Implementation of Fuzzy Mamdani For Recommended Tourist Locations In Madura - Indonesia

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Abstract. As a developing country, Indonesia is currently actively developing itself in all its main fields of tourism. Diversity of tourism in Indonesia, one of which is located on Madura Island which has approximately 60 attractions spread across four districts namely Bangkalan, Sampang, Pamekasan and Sumenep. However, the current condition, there are many attractions that are not explored in the outside community so that many tourists do not know which attractions are revised. This study focuses on how to make a decision support system that provides tourist attractions for tourists. The method used is Fuzzy Mamdani which can produce the best decision by determining the Min-Max value and finding the fuzzy value based on its center. This research succeeded in making a system that provides tourist attraction recommendations for tourists by using fuzzy mamdani based on three criteria, namely the number of visitors, the distance of the tourist location to the city center, and the review of visitors on the internet.

Keywords: Tourism, attractions, Madura Island, Fuzzy Mamdani

1. Introduction

Tourism is a person's activity to travel temporarily from his place of residence to another place which is driven by cultural, economic, social and political interest [1][2]. The purpose of traveling is to enjoy the services and facilities needed while traveling. By traveling, physical needs will be met, even it is to get time to rest and enjoy vacation time. Tourism contributes significantly to the world economy, which is around 10% of the gross economy. Tourist destinations are not only natural attractions, big cities and distribution centers are also part of the tourist destinations sought by visitors [3]. Because it is part of the global economy, the tourism sector is one of the strategic sectors in driving the Indonesian economy.

Indonesia has a variety of attractions, one of which is on Madura Island. Madura Island is one of the islands located in East Java province which has a lot of tourism potential. Madura Island has 4 districts including Bangkalan, Sampang, Pamekasan and Sumenep. Madura is an island which the position is at the northeast of East Java. The width is smaller than the island of Bali with an area of approximately 5,168 km2 with a population of nearly 4 million inhabitants. Madura Island with its long history is reflected in culture and art with strong religious influences [2]. Attractions on Madura Island are quite varied but are still not too well known by the people so that it requires tourism publications about variations in the selection of tourist objects to be better known by the wider community and can advance tourism objects in Madura.
The concentration of the development of tourism in East Java is based on natural and cultural attractions. The centralized structure of tourism activities in East Java have resulted in a lack of ability to service existing tourism facilities and a decline in the quality of the tourism environment due to the uses that exceed the carrying capacity. So we need a system that can precisely help make decisions in choosing an efficient tourist attraction [1].

In a decision support system, there are various kinds of decision making methods, one of which is the Fuzzy Logic Method. Fuzzy logic is a calculation framework based on the concepts of setting the theory and fuzzy thinking to be used in drawing conclusions or decisions. Fuzzy Logic Method has several advantages including easy to understand and can be adjusted for needs, because fuzzy is also tolerant of homogeneous data, so it does not require training processes [4][5][6]. The concept of fuzzy sets is mapped from the input domain to the output domain [7]. Mamdani Fuzzy Method is one part of the Fuzzy method that is useful for getting the best decisions in uncertain problems. Fuzzy Mamdani is known as the Max-Min method which goes through several stages, namely the formation of fuzzy sets, application of function implications, composition of rules, defuzzification [8].

This study identified several tourism attributes that become the criteria in making decisions with the Fuzzy Mamdani method to produce information and recommendations on the selection of attractions.

2. Methods

2.1. Fuzzy Mamdani

Decision support system is an interactive computer-based system that is used to help make decisions by utilizing data and models in solving unstructured problems [1][9]. Fuzzy Logic is a branch of artificial intelligence that was developed to help making optimal decisions from several alternatives. Fuzzy logic is used to resolve situations where there is uncertainty whether something is right or wrong. This situation is often a situation that occurs in the real world [4][10].

The Membership Function is a mapping of the truth value of all real numbers at interval values between 0 and 1. The degree of membership of the variable x can be symbolized as μA (x) which is characterized by the symbol A = {(x, μA (x))} x X, μA (x): X [0,1] where x is a real number describing the element, while x is a reference. A value is a subset of X. The way the fuzzy mamdani method works is by performing MIN-MAX or MAX-PRODUCT operations. To be able to produce an output, one must perform 4 algorithm stages, namely:

1. Fuzzyfication

Fuzzyfication is the first step to take input values of crisp, x1 and y1 (project funding and project staff). Fuzzyfication also has fuzzy values, where crisp values will be converted into fuzzy values which will be grouped in the fuzzy set.

2. Rule Evaluation

Rule Evaluation is the second step to take values that have been fuzzified into antecedents for the implication process that uses the Min function

\[\muA\capB(x) = \min[\muA(x), \muB(x)] \quad \text{..................(1)}\]

3. Aggregation Rule

Aggregation is the third step to combine output values using the Max method. The Max function can produce a new fuzzy set by taking the maximum value to modify fuzzy.

\[\muA\cupB(x) = \max[\muA(x), \muB(x)] \quad \text{..................(2)}\]

4. Defuzzyfication uses the Centroid method.

Defuzzyfication is the final step in the fuzzy inference process to help evaluate the obscurity of the fuzzy results. In defuzzyfication The method used for Mamdani fuzzy inference is the Centroid (Center of gravity / COG) method. In theory, COG is for continuous calculation of aggregate membership functions. In this case, generally can be formulated

\[x^* = \frac{\sum_{j=1}^{n} y_j u_j}{\sum_{j=1}^{n} u_j} \quad \text{..................(3)}\]

2.2. Research Data

This study used 60 data attractions in 4 districts of Madura Island there are Bangkalan, Sampang, Pamekasan, Sampang and Sumenep. The criteria used are the number of visitors each quarter of 2017,
the distance of tourist sites from downtown, and the results of visitor reviews on the internet. Table 1-4 shows tourism location data in each district on Madura Island along with supporting parameters as input to the fuzzy calculation. Whereas in Table 5-8 is the value of the degree of membership in each parameter in each district.

Table 1. Tourism data in Bangkalan Regency.

| No | Travel Attractions  | Number of Visitors | Distance | Review Number of Reviews |
|----|---------------------|---------------------|----------|-------------------------|
| 1  | Api Alam Konang     | 2301                | 90 Km    | 3.4                     |
| 2  | Gunung Geger        | 3236                | 35 Km    | 3.6                     |
| 3  | Kerapan Sapi        | 1965                | 2.3 Km   | 0                       |
| 4  | Kolla Langundih     | 978                 | 5.5 Km   | 4.1                     |
| 5  | Makam Air Mata Ibu | 630000              | 15 Km    | 4.2                     |
| 6  | Makam Sultan Abdul Kadirun | 46452 | 0.5 Km | 3.8                 |
| 7  | Makam Syechona Cholil  | 607732              | 2 Km     | 4.8                     |
| 8  | Mercusuar           | 1606                | 9 Km     | 3.9                     |
| 9  | Museum Bangkalan    | 848                 | 2.5 Km   | 4.3                     |
| 10 | Pantai Maneron      | 1892                | 42 Km    | 3.5                     |
| 11 | Pantai Rongkang     | 1538                | 30 Km    | 3.4                     |
| 12 | Pantai Siring Kemuning | 11499              | 42 Km    | 3.8                     |
| 13 | Taman Rekreasi Kota | 29862               | 2 Km     | 4                       |
| 14 | Bukit Kapur Jaddih | 4767                | 9.7 Km   | 4                       |
| 15 | Bukit Pelalangan Aroshaya | 1750 | 17 Km | 4.1                     |
| 16 | Hutan Mangrove Kec. Sepuluh | 2045 | 35 Km | 4.1                     |
| 17 | Makam Sunan Cendana | 1558                | 30 Km    | 4.4                     |
| 18 | Air Terjun Bidadari Dhurjan | 969 | 60 Km | 3.9                     |
| 19 | Air Terjun Kec. Galis | 1217               | 31 Km    | 0                       |
| 20 | Pantai Bumi Anyar   | 979                 | 48 Km    | 0                       |

Table 2. Tourism data in Pamekasan Regency

| No | Travel Attractions  | Number of Visitors | Distance | Review Number of Reviews |
|----|---------------------|---------------------|----------|-------------------------|
| 1  | Api Tak Kunjun Padam | 9.723               | 6.1 Km   | 4                       |
| 2  | Batu Ampar          | 15.000              | 15.7 Km  | 4.1                     |
| 3  | Makam Ronggo Sukowati | 1.285               | 1.1 Km   | 0                       |
| 4  | Museum Umum Mandilaras | 1.782               | 0.004 Km | 0                       |
| 5  | Pantai Jumiang      | 13.726              | 13.7 Km  | 4.1                     |
| 6  | Pantai Talang Siring | 11.022              | 13.7 Km  | 3.8                     |

Table 3. Tourism data in Sampang Regency

| No | Travel Attractions  | Number of Visitors | Distance | Review Number of Reviews |
|----|---------------------|---------------------|----------|-------------------------|
| 1  | Pantai Camplong     | 42000               | 9.5 Km   | 3.9                     |
| 2  | Kolam Renang Sumber Oto' | 3179               | 14 Km    | 0                       |
| 3  | Gua Lebar           | 8496                | 0.3 Km   | 4                       |
| 4  | Wadak Klapmis       | 3024                | 12.3 Km  | 4.5                     |
| 5  | Hutan Kera Nepal    | 28378               | 51.4 Km  | 4.4                     |
| 6  | Air Terjun Toroan   | 15565               | 44 Km    | 4.1                     |
| 7  | Situs Ratu Bu      | 9539                | 3.4 Km   | 3.9                     |
| 8  | Situs Trunojoyo     | 1731                | 0.07 Km  | 5                       |
| 9  | Makam Sayid Utsman  | 3447                | 62.5 Km  | 0                       |
| 10 | Makam dan Sumur Tujah PanjiLaras | 3019 | 3.2 Km | 5                 |
| 11 | Karang Laut Mandangin | 3464               | 13.6 Km  | 3.9                     |
| 12 | Kolam Pancing Aji Gunung | 1513               | 1.8 Km   | 0                       |
Table 8. Membership functions of each parameter in Sumenep Regency

| Criteria                     | No | Membership Function | Boundary       | Domain                  |
|------------------------------|----|---------------------|----------------|-------------------------|
| The total number of visitors | 1  | Lots                | 270000         | >=18000                 |
|                              | 2  | Medium              | 180000         | 90000-270000            |
|                              | 3  | A few               | 90000          | <=18000                 |
| The distance from the center of the city | 1  | Far                 | 34.7 Km       | >=23.13                 |
|                              | 2  | Medium              | 23,133         | 11.567-34.7             |
|                              | 3  | Close               | 11,567         | <=23.13                 |
| The review of the tourism places | 1 | Good                | 5              | >=3.33                  |
|                              | 2  | Medium              | 3.333          | 1.67-5                  |
|                              | 3  | Bad                 | 1.667          | <=3.33                  |

Figure 1. Flowchart Fuzzy Mamdani

3. Result

Figure 1 is a system flow plan for the tourist recommendation process using the Fuzzy Mamdani method. The initial stage is to enter the desired tourist attraction criteria, while the next thing to do is to calculate using the Fuzzy method to produce a recommendation for the selected tourist attraction. Figure 1 explains the flow of the Fuzzy method which consists of:

1. Input the type of attraction, then determine the parameters of the attraction and the value of the set.
2. Determination of membership functions through a function approach which will later produce a value between 0 and 1.
3. Perform the fuzzification process by changing the firm value to the fuzzy value, where the output of the fuzzification process will produce a fuzzy input value or commonly referred to as fuzzy input.
4. Perform the query fuzzification process by applying a basic system of fuzzy query logic, namely with the syntax "select from where".
5. Perform fuzzy set operations using the basic operator Zadeh "AND" which will produce \( \alpha \)-predicate (fire strength). Alternative attractions that are recommended are alternatives that have a
value of fire strength or level of conformity with the selection criteria above the numbers 0 through 1.

**Determine fuzzy variables and sets.**

Fuzzy variables used in the study include the number of visitors, distance from the city center, review of tourist attractions. The variable number of visitors is divided into 3 fuzzy sets, namely many, medium and few. The distance variable from the city center is divided into 3 fuzzy sets, which are far, medium and close. The tourist variable review variable is divided into 3 fuzzy sets, which are good, medium and bad.

**Determination of membership functions.**

The membership function used in this research is through the representation of trapezoid curves and triangular curves, which consist of linear up and down linear representations. From the results of determining the membership function can be known the value of each criterion that ranges from 0 to 1.

**Fuzzification process.**

Fuzzification process is done by changing the firm value of each criterion into fuzzy value, which later the fuzzy value is used as input for the fuzzy query process.

**Fuzzy Rule Rules**

Variables - variables entered in the fuzzy set, formed rules, the rules / rules there are 3 parameters rules / rule. With a total of 27 rules. Formation of the rules in the tourist attraction recommendations there are 3 criteria rules / rule, namely: Recommended, Being Recommended, and Not Recommended.

- Rule 1: If Visitors are Lots AND Distance from City Center is Far AND Review is Good THEN Recommended.
- Rule 2: If the Visitor is Lots AND The Distance from the City Center is Far AND The Review is Being THEN Recommended.
- Rule 3: If Visitors are Lots AND Distance from City Center is Far AND Review is Bad THEN Recommended.
- Rule 4: If Visitors are Lots AND Distance from City Center is Medium AND Review is Good THEN Recommended.
- Rule 5: If Visitors are Lots AND Distance from City Center is Medium AND Review is Medium Recommended.
- Rule 6: If Visitors are Lots AND Distance from City Center is Medium AND Review is Bad THEN Recommended.
- Rule 7: If Visitors are Lots AND Distance from City Center is Near AND Review is Good THEN Recommended.
- Rule 8: If Visitors are Lots AND Distance from City Center is Near AND Review is Being THEN Recommended.
- Rule 9: If Visitors are Lots AND Distance from City Center is Near AND Review is Bad THEN Recommended.
- Rule 10: If the Visitor is Moderate AND Distance from the City Center is Far AND The Review is Good THEN Recommended.
- Rule 11: If the visitor is moderate AND the distance from the city center is far AND the review is the recommended THEN.
- Rule 12: If the Visitor is Moderate AND Distance from the City Center is Distant AND the Review is Bad THEN Being Recommended.
- Rule 13: If the Visitor is Medium AND Distance from City Center is Medium AND Review is Good THEN Recommended.
- Rule 14: If the Visitor is Medium AND Distance from City Center is Medium AND Review is Medium Recommended.
- Rule 15: If the Visitor is Moderate AND Distance from the City Center is Moderate AND Review is Bad THEN Being Recommended.
- Rule 16: If the Visitor is Medium AND Distance from City Center is Near AND Review is Good THEN Recommended.
- Rule 17: If the Visitor is Medium AND Distance from City Center is Near AND Review is Medium THEN is being Recommended.
- Rule 18: If the Visitor is Moderate AND Distance from the City Center is Near AND Review is Bad THEN Being Recommended.
- Rule 19: If the Visitor is a Little AND The Distance from the City Center is Far AND The Review is Good THEN Being Recommended.
- Rule 20: If the Visitor is a Little AND The Distance from the City Center is Far AND The Review is While THEN Is Not Recommended.
- Rule 21: If the Visitor is a Little AND The Distance from the City Center is Far AND The Review is a Bad THEN Not Recommended.
- Rule 22: If the visitor is a little AND the distance from the city center is medium AND the review is good THEN is being recommended.
- Rule 23: If the Visitor is Slight AND Distance from the City Center is Medium AND Review is Medium THEN Not Recommended.
- Rule 24: If the Visitor is Slight AND Distance from the City Center is Medium AND Review is Bad THEN Not Recommended.
- Rule 25: If the Visitor is a Little AND Distance from the City Center is Near AND Review is Good THEN Being Recommended.
- Rule 26: If the visitor is a little AND the distance from the city center is near AND the review is being THEN not recommended.
- Rule 27: If the Visitor is a Little AND Distance from the City Center is Near AND Review is Bad THEN Not Recommended.

Defuzzification

To find out the success rate of this method, the next step is the Affirmation (Defuzzification) used is the centroid method. With the formula looking for the value of $z * (center point)$ based on the equation contained in the theoretical basis. The first thing that needs to be done at the defuzzification stage is to look for moments 1, 2 and 3.

Based on calculations from the results of system testing, it can be seen that the system can run well. The test results are based on data on attractions which are then performed fuzzy method calculations so as to produce a recommendation in accordance with the wishes of tourists.

Based on the system calculation results, it is found that:

- In Bangkalan Regency, the results shows the no-recommended attraction are 0, the recommended 16 attractions have a center point 454669.71547079, and recommended 4 attractions have a number of center points 628606.6940455.
- In Sampang Regency, the results shows the no-recommended attraction are 0, the recommended 9 attractions have the number of focal points 31845.821916762, and the recommended 3 attractions have a number of center points 47144.1072191.
- In Pamekasan Regency, the results shows the no-recommended attraction are 0, the recommended 5 attractions have the number of focal points 10895.136740314, and the recommended 1 tourist attraction has number of center points 13539.876075085.

In Sumenep Regency, the results shows the no-recommended attraction are 0, the recommended 17 attractions have the number of center points 189611.55579663, and the recommended 5 attractions has a number of center points 280888.67283781

4. Conclusion

Based on the results of research that has been done, the following conclusions can be drawn:

1. The tourism object selection decision support system in Madura was built using the Fuzzy Mamdani method that uses visitor criteria, distance from the city center, and a review of attractions that are able to provide recommendations for selected tourist attractions.
2. Four districts in Madura can be known tourist places that are mostly visited by tourists. this can be a recommendation for tourists who will visit tourist attractions in Madura.
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