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Fuzzy mamdani for the primary balloon shooter game

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ABSTRACT

Counting is a material that is considered not easy for most elementary school students. Not only from the considerations that are considered challenging but also the influence of the teacher's teaching style which makes bored, and boring is also a problem. In this study, an educational game balloon shooter prime numbers were made. In game design, the Mamdani fuzzy algorithm is applied to calculate the jumrance of balloons with the input variables of remaining_balloon and remaining_time. The application of the Mamdani fuzzy algorithm is considered successful, as evidenced by the high percentage rate of appearance of all balloons, reaching 76.4%.

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1. INTRODUCTION

Prime number is one of the mathematics teaching materials that is considered difficult among elementary school students. Many students complain about the teacher's teaching style. It tends to be monotonous. Therefore, more interesting media to support the learning process so that it is easily accessible is needed. Playing is an entertaining activity that is loved by various groups, from children to adults. Traditional games that are usually played in real life can now be played in digital form. Digital games can be easily accessed on the device so that it can be played anytime and anywhere [1]. Games become more appealing to players if they can depict real-world events, which necessitates the use of artificial intelligence (AI) in their development. The application of an artificial intelligence system improves the player's behavioral and emotional abilities [2].

In this study, the game design based on mathematics taught to elementary school students is a prime balloon shooter. This game utilizes artificial intelligence. The concept is shooting the balloons with prime numbers. Balloon shooter games are very diverse, such as arithmetic balloon shooter games with color combinations [3] or balloon shooter games designed as digital art [4]. However, among various types of balloon shooters, it is still rare to use artificial intelligence, especially fuzzy logic. In terms of decision-making, fuzzy logic is often used with calculations that model human reasoning through if-then rules to relate input and output variables [5].

The fuzzy method used in this game is fuzzy Mamdani. The min-max method on fuzzy Mamdani influences the assessment of the difficulty level according to the level in the balloon shooter game. The use of the Mamdani fuzzy method is divided into several stages, namely the formation of fuzzy sets, inference, rules components, and defuzzification. The implementation of fuzzy Mamdani has been widely used, for example in the recommendation for tourist attractions in Madura[6] . Based on this first research review, fuzzy Mamdani was applied to analyze the criteria for visitors, distance from the city center, and a review of objects that have been determined to provide tourist recommendations to tourists visiting Madura. Then another example of implementing fuzzy Mamdani is determining the amount of durian pancake production [7]. Mamdani fuzzy can also be applied to determine the feasibility of pancake products based on supply and demand data.

In this study, fuzzy Mamdani was applied in a balloon shooter with prime numbers to pop balloons at each level. The number of balloons that sum will be determined by time. The application of fuzzy Mamdani to these aspects can determine the level of difficulty in the balloon shooter game.

2. THEORETICAL ASPECT OF THE FUZZY METHOD

Fuzzy logic

The basic concept of fuzzy logic is the value of reasoning or uncertainty [8]. This condition indicates that the numerical variables are shown in the form of linguistic expressions for modeling. Values in the form of linguistic expressions can produce many possibilities [9].

Mamdani inference system

Fuzzification

Fuzzification is a process that places a crisp value, also called as a firm value, with a membership degree value of only 0 and 1 into a fuzzy set form with a membership degree value located in the range of values 0 to 1. In boolean logic, the result is always 0 or 1 (true or false), while in fuzzy logic, the result is somewhere between 0 and 1 [10]. The fuzzy set is a linguistic value that is then processed based on the membership function limits[11]. The shape of the curve follows the membership function for each set (trapezoid, triangle, Gaussian, etc.). As for the membership function, in fact, it represents the degree of a predetermined value [12].

Inference

The inference is a fuzzy input processing process in the form of crisp values that are calculated based on predetermined rules in the form of "IF-THEN". After the rules have been determined, then evaluate the rules[13]. In this Mamdani method, the MIN implication function is used for each rule. After the results of the MIN implication are obtained, the composition of the new rules is carried out using the MAX function to produce a new fuzzy set output [7].

Defuzzyfication

Defuzzification is the process of combining the outputs of the previous processes (fuzzification and inference) to produce a fuzzy output, which is transformed back into firm numbers [14]. In this study, defuzzification was carried out using the centroid method to calculate the crisp value with the centre point (y*) of the fuzzy region [10]. The formula for the centroid method is shown in (1).

$$y *= \frac{\sum y\mu R(y)}{\sum y\mu R(y)} \quad (1)$$

3. RECENT STUDIES ON THE FUZZY METHOD

Comparison with several other studies is the implementation of fuzzy Mamdani for the recommendation of tourist sites in Madura-Indonesia [6]. This research shows that the application of fuzzy Mamdani is very appropriate for the decision-making system. It selects tourist objects by applying three parameters, namely visitor criteria, distance, and tourist attraction reviews. The results will show recommendations for tourist attractions based on tourist attractions that have a large number of visitors[7].

Another research conducted by Apriani and Perwira is the implementation of the fuzzy inference system in determining the amount of production based on supply data. The output value generated in the simulation shows results that are in accordance with manual calculations. In a study conducted by Mohammed and Hussain, namely the application of fuzzy Mamdani to identify and recognize moving objects with an accuracy rate of 98% [15]. In this study, there were 27,307 animal images for identification and classification. Research conducted by Ningrum et al. [16] in loading the SCADA system of distribution transformers at substations using the Mamdani fuzzy inference system.

In research conducted by Sukandy et al. [11], the aim is to create an application that applies the Fuzzy Mamdani method to predict the amount of palm oil production. It is based on supply and demand data. In this study, the parameters of normal current, voltage, and traffic are used. The results were obtained in the form of a transformer load based on the simulation carried out.

In a study conducted by Mohamad Irfan et al., fuzzy Mamdani was implemented in the analysis of student status [17]. The result of the accuracy test was carried out five times with 100% accurate results. From these results, it can be used as a decision maker to analyze which students should be given a warning or drop out.

4. MODEL

Intelligent system flow is used to determine the appearance of the balloons in the balloon shooter game. The flow of the intelligent system can be seen in Figure 4.1.

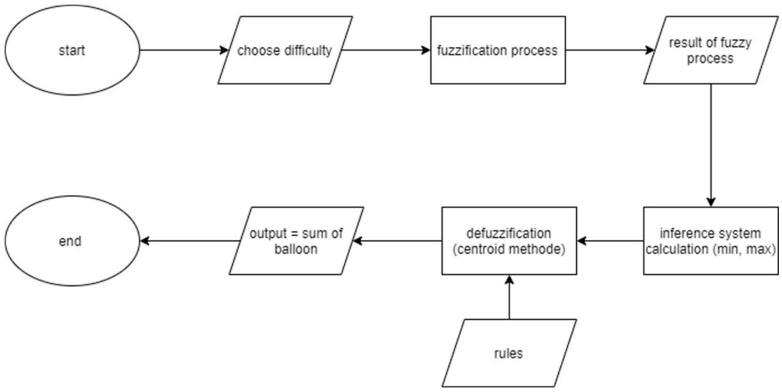

Figure 4. 1 flow system

The smart plot starts with the game difficulty input in the form of "choice", namely "easy-difficult". Then the input is calculated by the fuzzification process. The results of the fuzzification process are then processed together with the rules that have been made for the Mamdani system inference process (MIN-MAX method). The implication of min is to determine the minimum value of the input value with rules. The result of the min implication is then processed in the max implication process by taking the largest value. The results of the MAX method process are then processed in defuzzification with the centroid method. Finally, the output is the number of a balloons. The process of managing the results of fuzzy calculations is as follows.

Determine which variable to use.

In this study, we used a set of fuzzy variables as follows:

inputs:

• remaining time {short, medium, long},

• remaining balloons {little, medium, lots of}.

Output: appearance {little, medium, many}.

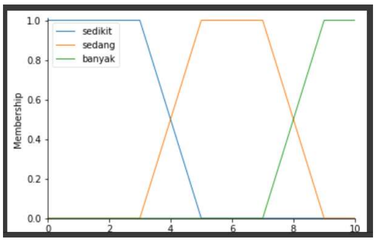

Figure 2. 1 remaining balloon membership function

- remaining_balloon

little : x ≤ 3	not little : x 5≥
medium : x ≤ 5 and x ≥ 7	medium notes : x ≤ 3 and x ≥ 9
lot of : x ≥ 9	not lot of: x≤ 7

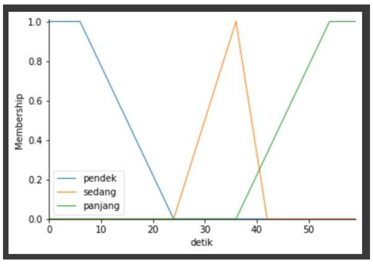

Figure 2. 2 remaining time membership function

- remaining time
  short : x ≤ 6 not short : x ≥ 24
  medium : x = 36 medium: x ≤ 24 and x ≥ 42
  long : x ≥ 54 not long : x≤ 36

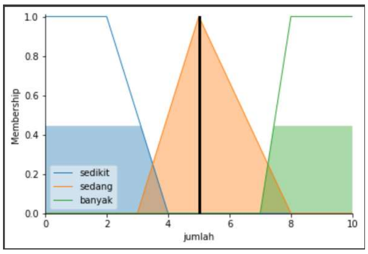

Figure 2. 3 outputs

- appearance
  little : x ≤ 2 not little : x ≥ 4
  medium : x = 5 medium: x ≤ 3 and x ≥ 8
  many : x ≥ 8 not many : x≤ 7

Based on the linguistic values above, the following is the value of the membership function:

- remaining balloons

$$\mu little[x] = \begin{Bmatrix} x \leq 5 \,;0 \\ 3 < x < 5 \,; \frac{x-3}{5-3} \\ x \geq 3 \,; 1 \end{Bmatrix} \quad (2)$$

$$\mu medium[x] = \begin{Bmatrix} x \leq 3 \; or \; x \geq 9 \,; 0 \\ 3 < x < 5 \,; \frac{x-3}{5-3} \\ 7 < x < 9 \,; \frac{9-x}{9-7} \\ x = 5 \,; 1 \end{Bmatrix} \quad (3)$$

$$\mu lots\; of[x] = \begin{Bmatrix} x \leq 7 \,; 0 \\ 7 < x < 9 \,; \frac{x-7}{9-7} \\ x \geq 7 \,; 1 \end{Bmatrix} \quad (4)$$

- remaining time

$$\mu short[x] = \begin{Bmatrix} x \leq 24 \,; 0 \\ 6 < x < 24 \,; \frac{x-6}{24-6} \\ x \geq 6 \,; 1 \end{Bmatrix} \quad (5)$$

$$\mu medium[x] = \begin{cases} x \le 24 \ or \ x \ge 42 \ ; 0 \\ 24 < x < 36 \ ; \frac{x-24}{36-2} \\ 24 < x < 42 \ ; \frac{42-x}{42-24} \\ x = 36 \ ; 1 \end{cases} \quad (6)$$

$$\mu long[x] = \begin{cases} x \le 30 \ ; 0 \\ 30 < x < 36 \ ; \frac{x-30}{36-30} \\ x \ge 36 \ ; 1 \end{cases} \quad (7)$$

- Appearance

$$\mu little[x] = \begin{cases} x \le 4 \ ; 0 \\ 2 < x < 4 \ ; \frac{x-2}{4-2} \\ x \ge 2 \ ; 1 \end{cases} \quad (8)$$

$$\mu medium[x] = \begin{cases} x \le 3 \ or \ x \ge 8 \ ; 0 \\ 3 < x < 5 \ ; \frac{x-3}{5-3} \\ 5 < x < 8 \ ; \frac{8-x}{8-5} \\ x = 5 \ ; 1 \end{cases} \quad (9)$$

$$\mu many[x] = \begin{cases} x \le 7 \ ; 0 \\ 7 < x < 8 \ ; \frac{x-7}{8-7} \\ x \ge 8 \ ; 1 \end{cases} \quad (10)$$

- Rules

Table 1. Relation between the inputs and appearance

No.	Remaining balloons	Remaining time	appearance
1.	little	short	little
2.	medium	short	medium
3.	little	short	many
4.	medium	medium	little
5.	lots of	medium	medium
6.	little	medium	many
7.	medium	long	little
8.	lots of	long	medium
9.	little	long	many

1. IF remaining_balloon = little AND remaining_time = little THEN appearance = little
2. IF remaining_balloon = medium AND remaining_time = little THEN appearance = medium
3. IF remaining_balloon = lots of AND remaining_time = little THEN appearance = many
4. IF remaining_balloon = little AND remaining_time = medium THEN appearance = little
5. IF remaining_balloon = medium AND remaining_time = medium THEN appearance = medium
6. IF remaining_balloon = lots of AND remaining_time = medium THEN appearance = many
7. IF remaining_balloon = little AND remaining_time = long THEN appearance = little
8. IF remaining_balloon = medium AND remaining_time = long THEN appearance = medium
9. IF remaining_balloon = lots of AND remaining_time = long THEN appearance = many

Figure 3. 1 Shoting Game Interface

Mamdani's fuzzy calculation in this game is located when the user starts shooting, as shown in Fig. 3.1. The player starts firing bullets at the prime numbered balloons. Each shot of a prime numbered balloon determines the appearance of the next balloon. The balloon popping is governed by the remaining balloon count which is indicated by the remaining balloon status at the top right. Each appearance of a balloon is affected by the remaining time and unshot balloons on the layer. Mamdani fuzzy testing is done with input data by the user, which has been calculated manually and produces a presentation of the appearance of the balloons of 76.4%.

The example calculation of the fuzzy Mamdani is for input on the remaining 4 pieces of balloons and the remaining time is 44 seconds. Fuzzy calculations to determine the number of occurrences of these cases are as follows

- Fuzzification

  Remaining balloon = little:

$$\mu(x = 4) = \frac{4-3}{5-3} = 0,5$$

  Remaining balloon = medium:

$$\mu(x = 4) = \frac{4-3}{5-3} = 0,5$$

  Remaining time = lots of:

$$\mu(x = 44) = \frac{44-30}{36-30} = 2,3$$

- Inference

  There are rules that match the fuzzification results, remaining_balloon = little (0,5), remaining_balloon = medium (0.5) and remaining_time = long (2,3) there is:

– Rule 7: if remaining_balloon = little and remaining_time = long then appearance = little
– Rule 8: if remaining_balloon = medium and remaining_time = long then appearance = medium

Implications min =
– µappearance little = µ remaining_balloon a little ∩ µ remaining_time long
  µappearance little = min (0.5; 2.3) = 0.5
– µappearance medium = µ remaining_balloon medium ∩ µ remaining_time long
  µappearance medium = min (0.5; 2.3) = 0.5
  max value =
– µappearance = µappearance little V µappearance medium
  µappearance = max (0.5; 0.5) = 0.5

- defuzzification

  defuzzification is solved by the centroid method.

$$\frac{(35+55+65+75+80)0,5 + (82+87+90+95+100)0,5}{(0,5+0,5+0,5+0,5+0,5) + (0,5+0,5+0,5+0,5+0,5)}$$

$$= \frac{155+227}{2,5+2,5}$$

=76.4

Based on the calculation results above, the defuzzification value is 76.4. This defuzzification value is used as a percentage of the number of occurrences of all balloons, which is 76.4%.

5. CONCLUSION

This research has demonstrated the design and development of a prime number math learning game called the prime number balloon shooter. This game is designed by using the fuzzy mamdani algorithm. Fuzzy mamdani is suitable to be used in making decisions on the appearance of the number of balloons. The inputs are the number of remaining balloons and remaining time. It provides feedback to players so that user don't feel bored. The result shows that the appearance probability of balloons is 76.4%.

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