Short Research Article

COMPARATIVE STUDY OF FUZZY LOGICAL OPERATORS.

Abstract

Fuzzy logic is currently very relevant as it offers a new way to address tuning and decision-making problems. In this article, we present a comparative study of the methods for evaluating fuzzy inference rules in artificial intelligence. We have discussed the output cuts derived from Zadeh's method compared to the so-called probabilistic approach.

To better illustrate this duality, we focused on the fuzzy control of a household fan with two inputs (temperature and humidity) and one output (fan speed). After fuzzification, rule evaluation, output aggregation, and defuzzification, we identified the fuzzy operators that maximize and minimize the outputs.

Keywords: Fuzzification, defuzzification, centroid, degree of membership, fuzzy logical operators, Probor.

I. Problematic

Fuzzy inference is an operation by which one admits a proposition related to other previously admitted propositions. [8]

fuzzy command or control systems , allowing a clear conclusion of the different outputs of the fuzzy rules, passing respectively through the following steps:

- Fuzzification
- Evaluation of rules
- Aggregation of rule outputs
- Defuzzification .

Defuzzification is the last step of fuzzy inference which aims to transform fuzzy values into a clear value called a real output. [9]

We know that two methods are then applicable to obtain the retained value of the variable to be predicted, namely:

- The weighted average (WA) method
- The Center of Gravity (COG) Method

We found that several authors have separately applied Zadeh fuzzy and probability operators for output defuzzification , but they have not made explicit which of these two families of operators maximizes or minimizes the output value.

Thus, the problem of our article revolves around the following question:

Is it possible to optimize output values during defuzzification ?

II. Hypotheses

It would be possible to maximize or minimize the values of the outputs of the rules in the following way:

After the step of aggregating the outputs of the rules, we will defuzzify by applying the fuzzy operators of Zadeh and those of probability and then we will proceed to a comparison of the results obtained after applying the aforementioned methods.

The objective pursued in this paper is to apply the two families of operators cited above in order to:

- to compare the results obtained after defuzzification .

- to identify fuzzy operators that minimize the outputs between the two families.

III. Definition of fuzzy operators [2] [3]

By fuzzy operators, we mean all those that are used to combine premises linked by the conjunction AND or the disjunction OR. We focus on these two, although there may be others.

III.1. Zadeh fuzzy operators

In this paper, we address the two fuzzy connectors namely AND and OR by considering the approach advocated by Zadeh . As follows: Let A_1 and be A_2 two fuzzy subsets of the universe X, and $\mu_{A_i}(x)$ the membership degrees of x to the subsets A_1 And A_2 .

- Fuzzy intersection case (ET/AND): $\mu_{A_1} \cap \mu_{A_2}(x) = Min\left[\mu_{A_1}(x), \mu_{A_2}(x)\right]$ where are the membership degrees of x to the $\mu_{A_i}(x)$ fuzzy A_i subsets .
- Case of the fuzzy meeting (OU/OR) : $\mu_{A_1} \cup \mu_{A_2}(x) = Max\left[\mu_{A_1}(x), \mu_{A_2}(x)\right]$

In this Approach, Max and Min are respectively the maximum and minimum of two membership degrees of x to the fuzzy A_i subsets .

III.2. Probabilistic fuzzy operators

Fuzzy operators by the probabilistic approach are applied in the following way

- Case of fuzzy intersection (ET/AND): $\mu_{A_i \cap A_2}(x) = \mu_{A_1}(x) \times \mu_{A_2}(x)$

fuzzy A_i subsets .

- Case of the fuzzy meeting (OU/OR) $\mu_{A_i \cup A_2}(x) = \mu_{A_1}(x) + \mu_{A_2}(x) - \mu_{A_1}(x) \cdot \mu_{A_2}(x)$

The OR operator is defined as a total probability of two degrees of membership of x to the fuzzy subsets A_1 And A_2.

IV. Results & Application

In this part we consider the control data of a house fan, with two inputs (temperature and humidity) and one output (fan speed) processed by Baali Sabeur & Mahmoudi Messaoud in 2022 where $\mu_{A_1}(x) = 0{,}5 \text{and} \mu_{B_1}(y) = 0{,}25$,$\mu_{A_2}(x) = 0{,}33$ And $\mu_{B_2}(y) = 0{,}55$, $\mu_{A_3}(x) = 0{,}5 \text{And} \mu_{B_3}(y) = 0{,}25$

IV.1. Fuzzification

If X is $A_1(0.5)$ or Y is $B_1(0.25)$ then Z is $C_1(?)$

If X is $A_2(0.33)$ and Y is B_2 (0.75) then Z is C_2 (?)

If X is $A_3(0,0)$ and Y is $B_3(0,0)$ then Z is $C_3(?)$

IV.2. Evaluation of the rules:

We first recall here the evaluation of the rules by the Probor Method with two Inputs: Temperature $\mu_T(x) = 0{,}5$ and Humidity $\mu_H(y) = 0{,}25$

For rule 1: $\mu_{T \cup H}(x, y) = \mu_T(x) + \mu_H(y) - \mu_T(x) \cdot \mu_H(y)$

= 0.5 + 0.25 – 0.5 x 0.25

= 0.625

For rule 2: $\mu_{T \cap H}(x, y) = \mu_{A_1}(x) \bullet \mu_{A_2}(y)$

= 0.33 x 0.75

= 0.25

Table 1: Table of outputs of rules with Zadeh operators and those of Probor

Operator	Exit	Rules
Zadeh	$C_1(0.5)$,	R1
	$C_2(0.33)$	R2
	$C_3(0.00)$	R3
Probor	$C_1(0.625)$	R1
	$C_2(0.25)$	R2
	$C_3(0.00)$	R3

IV.3. Aggregation of rule outputs [9]

IV.3.1. Aggregation of rule outputs According to Zadeh

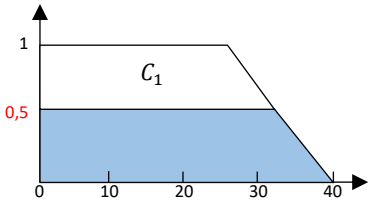

Fig. 1 : Cutoff of Output 1

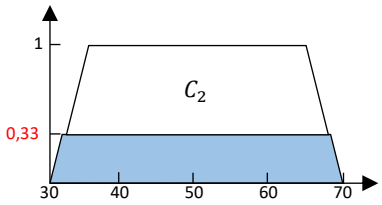

Fig. 2 : Cutoff of Output *2*

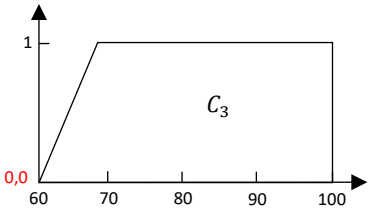

Fig. 3 : Cutoff of Output *3*

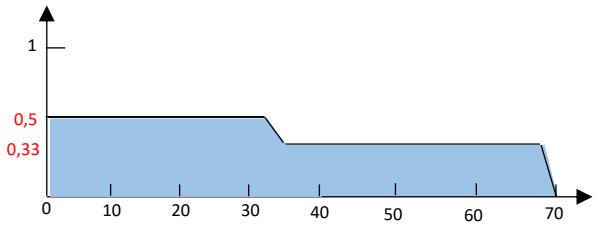

Fig. 4 Aggregation of Rule Outputs According to Zadeh

a. Aggregation of rule outputs According to Probor

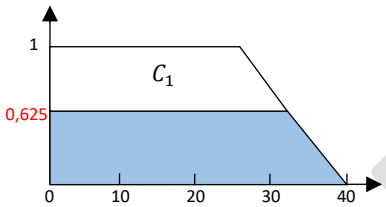

Fig. 5 : Cutoff of Output *1*

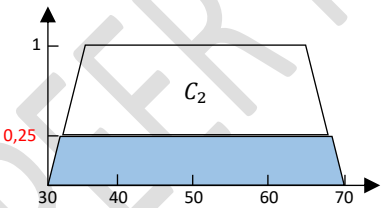

Fig. 6 : Cutoff of Output *2*

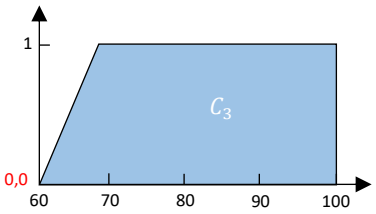

Fig. 7 : Cutoff of Output *3*

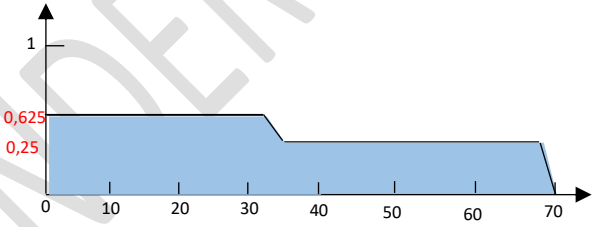

Fig. 8: Aggregation of Rule Outputs According to Probor

IV.4. Defuzzification

In this article, to get the unique net output, we will apply the centroid method [8], [9].

$$CG = \frac{\sum_{x=a}^{b} \mu_A(x).x}{\sum_{x=a}^{b} \mu_A(x)}$$

A) **When we deflourify with Zadeh operators , we will have** :

$$CG = \frac{(0+10+20+30)(0,5)+(40+50+60).(0,33)+(70+80+90+100).0}{(0,5\ .\ 4)+(0,33\ .\ 3\ )\ +(0.4)}$$

$$CG = 27$$

B) **When we apply the Probability operators, we will have** :

$$CG=\frac{(0+10+20+30)(0,625)+(40+50+60).(0,25)+(70+80+90+100).0}{(0,625\ .4)+(0,25\ .3)\ +(0.4)}$$

$$CG= 23$$

After defuzzifying the rule outputs, it should be noted that:

- The results of the outputs by the CG method are different.
- Zadeh operators maximized the output to 27%.
- Probor operators downplayed the outflow to 23%.

V. Conclusion

Throughout this article, the objective pursued was to conduct a comparative study of values of the outputs of the rules by applying the fuzzy operators of Zadeh and those of probability. After having carried out the steps of fuzzy inference, we realize that the decision is taken with low percentage when using the probability operators.

References

1. Baali Sabeur & Mahmoudi Messaoud, Temperature and humidity regulator of a chicken coop, 2022

2. Dubois D. and Prade H, operations on fuzzy numbers . Int. J. systems science vol. D; pp.613-626, 1978;

3. Gabriel Cormier, Fuzzy Logic 9 GELE 533

4. Gradi Kamingu , fuzzy set theory, properties and operations, lareg , 2016.

5. https://docplayer.fr/15372131-11-1-comparaison-la-logic-floue-et-logic-classique.html

6. Marie Hélène Massou , Contribution of the theory of possibilities and growth functions to the analysis of imprecise data. Thesis for the research management diploma at the University of Technology Compiègne.

7. PAUL Antoine BISGAMBIGLIA, Contribution of Approximate Modeling for Discrete Event Systems. Application to the study of forest fire propagation, Doctoral thesis report, University of Corsica, 2008.

8. Paul Martin, Application of fuzzy set theory to the development of a model to predict success in an engineering school from the score on a diagnostic test. Doctoral thesis in educational sciences, University of Montreal, 2007.

9. Temperature Control using Fuzzy Logic P. Singhala1, DN Shah2, B. Patel, 2014.

10. Zadeh L. The Concept of a linguistic variable and its application to approximate reasoning, Inf sci part 1. 9, VOL 8, PP 1975;

11. ZadEh LA Fuzzy sets as a basis for a theory of possibility, Int , j for Fuzzy sets and system , Vol.1 n°1, PP.3-29, 1978.