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Lecturer Performance Assessment Model with the Application of Fuzzy Mamdani

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ABSTRACT :*(In order to effectively attain the best value for function optimization in the context of the evaluation of lecturer performance, the purpose of this research is to make use of the Mamdani Method. There are three variables that make up the input: the material variable, the discipline variable, and the attitude variable and their respective values. According to the findings of this investigation, the optimized function has determined the value that would result in the professor who is the most proficient in terms of performance.*

KEYWORDS *assessment model, fuzzy mamdani, lecture performance.*

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I. INTRODUCTION

The goal of colleges and universities is to produce graduates of high calibre. In light of this, there is a requirement for teachers who are skilled in the art of teaching.When it comes to evaluating and monitoring the learning process, every tertiary institution is required to have a system in place[1]. This system is implemented by evaluating the questionnaires that students fill out, checking the Learning Event Reports (BAP), and determining the accuracy of lecturers' admission based on the results of employee monitoring in teach.

The term "fuzzy" refers to a control system that relies on data acquisition for the purpose of computer-based problem solving. In fuzzy logic, there are two possible outcomes, such as "true" or "false" or "true" or "true." It is possible for fuzzy to differentiate between the membership value and the weight it possesses, despite the fact that the membership value remains the same. In addition to being able to model extremely complicated non-linear processes, fuzzy is able to tolerate erroneous input and communicate in a natural language, making it simple to comprehend[2].

The process of mapping an input space into an output space is referred to as fuzzy logic. In the year 1965, Professor Lotfi A. Zadeh of the University of California, Berkeley made the discovery that would later become known as fuzzy logic[3]. In the time before the development of fuzzy logic theory, there was a type of logic known as crisp logic, which contained values that were either true or false. The other type of logic is known as fuzzy logic, and it is characterized by a lack of clarity or fuzziness between true and false. It is possible for a value to be true or false at the same time in fuzzy logic theory; however, the degree to which a value is true or false is determined by the weight or degree of membership it possesses. It is a well-known fact in the field of fuzzy logic theory that fuzzy sets are a classification of things that are structured according to linguistic variables that are stated in membership functions[4].

In the traditional theory of sets, the membership value of an object in a set can only be one of two possible values: either one (1), which indicates that the object is a member of the set, or zero (0), which indicates that the object is not a member of the set.2 [5]. As a matter of fact, it is not always obvious whether an object is a member of a particular set or not. This might be attributed to a lack of understanding or to data that is wrong or incomplete[6].

II. LITERATURE REVIEW

Max-Min method is another name that is frequently used to refer to the Mamdani method[7].In the year 1975, Ebrahim Mamdani was the one who first presented this method. Four phases are required in order to obtain the output[8]:

1. The development of fuzzy sequences
2. The implementation of implication functions, often known as rules
3. Rule composition and structure
4. Defuzzification:
   a. Establishment of some fuzzy sets
   When using the Mamdani Method, the variables that are input and those that are output are separated into one or more fuzzy sets separately.
   b. Implementation of the implication function in the context
   The implication function that is utilized in the Mamdani Method is known as Min.
   c. The Constituents of the Rules
   In contrast to the monotonous reasoning approach, inference is produced from the collection of rules and the connection between them when the system in question is composed of multiple rules.

The probabilistic OR (probor) method, the max method, and the additive method are the three approaches that are utilized in the process of fuzzy system inference[5].

1. The Max Method (Maximum)
   In this approach, the fuzzy set solution is found by first determining the maximum value of the rule, then applying that value to the fuzzy area in order to modify it, and then applying the modified fuzzy area to the output by use of the operations operator (union). When all of the propositions have been analyzed, the output will include a fuzzy set that shows the proportion of each proposition that contributed to the overall result. It is possible to summarize it as follows[6]:

   $\mu sf[xi] \leftarrow \max(\mu sf[xi], \mu kf[xi])$
   with:
   $\mu sf[xi]$ = membership value of the fuzzy solution up to the i^{th} rule;
   $\mu kf[xi]$ = fuzzy consequent membership value of the i^{th} rule;

   For example, there are 3 rules (propositions) as follows:
   [R1] IF Production Costs LOW And Demand INCREASES THEN Production INCREASES;
   [R2] IF STANDARD Production Costs THEN Production NORMAL;
   [R3] IF Production Costs are HIGH and Demand DECREASES THEN Production DECREASES;

2. Additive Method (Sum)
   In this method, the fuzzy set solution is obtained by doing a bounded-sum on all fuzzy area outputs. Generally written:

   $\mu sf[xi] \leftarrow \min(1, \mu sf[xi]+ \mu kf[xi]$
   with:
   $\mu sf[xi]$ = membership value of the fuzzy solution up to the i^{th} rule;
   $\mu kf[xi]$ = fuzzy consequent membership value of the i^{th} rule;

3. Probabilistic OR (probor) method. In this method, the fuzzy set solution is obtained by performing a product on all fuzzy area outputs. Generallywritten:

   $\mu sf[xi] \leftarrow \mu sf[xi]+ \mu kf[xi]) - (\mu sf[xi]$
   $* \mu kf[xi])$
   with:
   $\mu sf[xi]$ = membership value of the fuzzy solution up to the i^{th} rule;
   $\mu kf[xi]$ = fuzzy consequent membership value of the i^{th} rule;

Defuzzification

The input of the defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the fuzzy set domain. So if you are given a fuzzy set in a certain range, you must be able to take a certain crisp value as output[9].

There are several defuzzification methods in the composition of MAMDANI rules, including:

a. Centroid Method (Composite Moment)
   In this method, a crisp solution is obtained by taking the center point (z*) of the fuzzy area.
b. Bisector Method
   In this method, the crisp solution is obtained by taking the value in the fuzzy domain which has a membership value of half the total number of membership values in the fuzzy area.
c. Mean of Maximum (MOM) Method
   In this method, the crisp solution is obtained by taking the average value of the domain that has the maximum membership value.
d. Largest of Maximum (LOM) Method
   In this method, the crisp solution is obtained by taking the largest value from the domain that has the maximum membership value.
e. Smallest of Maximum (SOM) Method
   In this method, the crisp solution is obtained by taking the smallest value from the domain that has the maximum membership value.

III. RESEARCH METHODS

Fuzzy logic-based decision making is influenced by many factors. Several dominant factors that influence this decision include the membership function model and the FIS method. Each of these factors provides different results and can be proven in measurement and analysis.

Data collection

In determining the membership function of a fuzzy inference system, the author requires input data consisting of three variables and one output variable. Input variablesconsistof:

1. Material Variables
2. DisciplineVariables
3. AttitudeVariable

The MamdaniMethod

The defuzzification method in Mamdani uses the Centroid method[10]. Calculation of the output value (z) for the centroid is determined using the equation:

$$Z^* = \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz} \qquad (1)$$

IV. RESULTS AND DISCUSSION

Mamdani Data Collection Results

Classical Mamdani is a FIS Mamdani method that refers to a membership function that has not been optimized. In table 1 below, the results of fuzzy reasoning on predicting the best lecturer grades are displayed by comparing them with the actual lecturer grades.

Table 1. Mamdani

No	Mamdani Classic	REAL data	No	Mamdani Classic	REAL data
1	13,580	14,807	40	13,590	14,840
2	14,000	14,267	41	14,000	15,240
3	12,650	13,420	42	12,000	12,560
4	14,000	15,280	43	13,400	13,880
5	14,000	15,200	44	13,210	14,160
6	14,000	15,240	45	13,360	14,840
7	14,000	15,320	46	13,550	14,280
8	11,000	11,120	47	13,030	14,320
9	13,030	14,720	48	13,610	14,960
10	12,170	13,720	49	11,530	11,720
11	13,440	13,960	50	12,490	12,400

12	14,000	14,560	51	11,800	12,480
13	14,000	14,800	52	12,000	13,560
14	13,800	14,520	53	13,920	15,040
15	14,000	14,960	54	12,000	13,560
16	14,000	15,040	55	13,100	14,760
17	13,670	14,960	56	14,000	15,080
18	13,360	15,520	57	14,000	14,960
19	12,500	13,960	58	14,000	15,200
20	13,230	13,600	59	12,740	13,320
21	11,260	11,440	60	12,150	11,960
22	13,060	13,320	61	12,670	13,000
23	14,000	14,800	62	11,030	11,040
24	13,330	14,400	63	12,600	12,880
25	13,880	14,560	64	13,690	9,920
26	14,000	15,120	65	12,700	13,560
27	13,000	14,880	66	12,640	13,920
28	14,000	15,080	67	13,000	14,120
29	13,000	14,040	68	13,000	14,240
30	13,260	14,400	69	12,970	14,040
31	12,620	14,040	70	14,000	14,480
32	11,740	11,560	71	12,630	14,040
33	11,560	11,800	72	14,000	15,000
34	12,900	14,120	73	13,270	15,160
35	11,830	11,880	74	14,000	15,240
36	13,300	14,360	75	13,000	15,560
37	14,000	14,160	76	13,810	14,720
38	13,460	14,240	77	13,630	15,000
39	13,570	15,120	78	14,000	15,320

In the table above, the lecturer with serial number 1 has a real value of 14,807, with the classical Mamdani method a value of 13,580 is obtained. Likewise, lecturer number 2 has a real score of 14,267 and using the classic Mamdani method he gets a score of 14,000. The manual calculations in the Mamdani Method use the Centroid Method and the Sugeno Method uses Weighted Average (WA). The manual calculation steps for the Centroid and Weighed Average (WA) methods are the same, in this research the author will explain the calculation of the centroid method using real Material, discipline and attitude data.

Table 2. Fuzzy Mamdani Rules

1	IF	Material	0	AND Discipline	0	AND Attitude	0	0
2	IF	Material	0	AND Discipline	0	AND Attitude	0	0
3	IF	Material	0	AND Discipline	0	AND Attitude	0	0
4	IF	Material	0	AND Discipline	0	AND Attitude	0	0
5	IF	Material	0	AND Discipline	0	AND Attitude	0,596	0
6	IF	Material	0	AND Discipline	0	AND Attitude	0	0
7	IF	Material	0	AND Discipline	0	AND Attitude	0	0
8	IF	Material	0	AND Discipline	0	AND Attitude	0	0
9	IF	Material	0	AND Discipline	0	AND Attitude	0	0
10	IF	Material	0	AND Discipline	0	AND Attitude	0,596	0
11	IF	Material	0	AND Discipline	0	AND Attitude	0	0
12	IF	Material	0	AND Discipline	0	AND Attitude	0	0
13	IF	Material	0	AND Discipline	0	AND Attitude	0	0
14	IF	Material	0	AND Discipline	0	AND Attitude	0	0
15	IF	Material	0	AND Discipline	0	AND Attitude	0,596	0
16	IF	Material	0	AND Discipline	0	AND Attitude	0	0
17	IF	Material	0	AND Discipline	0	AND Attitude	0	0
18	IF	Material	0	AND Discipline	0	AND Attitude	0	0
19	IF	Material	0	AND Discipline	0	AND Attitude	0	0
20	IF	Material	0	AND Discipline	0	AND Attitude	0,596	0
21	IF	Material	0	AND Discipline	0,355	AND Attitude	0	0
22	IF	Material	0	AND Discipline	0,355	AND Attitude	0	0
23	IF	Material	0	AND Discipline	0,355	AND Attitude	0	0
24	IF	Material	0	AND Discipline	0,355	AND Attitude	0	0
25	IF	Material	0	AND Discipline	0,355	AND Attitude	0,596	0
26	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
27	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
28	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
29	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
30	IF	Material	0,1	AND Discipline	0	AND Attitude	0,596	0
31	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
32	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
33	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0

34	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
35	IF	Material	0,1	AND Discipline	0	AND Attitude	0,596	0
36	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
37	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
38	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
39	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
40	IF	Material	0,1	AND Discipline	0	AND Attitude	0,596	0
41	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
42	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
43	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
44	IF	Material	0,1	AND Discipline	0	AND Attitude	0	0
45	IF	Material	0,1	AND Discipline	0	AND Attitude	0,596	0
46	IF	Material	0,1	AND Discipline	0,355	AND Attitude	0	0
47	IF	Material	0,1	AND Discipline	0,355	AND Attitude	0	0
48	IF	Material	0,1	AND Discipline	0,355	AND Attitude	0	0
49	IF	Material	0,1	AND Discipline	0,355	AND Attitude	0	0
50	IF	Material	0,1	AND Discipline	0,355	AND Attitude	0,596	0,1
51	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
52	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
53	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
54	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
55	IF	Material	0,9	AND Discipline	0	AND Attitude	0,596	0
56	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
57	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
58	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
59	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
60	IF	Material	0,9	AND Discipline	0	AND Attitude	0,596	0
61	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
62	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
63	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
64	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
65	IF	Material	0,9	AND Discipline	0	AND Attitude	0,596	0
66	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
67	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
68	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
69	IF	Material	0,9	AND Discipline	0	AND Attitude	0	0
70	IF	Material	0,9	AND Discipline	0	AND Attitude	0,596	0
71	IF	Material	0,9	AND Discipline	0,355	AND Attitude	0	0
72	IF	Material	0,9	AND Discipline	0,355	AND Attitude	0	0
73	IF	Material	0,9	AND Discipline	0,355	AND Attitude	0	0
74	IF	Material	0,9	AND Discipline	0,355	AND Attitude	0	0
75	IF	Material	0,9	AND Discipline	0,355	AND Attitude	0,596	0,355
76	IF	Material	0	AND Discipline	0	AND Attitude	0	0
77	IF	Material	0	AND Discipline	0	AND Attitude	0	0
78	IF	Material	0	AND Discipline	0,355	AND Attitude	0,596	0
79	IF	Material	0	AND Discipline	0	AND Attitude	0	0

The first step:

Material : 13,800
μC = 0
μB = (14 – 13,8)/ (14-12) = (0,2)/2 =0,1
μSB = (13,8-12)/ (14-12) =(1,8)/2 = 0,9

Disciplin : 15,290
μSR= 0
μR = 0
μC = 0
μB = 0
μSB= (16 – 15,29)/(16-14) = 0,71/2 = 0,355

Attitude : 14,807
μSR= 0
μR = 0
μC = 0
μB = 0

µSB= (16 – 14,807)/(16-14) = 1,193/2 = 0,596

The second step:

Determining Fuzzy Regions in Triangular Membership Function Graphs

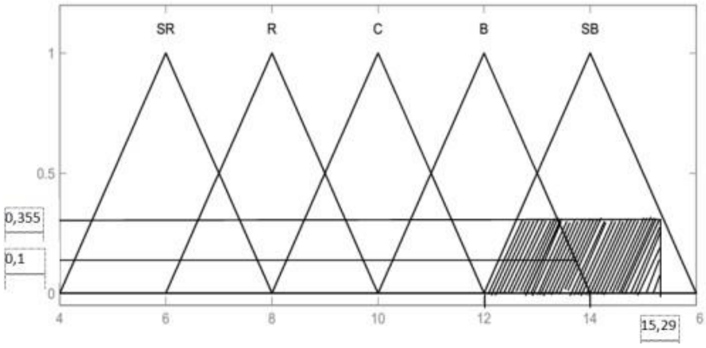
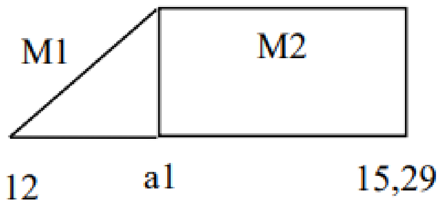


Figure 1. Membership Function

The third step:



$$a1 = \frac{14-a1}{(14-12)} = 0.355$$

$$= \frac{14-a1}{(2)} = 0.355$$

14-a1 = (0.355) (2)
= 0.701

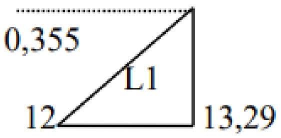
a1 = 14 – 0.701 = 13.29

The forth step:

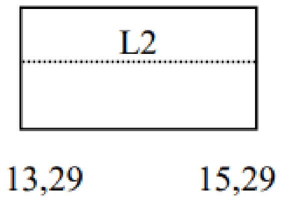
$$M1 = \int_{12}^{13.29} 0.355\, dz = 13.153$$

$$M2 = \int_{13.29}^{15.29} 0.355\, dz = 0.3867$$

The fifth Step:



$$L1 = \left(\frac{13-29}{2}\right) \text{ x } 0.355 = 0.0905$$



L2 = (15-29 – 13.29) x 0.355
L3 = 0.9259

Sixth step : Centroid

$$Z = \frac{M1+M2}{L1+L2} = \frac{13.153+0.3867}{0.0905+0.9159} = \frac{13.53913}{1.00642} = 13.50$$

V. CONCLUSION

In the process of implementing lecturer performance evaluation, the Mamdani Method can be utilized to assist in determining which lecturers are the most qualified by utilizing the rule table calculations that are included in the Mamdani Method.

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