\ 0; & x > 15.000 \end{cases} \quad (1)$$

$$\mu\, Medium\ Price\ (x) = \begin{cases} \frac{55.000 - x}{55.000 - 32.500}\,; & 32.500 \le x \le 55.000 \\ \frac{x - 10.000}{32.500 - 10.000}; & 10.000 \le x \le 32.500 \\ 0; & x \le 10.000\ or\ x \ge 55.000 \end{cases} \quad (2)$$

$$\mu\, High\ Price\ (x) = \begin{cases} 1\,; & x \ge 55.000 \\ \frac{55.000 - x}{55.000 - 50.000}; & 50.000 \le x \le 55.000 \\ 0; & x \le 50.000 \end{cases} \quad (3)$$

Furthermore, the distance variable has 3 fuzzy sets, which are close, medium and far. The size of the distance has been determined to be closer to less than 20 km, the medium

between 17.5 km - 42.5 km and far greater than 40 km. For near and far sets also use the trapezoid membership function and the set is using the triangle membership function as shown in figure 3.

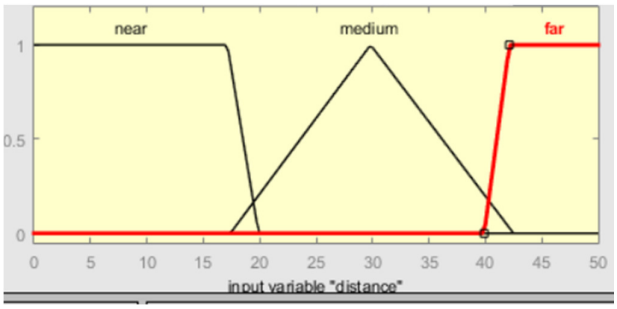

Fig. 3. Distance Membership Function

From the membership membership function in Figure 3, it can be formulated as follows.

$$\mu\ Near\ Distance\ (y) = \begin{cases} 1\ ; & y \le 17{,}5 \\ \frac{20-y}{20-17{,}5}; & 17{,}5 \le y \le 20 \\ 0; & y \ge 20 \end{cases} \quad (4)$$

$$\mu\ Medium\ Distance\ (y) = \begin{cases} \frac{42{,}5-y}{42{,}5-30}\ ; & 30 \le y \le 42{,}5 \\ \frac{y-17{,}5}{30-17{,}5}; & 17{,}5 \le y \le 30 \\ 0; & y \le 17{,}5\ or\ y \ge 40 \end{cases} \quad (5)$$

$$\mu\ Far\ Distance\ (y) = \begin{cases} 1\ ; & y \ge 42{,}5 \\ \frac{42{,}5-y}{42{,}5-40}; & 40 \le y \le 42{,}5 \\ 0; & y \le 40 \end{cases} \quad (6)$$

The last variable is the time variable which means the length of vacation time. The time variable has 3 sets, namely fast, medium and long. For the duration of the vacation, it has been determined quickly to be smaller than 30 minutes, medium between 20 minutes to 100 minutes and far greater than 90 minutes. For the fast and old set also uses the trapezoid membership function and the set is using the triangle membership function as shown in Figure 4.

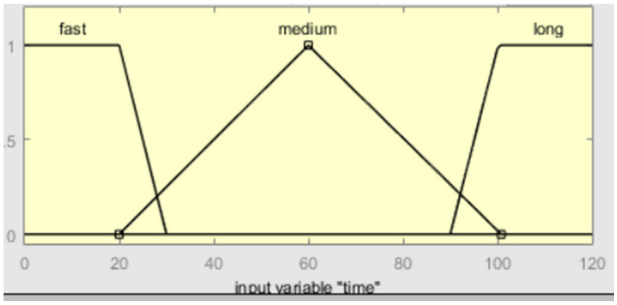

Fig. 4. Time Membership Function

From the time membership function in figure 4 it can be formulated as follows:

$$\mu\ Fast\ Time\ (z) = \begin{cases} 1\ ; & z \le 20 \\ \frac{20-z}{30-20}; & 20 \le z \le 30 \\ 0; & z \ge 30 \end{cases} \quad (7)$$

$$\mu\ Medium\ Time\ (z) = \begin{cases} \frac{100-z}{100-60}\ ; & 60 \le z \le 100 \\ \frac{z-20}{60-20}; & 20 \le z \le 60 \\ 0; & z \le 20\ or\ z \ge 100 \end{cases} \quad (8)$$

$$\mu\ Long\ Time(z) = \begin{cases} 1\ ; & z \ge 100 \\ \frac{100-z}{100-90}; & 90 \le z \le 100 \\ 0; & y \le 90 \end{cases} \quad (9)$$

B. Rules

From the 3 inputs that become fuzzy variables and each variable has 3 fuzzy sets, the number of rules can be formed are 27 rules as in table 1.

TABLE I. Rules

Rule	Price (x)	Distance (y)	Time (z)	Conclusion (v)
R1	Low	Near	Fast	Possible
R2	Low	Near	Medium	Possible
R3	Low	Near	Long	Possible
R4	Low	Medium	Fast	Possible
R5	Low	Medium	Medium	Possible
R6	Low	Medium	Long	Impossible
R7	Low	Far	Fast	Impossible
R8	Low	Far	Medium	Possible
R9	Low	Far	Long	Impossible
R10	Medium	Near	Fast	Possible
R11	Medium	Near	Medium	Possible
R12	Medium	Near	Long	Possible
R13	Medium	Medium	Fast	Possible
R14	Medium	Medium	Medium	Possible
R15	Medium	Medium	Long	Possible
R16	Medium	Far	Fast	Possible
R17	Medium	Far	Medium	Possible
R18	Medium	Far	Long	Impossible
R19	High	Near	Fast	Possible
R20	High	Near	Medium	Possible
R21	High	Near	Long	Possible
R22	High	Medium	Fast	Possible
R23	High	Medium	Medium	Possible
R24	High	Medium	Long	Possible
R25	High	Far	Fast	Impossible
R26	High	Far	Medium	Possible
R27	High	Far	Long	Possible

In this research, the rules use the additive (sub) method which will sum up the fuzzy set solution μ obtained to produce the best recommendation place.

C. Floyd Warshall Algorithm

The Floyd Warshall algorithm is the most common method to use in finding the shortest route. This algorithm has input from a graph that is very directional and weighty, in the form of node points from each route that can be traversed. Floyd Warshall algorithm is very suitable to use because the results of accurate and precise results so that it can provide a solution in finding the closest route from star point to point to be seventh.

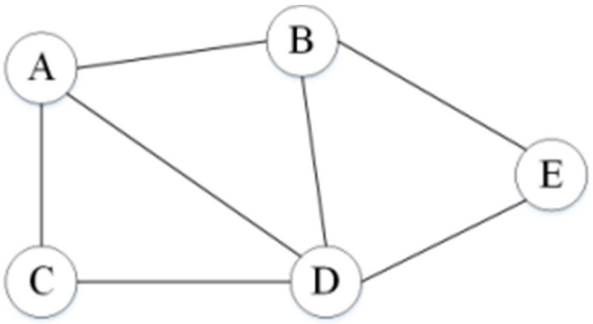

Fig. 5. Example of Graph or Route

To help calculate the distance between each point of the tourist spot with the start point, the HTML 5 function for geolocation will be used so that the user point is located in the form of latitude and longitude. By using the latitude and longitude can calculate the distance from the user's point to the tourist attractions to be addressed as well as the distance of tourist attractions with others so that it can form graph or route as in Figure 5.

IV. Analysis and Results

A. System Result Design

This design emphasizes the use of fuzzy methods to find the best place for recommendations and the use of the Floyd Warshall algorithm to find the best route. In the design of this system, there are several inputs needed which can be seen in Figure 6.

Figure 6 shows that there are three inputs needed by the system, namely price, distance and time. After that, the system will provide output in the form of recommendations for several tourist attractions that have been calculated based on previous inputs using the fuzzy logic method.

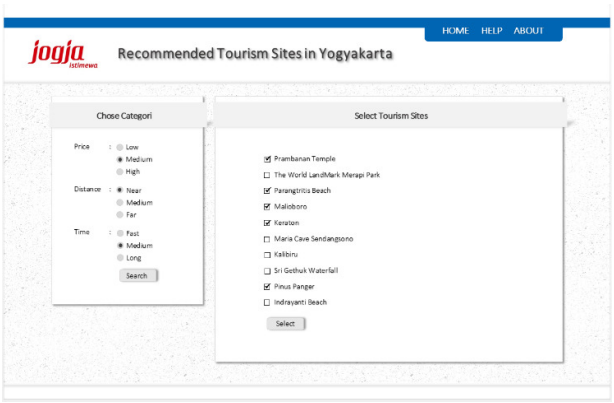

Fig. 6. Input by User

Then the system will calculate the best routes that can be traversed so that the trip becomes more optimum. The system will take the initial position by taking the point the user accesses the system with the geolocation function. The data obtained will be in the form of latitude and longitude which will be used in the calculation of the Floyd Warshall algorithm. Previously, data collection in the form of latitude and longitude has been carried out from each tourist spot in the Yogyakarta area so that it can issue the best route output such as the system design in Figure 7.

From Figure 7 it can be seen that there is a route that is the order of places to be visited by utilizing the Google Maps API so that it helps to get the optimum route.

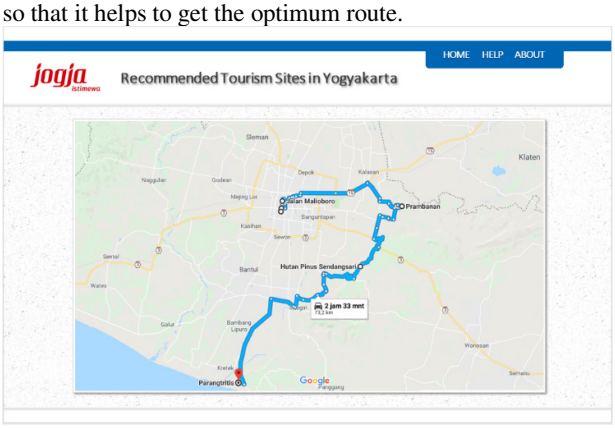

Fig. 7. Output System

B. Recommendation System Testing

In this section, an example of a system test will be shown where the first user input is the price in the medium category, the second distance is in the near and third category in the medium category.

In testing the system, 10 samples of tourism data were collected including Malioboro, Palace, Prambanan Temple, Indrayanti Beach, Parangtritis Beach, Maria Sendangsono Cave, The World Land Mark Merapi Park, Sri Getuk Waterfall, Kalibiru and Pine Pengger Forest

Previous rules have been determined in the system. In accordance with user input, the input is in accordance with rule 11 where the conclusion is possible.

TABLE II. Membership Degree Based on Price

No.	Price	Degree of Membership		
		Low	Medium	High
1.	Free	1	0	0
2.	10.000	1	0	0
3.	40.000	0	0.67	0
4.	10.000	1	0	0
5.	15.000	0	0.22	0
6.	Free	0	0	0
7.	15.000	0	0.22	0
8.	10.000	1	0	0
9.	10.000	1	0	0
10.	5.000	1	0	0

TABLE III. Membership Degree Based on Distance

No.	Distance (km)	Degree of Membership		
		Near	Medium	Far
1.	2.3	1	0	0
2.	0.55	1	0	0
3.	17.8	0.88	0.024	0
4.	65.8	0	0	1
5.	26.6	0	0.728	0
6.	30.3	0	0.976	0
7.	25.6	0	0.648	0
8.	34.4	0	0.648	0
9.	35.9	0	0.528	0
10.	21.3	0	0.304	0

TABLE IV. Membership Degree Based on Time

No.	Time (minute)	Degree of Membership		
		Fast	Medium	Long
1.	10	1	0	0
2.	2	1	0	0
3.	54	0	0.85	0
4.	107	0	0	1
5.	52	0	0.8	0
6.	64	0	0.9	0
7.	54	0	0.85	0
8.	73	0	0.675	0
9.	66	0	0.85	0
10.	46	0	0.65	0

In this research, taking a sample starting point at the zero kilometer point of the city of Jogjakarta to calculate the distance and time to tourist attractions so that the distance and time can change according to the user's access point to the system and also information obtained from the Google Map API. After calculating the degree of membership in each variable we obtain the weight of each place of recommendation, for determining the location of tourist attractions in accordance with the initial input, Price: Moderate, Distance: Near and Time: Medium.

TABLE V. Weight of Tourist Attractions

No.	Tourist Attraction	Price	Distance	Time	Result
1.	Malioboro	0	1	0	1
2.	Keraton	0	1	0	1
3.	Prambanan Temple	0.67	0.88	0.85	2.4
4.	Indrayanti Beach	0	0	0	0
5.	Parangtritis Beach	0.22	0	0.8	1.02
6.	Maria Cave Sendangsono	0	0	0.9	0.9
7.	The World Land Mark Merapi Park	0.22	0	0.85	1.07
8.	Sri Getuk Waterfall	0	0	0.675	0.675
9.	Kalibiru	0	0	0.85	0.85
10.	Pine forests Pengger	0	0	0.65	0.65

The results of the tests above show the level of strength of the value of the degree of membership. The higher the value of the membership level the greater the opportunity for a recommendation of tourist attractions. From table 5, it can be seen that the highest value of member membership is Prambanan Temple, making it the highest place in system recommendations, while Indrayanti Beach has a value of 0 so it does not become a recommendation from the system.

V. CONCLUSION

Tourism is one of the main roles in the economy in the Yogyakarta area. Yogyakarta has a variety of tourism places ranging from religious tourism, historical tourism, museums, beaches, and many others. With a high tourist attraction, the development of a tourism recommendation system will greatly help tourists to provide information and maximize tourist visits in the city of Yogyakarta. The recommended system for tourism places uses the Fuzzy Logic method and the Floyd Warshall algorithm. The use of Fuzzy Logic to be able to determine tourist attractions in accordance with 3 input variables, namely price, distance and duration of the vacation. The results will be recommended by several tourist attractions, after that the best route will be determined for tourist attractions where users access the system using the Floyd Warshall algorithm.

In the future, tourism recommendation research using Fuzzy Logic can increase the number of Fuzzy variables and sets. Additional variables may be selected by the type of transportation. In addition, it can also integrate tourism recommendations with the selection of hotels.

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