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PUBLIC TRANSPORTATION LINE PASSENGER PREDICTION USING MAMDANI METHOD OF FUZZY LOGIC TO FORESEE HOLIDAY PASSENGER SURGE

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Abstract. This study aims to predict the number of passengers on the Mall Pannakkukang-Galesong Harbor route on the "Teman Bus" fast transit transportation system in Makassar City. Public transportation modes often face the problem of an imbalance between the number of buses and the number of passengers, which can reduce the comfort and efficiency of passenger mobility. To overcome this problem, this study uses a fuzzy logic approach, specifically the Mamdani fuzzy method, to predict the number of passengers who will take the bus based on input variable data that has been collected, such as day temperature and weather, as well as the output variable, namely the number of passengers. The results obtained in this study are based on the inputs given, namely the day with a value of 0.5 and the weather temperature with a value of 30. The number of passengers is 1500, which means the number of passengers is included in the quiet category.

Keywords : Fuzzy Logic, Mamdani Method, Prediction, Bus Passenger

1. INTRODUCTION

Buses are one of the most common types of public transportation that are used by many people and play an essential role in urban mobility. The Buy the Service action for “Teman Bus” was put in place by the Ministry of Transportation of the Republic of Indonesia to improve non-cash public transportation in urban regions [1]. Teman Bus is an Indonesian quick transit system that runs in several locations, including Makassar on line 1, which covers the Pannakkukang Mall route to Galesong Harbor.

The imbalance between the number of buses and the number of passengers is a common issue in mass transit modes of transportation. This also occurred on Makassar City buses covering from Pannakkukang Mall to Galesong Harbor. Passenger density is significant on specific days or under particular weather conditions. This means that "Teman Bus" customers have to decide between cramming in the bus or waiting for the next bus, which is likely to take a long time, lowering the comfort of passenger mobility. As a result, it is necessary to anticipate the number of passengers who are expected to board the bus on the Pannakkukang Mall-Galesong Harbor route so that the number of buses arriving is equal to the number of passengers.

The authors of the research "*Implementation of Mamdani fuzzy implication in predicting traffic volume and duration of green lights on an intersection*" [2] used the Mamdani fuzzy logic approach to predict the number of positive COVID-19 in Java West. The descriptive method was utilized for the research, and the data collecting method was an observation on the Pikobar website. Researchers utilized variable data in the form of rises of ODP, PDP, and positive for COVID-19, with three predetermined categories for all variables, namely low, medium, and high. The output variable, on the other hand, is the result of a positive prediction 14 days later. A linear curve is employed for fuzzification needs. The MAX function was used to compile the rules, while Centroid was utilized for defuzzification.

Fuzzy logic can be utilized to predict the number of passengers. Fuzzy logic is a branch of mathematics that analyzes uncertainty. The Mamdani approach [3] is one of the fuzzy system principles utilized in the procedure of predicting the number of bus passengers. The Mamdani fuzzy technique is based on a mathematical idea that allows for very flexible fuzzy reasoning while also supporting imperfect data. Based on the computed research

results, the Mamdani fuzzy approach has a lower error rate compared to other fuzzy methods [4]. Mamdani's fuzzy logic implementation is expected to provide a more accurate prediction of the number of passengers based on relevant input variables like the time of day and conditions temperature, as well as the output variable, namely the quantity of passengers, so that "Teman Bus" companies can be more alert when there is a surge in passengers.

2. METHODS

A quantitative method is implemented in this research. Data collecting, creating fuzzy sets, implication function application, assertion (defuzzy), and deriving conclusions are the stages used in this research. **Figure 1** illustrates this issue.

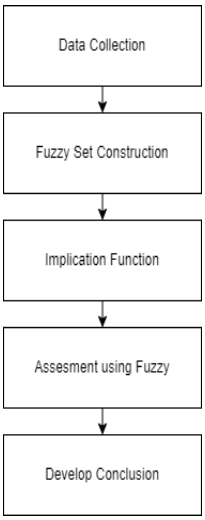

Figure 1. Research Process

This study's data collecting stage relied on primary data gathered through interviews and direct surveys of passengers and transportation system operators. Other data is secondary data, which contains historical data and records provided by PT Borlindo Mandiri Jaya in the form of number of passengers, what day, and the weather in March 2023. Table 1 shows the data.

Table 1. Bus Passenger Dataset in March

Date	Day (work day/holiday)	Temperature (celcius)	Number of Passengers (n)
01/03/2023	1	27	2019
02/03/2023	1	29	2117
03/03/2023	1	30	2071
04/03/2023	1	30	1936
05/03/2023	0	29	1600
06/03/2023	1	28	1997
07/03/2023	1	29	2079
08/03/2023	1	31	1965
09/03/2023	1	31	2246
		…..	
		…..	
31/03/2023	1	30	1684

Following the collection of data, the prediction process begins, which in this case utilizes the fuzzy logic of the Mamdani method. Fuzzy logic is logic with a fuzziness value between true and false [5]. A fuzzy system is a system that is constructed on clear definitions, functioning procedures, and descriptions that are based on fuzzy logic. The Fuzzy Inference System (FIS) employs fuzzy logic to map the input space into the output space using the IF_THEN rule[15][16]. FIS is based on linguistic concepts and employs fuzzy algorithms to provide a mathematically studied method. In this case, the fuzzy logic used is Mamdani fuzzy logic. Ebrahim Mamdani developed the Mamdani method as the MAX-MIN method in 1975. The steps of fuzzy mamdani are fuzzy set construction (fuzzification), inference, and defuzzification [6], [7]. The fuzzification stage is the process of

converting numeric input into a linguistic value that the system can accept. The inference phase is concerned with the linguistic rules that are employed to generate uncertain output values. Defuzzification is the process of converting ambiguous output data into numerical values that humans comprehend [8].

The Mamdani fuzzy method has been widely used in a variety of research fields[14], including previous studies with a similar theme, specifically predicting the number of positive COVID-19 with the Mamdani fuzzy system [9], and Renaldi Primaswaraa Prasetya with the subject of determining the duration of traffic lights with the Mamdani fuzzy logic system [10]. In the case of this research, the data utilized is imprecise and ambiguous. Mamdani's fuzzy logic makes it achievable to represent uncertain human thinking using linguistic variables and fuzzy rules. Mamdani's fuzzy logic can overcome this uncertainty and deliver more accurate results by employing the concept of fuzzy membership. This indicates that Mamdani's fuzzy logic was effective in forecasting the number of passengers on the Pannakkukang Mall line to Galesong Port.

3. RESULTS AND DISCUSSION

This study utilizes input variable data, namely day and weather temperature, to forecast the number of bus passengers on the Pannakkukang Mall-Galesong Harbor using Mamdani fuzzy logic, while the output variable is the number of passengers. Table 2 shows the variables that were used.

Table 2. Input and Output Variable

Function	Variable	Environment of Topic
Input	Days	[0-1]
	Temperature	[20-40]
Output	Number of Passengers	[0-2800]

The variables that are gathered are used to create fuzzy sets. The fuzzy sets for the input variable days are divided into two categories, whereas the fuzzy sets for the input variables weather temperature and output are divided into three groups. Table 3 shows these variables and sets.

Table 3. Variable of Fuzzy Set

Variable	Fuzzy Set	Domain
Days	Holiday	[0, 0.3, 0.6]
	Working Day	[0.5, 0.8, 1]
Temperature	Low	[20, 25, 30]
	Middle	[25, 30, 35]
	High	[30, 35, 40]
Number of Passengers	Quite	[0, 0, 800, 1500]
	Normal	[800, 1500, 2200]
	Crowded	[1500, 2200, 2800, 2800]

According to **Table 3**, the fuzzy set can be represented by the variables of the day, weather temperature, and passenger number as follows:

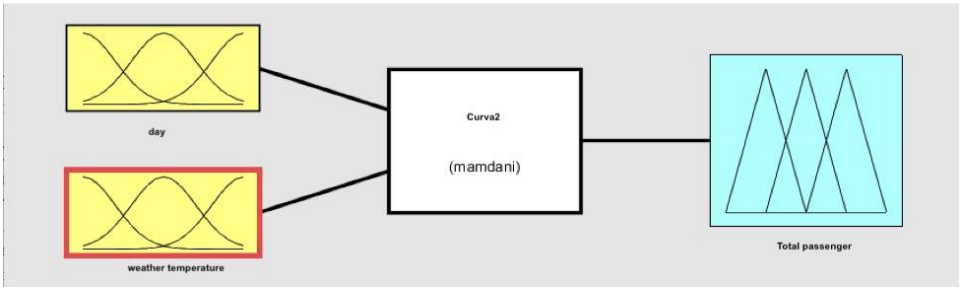

Figure 2. Membership function of Input and Output Variable

3.1 Fuzzy Sets of Inputs

In this study, the input variables were divided into two categories: days and temperature. As shown in Table 3, we separated each group into various classifications ranging from low to high. Figures 3(a) and 3(b) depict each set of input.

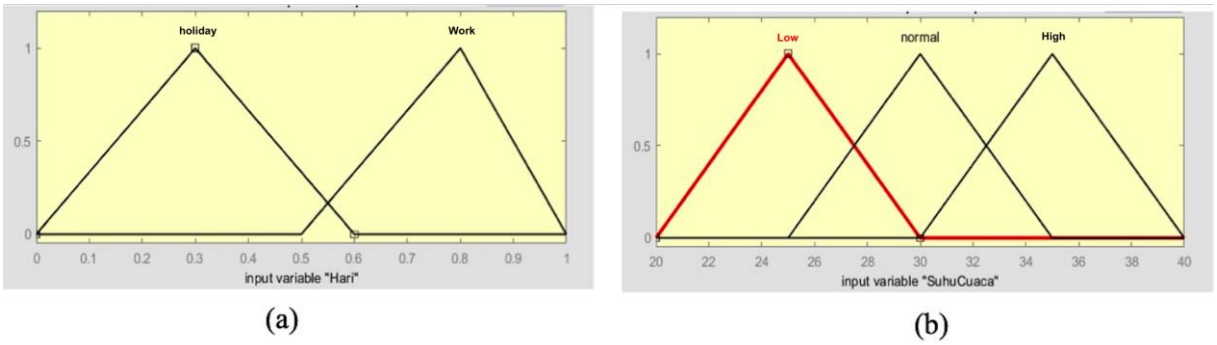

Figure 3. Fuzzy sets representation of input variables (a) Days (b) Temperature

3.2 Fuzzy Set of Output

This Fuzzy System's output is the number of passengers. Output is classified into three categories based on its prospective range, namely quiet, normal, and crowded. The output grouping is used as an indicator for the company to determine whether or not it should increase or decrease the quantity of buses operating at the time. Figure 4 displays a fuzzy set graph for the number of bus passengers.

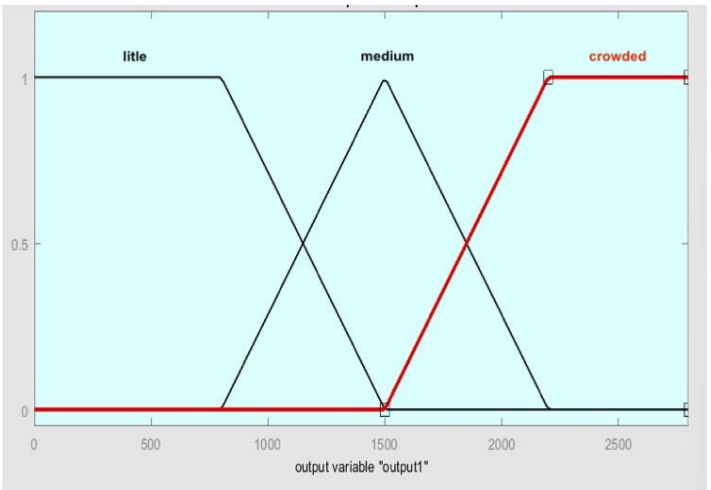

Figure 4. Fuzzy set of output variable

3.3 Fuzzy Rules

The relationship between the conditions on the input variables and the fuzzy sets on the output variables is described by fuzzy rules. Each fuzzy logic rule has an implication [11][13]. The AND operator is used for coordinating the fuzzy sets between the two input variables in the form of fuzzy rules. The IF-THEN operator, on the other hand, is used to map between fuzzy sets on input and output variables. **Figure 5** shows fuzzy rules set on the Matlab program.

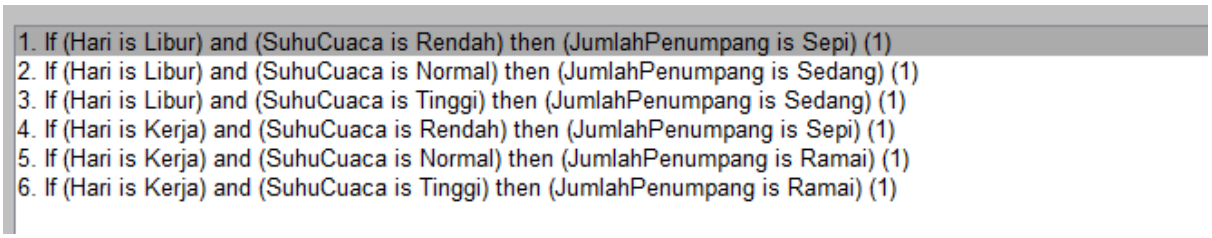

Figure 5. Fuzzy rules sets in Matlab Program

3.4 Defuzzification

The centroid (composite moment) method was utilized in this study's Mamdani fuzzy logic defuzzification method t generate cisp values by taking the center point (z*) in the fuzzy area. In general, centroid determination can be formulated by. $z^* = \frac{\int z\mu(z)dz}{\int \mu(z_j)}$

Where: (Equation 1.1)[12]

z = domain valuevalue$\mu(z)$ = membership function

z^* = defuzzification value

The fuzzy rule composition provides the input for the defuzzification process, and the resulting output is a number in the fuzzy set's domain [6].

The following is the result of using the Matlab program to test the implementation of mamdani fuzzy logic to anticipate the number of passengers on the Pannakkukang Mall - Galesong Harbor line bus. The number of passengers is 1,500 when the day value = 0.5 and the weather temperature = 30 is provided. As a result, the number of passengers is classified as quiet. PT Borlindo Mandiri Jaya was able to lower the number of bus units in operation after obtaining the "quiet" category from the output of the Mamdani fuzzy system. PT Borlindo Jaya can increase the number of bus partners who will operate if the Mamdani fuzzy system output of the number of passengers is "crowded." **Figure 6** shows the test result of the fuzzy system.

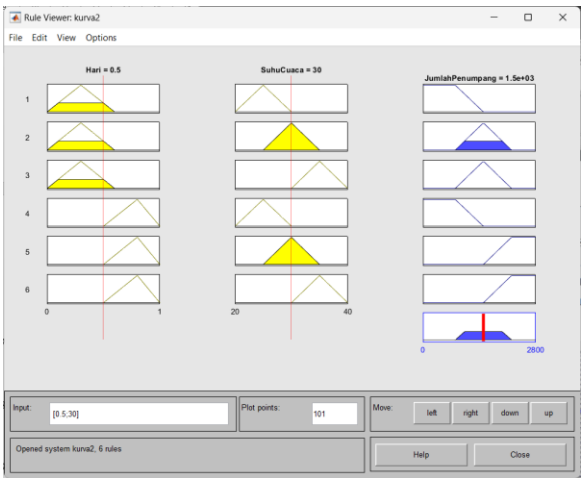

Figure 6. Fuzzy system test results

4. CONCLUSION

Based on the findings of the study, the following conclusions can be drawn:

1) The Mamdani approach can be utilized to anticipate the number of bus passengers on the Pannakkukang Mall route to Galesong Port using a fuzzy inference system (FIS).

2) Based on the input of the day value and weather temperature, the test results are 1,500, indicating that the number of passengers is low. In other words, when the "quiet" category is acquired from the Mamdani fuzzy system output, PT Borlindo Mandiri Jaya can reduce the number of bus units in operation, and vice versa.

5. ACKNOWLEDGEMENT

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