Determination of Giving ‘Tips’ Using Fuzzy Logic To Determine Restaurant Customer Service Satisfaction

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Abstract. Fuzzy logic can be used to represent obscurity based on terms such as high, old, hot, cold, and so on. Fuzzy logic can extend the range of truth values to all real numbers in intervals between 0 and 1. Numbers in this interval represent the possibility that the statement given is "true" or "wrong". The use of fuzzy logic can be used in everyday life, such as in the fields of medicine, engineering, agriculture, transportation, environmental science and also in economic and business applications. As in this study, it was used to calculate the ideal amount of 'tips' for restaurant waiters based on the service provided by restaurant waiters. The method used in this study is to use Mamdani fuzzy logic with the process of defuzzification using the Centroid of area (COA). The results of this study are that it can be determined the value crisp of giving tips to restaurant waiters is 45 thousand rupiah provided that the service provided for service = 7 (Excellent) and food service = 8 (Delicious).

1. Introduction
Fuzzy Logic is a logic that has existed for a long time, around 1965, which was introduced by Dr. Lotfi Zadeh from the University of California. The use of fuzzy logic along with the times has become more famous because in the modern world fuzzy logic is widely applied to all-automatic machines. Fuzzy logic can be used to represent obscurity based on terms such as high, old, hot, cold, etc. [1] Fuzzy logic can extend the range of truth values to all real numbers in intervals between 0 and 1. Numbers in this interval represent the possibility that the statement given is "true" or "wrong". For example, the possibility that a man as tall as 181 cm is really high can be set to a value of 0.86. It is very likely that the man is really tall, and improper reasoning techniques are often referred to as probability theories. [2] Fuzzy logic is an enhancement of Boolean logic which gives the concept of partial truth. [3] In classical logic it is stated that everything can be specified in binary terms zero (0) or one (1), yes or no), fuzzy logic provides boolean truth with the level of truth. Fuzzy Logic has a membership function called the membership function, which is a curve that gives an overview of mapping data input points into membership values (or also called membership degrees) which have an interval between 0 and 1. [4] The utilization of Fuzzy Logic is currently widely applied in various fields, including: [5]

1. Fuzzy rule Based Systems
2. Fuzzy Nonlinear Simulations
3. Fuzzy Decision Making
4. Fuzzy Classification
5. Fuzzy Pattern recognition
6. Fuzzy Control Systems

In the real world fuzzy logic can be used in everyday life such as, in medicine, engineering, agriculture, transportation, environmental sciences and also in economic and business applications. [6] Fuzzy techniques are translated into four steps, namely Linguistic variables, membership functions, fuzzy inference and defuzzification. Linguistic variables are variables in the form of natural language that are used every day to express something important in its context and usually in the form of words. For example "This room is hot" "This room is cold" "fast" "slow" and so on. Membership function is a curve that indicates the mapping of data input points into its membership value (commonly called the degree of membership) which has an interval between 0 to 1. [2] The method that can be used to obtain membership value is through a function approach. Functions that can be used, such as linear representation, triangle curve representation, trapezium curve representation, shoulder shape representation curve, S-curve representation, bell shape curve representation. [7] Fuzzy inference is the process of mapping input given to an output using fuzzy logic. The process involves all parts such as membership functions, fuzzy logic operators, and IF-THEN rules. [8]

Defuzzification, is the process of mapping the magnitude of a fuzzy set to a firm value. [9] There are five (5) ways to do defuzzyfication, namely the following:

1. Centroid of area (COA)
2. Bisector of area (BOA)
3. Mean of maximum (MOM)
4. Smallest of maximum (SOM)
5. Largest of maximum (LOM)

The process of solving defuzzyfication can use the Mamdani, Sugeno, and Stukamoto methods. Of the three methods it has its own characteristics which can be used in solving problems. As in the case of giving the ideal 'tips' to the restaurant waiter with the following problems: "there are two people who are eating in the restaurant, both of them want to give 'tips' to the waiter with a certain amount based on the service / service provided by the service. What is the nominal amount of the Tips that will be calculated with fuzzy logic to get the ideal tips value."

2. Method

The method used in this study is to use Mamdani fuzzy logic with the process of defuzification using the Centroid of area (COA). The stages in the solution are:

1. Fuzzification
2. Inference Engine and Rule base
3. Defuzzification

The description of the resolution can be seen from the following picture:

![Figure 1. Fuzzy Inference Systems](image-url)
3. Results and Discussion

As explained on the background of the application of fuzzy logic at the completion of determining the amount of tips given to the restaurant waiter for the services provided, it is determined as follows:

Two restaurant visitors with two inputs, one output and three rule problems. Two inputs: services with a range of values (0-10), food with a range of values (0-10). With three rule problems:

1. Rule 1: if service is poor or food is rancid, then tip is cheap
2. Rule 2: If service is good, then tip is average
3. Rule 3: If service is excellent or food is delicious, then tip is generous

How many tips are given if service = 7 and food = 8; (value range tips 10 thousand rupiah up to 50 thousand rupiah).

The first step that must be done is to determine the linguistic variable, as shown in table 1 linguistic variable.

| Activities | Kind of service | Range of functions | Minimum Value - maximum function |
|------------|-----------------|--------------------|----------------------------------|
| Service    | Poor            | 0 – 4              | 0 – 10                           |
|            | Good            | 3 – 7              |                                  |
|            | Excellent       | 6 – 10             |                                  |
| Food       | Rancid          | 0 – 6              | 0 – 10                           |
|            | Delicious       | 4 – 10             |                                  |
| Tips       | Cheap           | 10 – 30            | 10 – 50                          |
|            | Average         | 20 – 40            |                                  |
|            | Generous        | 30 – 50            |                                  |

Fuzzy Service:

\[
\mu_{\text{service poor}}(x) = \begin{cases} 
1, & x \leq 2 \\
\frac{4-x}{4-2}, & 2 \leq x \leq 4 \\
0, & x \geq 4 
\end{cases}
\]
\[ \mu \text{ service good} (x) = \begin{cases} 
0, & x \leq 3 \\
\frac{x - 3}{5 - 3}, & 3 \leq x \leq 5 \\
\frac{7 - x}{7 - 5}, & 5 \leq x \leq 7 
\end{cases} \]

\[ \mu \text{ service Excellent} (x) = \begin{cases} 
1, & x = 5 \\
\frac{x - 6}{8 - 6}, & 6 \leq x \leq 8 \\
1, & x \geq 8 \\
0, & x \leq 6 
\end{cases} \]

**Fuzzy Food:**

![Fuzzy food Graph](image)

**Figure 3. Fuzzy food Graph**

Membership functions:

\[ \mu \text{ Food Rancid} (y) = \begin{cases} 
1, & x \leq 3 \\
\frac{6 - x}{6 - 3}, & 3 \leq x \leq 6 \\
0, & x \geq 6 
\end{cases} \]

\[ \mu \text{ Food Delicious} (y) = \begin{cases} 
0, & x \leq 4 \\
\frac{x - 4}{7 - 4}, & 4 \leq x \leq 7 \\
1, & x \geq 7 
\end{cases} \]
Fuzzy Tips:

Membership functions:

\[
\mu \text{Tips Cheap}(z) = \begin{cases} 
1, & z \leq 20 \\
\frac{30 - z}{30 - 20}, & 20 \leq z \leq 30 \\
0, & z \geq 30
\end{cases}
\]

\[
\mu \text{Tips Average}(z) = \begin{cases} 
\frac{30 - z}{30 - 20}, & 20 \leq z \leq 30 \\
\frac{40 - z}{40 - 30}, & 30 \leq z \leq 40
\end{cases}
\]

\[
\mu \text{Tips Generous}(z) = \begin{cases} 
\frac{z - 30}{40 - 30}, & 30 \leq z \leq 40 \\
1, & z \geq 40
\end{cases}
\]

Fuzzyfication:

\(\mu\) service poor (7) = 0
\(\mu\) service good (7) = 0
\(\mu\) service excellent (7) = \(\frac{7 - 6}{8 - 6} = \frac{1}{2} = 0.5\)
\(\mu\) food rancid (8) = 0
\(\mu\) food delicious (8) = 1
\(\mu\) tips cheap = ?
\(\mu\) tips average = ?
\(\mu\) tips generous = ?

Implication:

Rule 1 (R1) : if service is poor or food is rancid, then tip is cheap
\(\alpha\) predikat = IF \(\mu\) service poor (7) \(\cup\) \(\mu\) food rancid (8) = \(\text{Max} [\mu\) service poor (0), \(\mu\) food rancid (0)] = \(\text{Max} [0, 0] = 0\)
Rule 2 (R2): if service is *good*, then tip is *average*

\[
\text{Rule 2 (R2) : if service is good, then tip is average} \\
\alpha \text{ predikat} = \text{IF } \mu_{\text{service good}}(7) \\
= \text{Max } [\mu_{\text{service good}}(0)] \\
= \text{Max } [0] \\
= 0
\]

Rule 3 (R3): if service is *excellent* or food is delicious, then tip is generous

\[
\text{Rule 3 (R3) : if service is excellent or food is delicious, then tip is generous} \\
\alpha \text{ predicate} = \text{IF } \mu_{\text{service excellent}}(7) \land \mu_{\text{food delicious}}(8) \\
= \text{Max } [\mu_{\text{service excellent}}(0,5), \mu_{\text{food delicious}}(1)] \\
= \text{Max } [0,5,1] \\
= 1
\]

Withdrawal Conclusion:
\[ COA = \frac{(10 + 20 + 30) \times 0 + (40 + 50) \times 1}{0 + 0 + 0 + 1 + 1} \]
\[ = \frac{90}{2} \]
\[ = 45 \]

So the results with service = 7 and food = 8 are given tips of 45 thousand rupiah.

4. Conclusion

This research concludes as follows:

1. Fuzzy Logic can be used to solve many problems relating to calculations that are vague in nature to be firm calculation of values (Crips).

2. A firm value of 45 thousand Rupiah for tips for restaurant servants can be determined with the provision of services provided for service = 7 (Excellent) and food services = 8 (Delicious).

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