Fuzzy Rule Base System for Student grade Classification in Online Test

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Abstract— this research will present a fuzzy rule-based model for student grade classification in the online test. The developed model tries to find an efficient and fair model to classify student grades, which represented by student level of knowledge according to multiple criteria. For example, student test degree and test time along with test level of complexity of the online-test.the proposed model designed and tested to evaluate student grades in Java Programming language. Online test package with different levels of complexity designed especially for this research work. The output results showed that using fuzzy rule base system with multiple conditions improve grade classification process in online test systems.

Index Terms— Fuzzy inference system, Fuzzy rule -based, online test, student, exam, levels, Java Exam

1 Introduction

Fuzzy logic systems have made significant succession solve a diverse class of problems [6]. In the context of student knowledge evaluation; it is important to find a reliable model to estimate student qualification under different conditions. Online tests may have different circumstances related to the testing level of complexity and test time, so the Process of finding a fair classification of student level of knowledge is somehow difficult with traditional if-then systems. These systems may focus on student score and ignore other conditions. In the other hand Fuzzy inference system considered to be a potential technique to reason about student's performance, as well as to classify his/her knowledge status [3][2].

Fuzzy logic first proposed by Zadeh in 1965.The concept of fuzzy logic founded to help computers deal with uncertain and ambiguous information [4]. This paper aims to find a fuzzy rule-based model that provide a well defined rule-based system to support student evaluation scheme in online tests.

2 Methodology

In this research work, we tried to introduce a fuzzy inference model based on Mamdani technique as a solution that employs multiple criteria to estimate student level of knowledge in online exams. The steps of the Fuzzy Inference system presented as:

- Input Variables and Linguistic term selection.
- Identifying fuzzy sets and Membership functions.
- Generate rules set.
- Applying rules and Defuzzification.

A general block diagram that reflects the proposed fuzzy inference model presented in the figure (1).

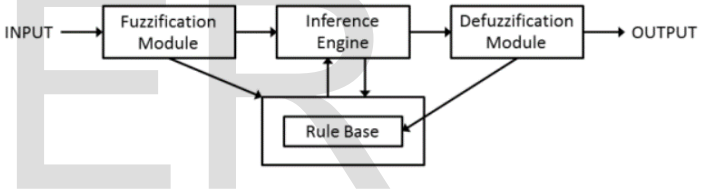

Figure (1) Fuzzy inference system

2.1 Linguistic term selection

Linguistic variables are described for a particular case such as recipes, actions or circumstances. In this paper, we use (Failure, Acceptable, Average, Good, Very Good, Excellent) linguistic variables for Result, (Short, Medium, Long) for Time, (Beginner, Intermediate, Advance) for Level of test, (Low, Acceptable, Good, Very Good) for Level of knowledge.

2.2 Identifying fuzzy sets and Membership functions

We have created the following membership functions for input variables: Result (Student Mark), Time (Amount of Time) and Level (Level of test), figures 2, 3 and 4 represent the membership functions for input variables. Figure (2) shows Membership functions for output variable: Level of knowledge (Student-level).

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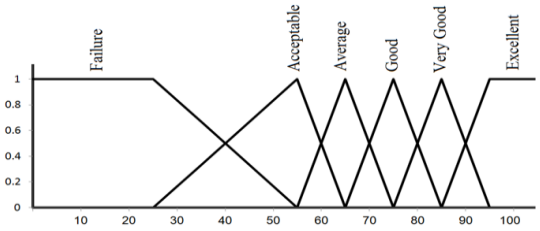

Figure (2) Membership functions for Result

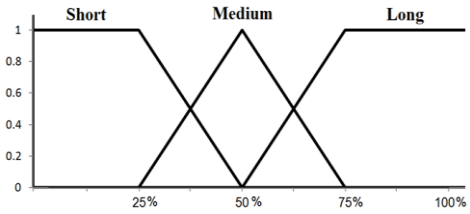

Figure (3) Membership functions for Time

$$\mu_{\text{Failure}}(x) = \begin{cases} 1; & x < 25 \\ \dfrac{55 - x}{55 - 25}; & 25 \le x \le 55 \\ 0; & x > 55 \end{cases}$$

Figure (2A) Formula (1)

$$\mu_{\text{Short}}(x) = \begin{cases} 1; & x < 25 \\ \dfrac{50 - x}{50 - 25}; & 25 \le x \le 50 \\ 0; & x > 50 \end{cases}$$

Figure (3A) Formula (1)

$$\mu_{\text{Acceptable}}(x) = \begin{cases} 0; & x < 25 \\ \dfrac{x - 25}{55 - 25}; & 25 \le x < 55 \\ 1; & x = 55 \\ \dfrac{65 - x}{65 - 55}; & 55 < x \le 65 \\ 0; & x > 65 \end{cases}$$

Figure (2B) Formula (2)

$$\mu_{\text{Medium}}(x) = \begin{cases} 0; & x < 25 \\ \dfrac{x - 25}{50 - 25}; & 25 \le x < 50 \\ 1; & x = 50 \\ \dfrac{75 - x}{75 - 50}; & 50 < x \le 75 \\ 0; & x > 75 \end{cases}$$

Figure (3B) Formula (2)

$$\mu_{\text{Average}}(x) = \begin{cases} 0; & x < 55 \\ \dfrac{x - 55}{65 - 55}; & 55 \le x < 65 \\ 1; & x = 65 \\ \dfrac{75 - x}{75 - 65}; & 65 < x \le 75 \\ 0; & x > 75 \end{cases}$$

Figure (2C) Formula (3)

$$\mu_{\text{Long}}(x) = \begin{cases} 0; & x < 50 \\ \dfrac{x - 50}{75 - 50}; & 50 \le x \le 75 \\ 1; & x > 75 \end{cases}$$

Figure (3C) Formula (3)

$$\mu_{\text{Very Good}}(x) = \begin{cases} 0; & x < 75 \\ \dfrac{x - 75}{85 - 75}; & 75 \le x < 85 \\ 1; & x = 85 \\ \dfrac{95 - x}{95 - 85}; & 85 < x \le 95 \\ 0; & x > 95 \end{cases}$$

Figure (2D) Formula (4)

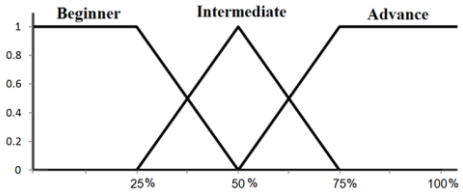

FIGURE (4) MEMBERSHIP FUNCTIONS FOR LEVEL

$$\mu_{\text{Excellent}}(x) = \begin{cases} 0; & x < 85 \\ \dfrac{x - 85}{95 - 85}; & 85 \le x \le 95 \\ 1; & x > 95 \end{cases}$$

Figure (2E) Formula (5)

$$\mu_{\text{beginner}}(x)\begin{cases} 1; & x < 25 \\ \dfrac{50-x}{50-25}; & 25 \le x \le 50 \\ 0; & x > 50 \end{cases}$$

Figure (4A) Formula (1)

$$\mu_{\text{Intermediate}}(x) = \begin{cases} 0; & x < 25 \\ \dfrac{x-25}{50-25}; & 25 \le x < 50 \\ 1; & x = 50 \\ \dfrac{75-x}{75-50}; & 50 < x \le 75 \\ 0; & x > 75 \end{cases}$$

Figure (4B) Formula (2)

$$\mu_{\text{Advance}}(x) = \begin{cases} 0; & x < 50 \\ \dfrac{x-50}{75-50}; & 50 \le x \le 75 \\ 1; & x > 75 \end{cases}$$

Figure (4C) Formula (3)

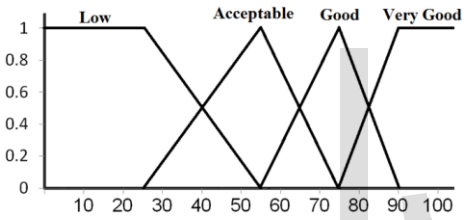

FIGURE (5) MEMBERSHIP FUNCTIONS FOR LEVEL OF KNOWLEDGE

$$\mu_{\text{Low}}(x) = \begin{cases} 1; & x < 25 \\ \dfrac{55-x}{55-25}; & 25 \le x \le 55 \\ 0; & x > 55 \end{cases}$$

Figure (5A) Formula (1)

$$\mu_{\text{Acceptable}}(x) = \begin{cases} 0; & x < 25 \\ \dfrac{x-25}{55-25}; & 25 \le x < 55 \\ 1; & x = 55 \\ \dfrac{75-x}{75-55}; & 55 < x \le 75 \\ 0; & x > 75 \end{cases}$$

Figure (5B) Formula (2)

$$\mu_{\text{Good}}(x) = \begin{cases} 0; & x < 55 \\ \dfrac{x-55}{75-55}; & 55 \le x < 75 \\ 1; & x = 75 \\ \dfrac{90-x}{90-75}; & 75 < x \le 90 \\ 0; & x > 90 \end{cases}$$

Figure (5C) Formula (3)

$$\mu_{\text{Very Good}}(x) = \begin{cases} 0; & x < 75 \\ \dfrac{x-75}{90-75}; & 75 \le x \le 90 \\ 1; & x > 90 \end{cases}$$

Figure (5D) Formula (4)

2.3 Generate rules set (Fuzzy rule base)

After the Fuzzification of input data, processing takes place in rule base of the fuzzy system. In this step, the knowledge base for complete the proposed fuzzy logic system is built, fuzzy rules determine by human experts. Rules of the level of knowledge consist 54 rules. Some of the fuzzy rules showed in the figure (6).

Let: LK=Level of knowledge
R 1 : If Result **is** Failure **And** Time **is** Short **And** Level **is** Beginner **Then** LK **is** Low
R 2 : If Result **is** Failure **And** Time **is** Medium **And** Level **is** Beginner **Then** LK **is** Low
R 3 : If Result **is** Failure **And** Time **is** Long **And** Level **is** Beginner **Then** LK **is** Low
R 4 : If Result **is** Acceptable **And** Time **is** Short **And** Level **is** Beginner **Then** LK **is** Low
R 5 : If Result **is** Acceptable **And** Time **is** Medium **And** Level **is** Beginner **Then** LK **is** Low
R 6 : If Result **is** Acceptable **And** Time **is** Long **And** Level **is** Beginner **Then** LK **is** Low
R 7 : If Result **is** Average **And** Time **is** Short **And** Level **is** Beginner **Then** LK **is** Acceptable
R 8 : If Result **is** Average **And** Time **is** Medium **And** Level **is** Beginner **Then** LK **is** Low
R 9 : If Result **is** Average **And** Time **is** Long **And** Level **is** Beginner **Then** LK **is** Low
R 10 : If Result **is** Good **And** Time **is** Short **And** Level **is** Beginner **Then** LK **is** Acceptable
R 11 : If Result **is** Good **And** Time **is** Medium **And** Level **is** Beginner **Then** LK **is** Acceptable
R 12 : If Result **is** Good **And** Time **is** Long **And** Level **is** Beginner **Then** LK **is** Low
. . . . . .

FIGURE (6) FUZZY RULE BASE

2.4 Applying fuzzy rules and Defuzzification:

Defuzzification is a process of converting fuzzy output variable into a crisp number; the calculations can be seen below:

$$\text{Final Output} = \frac{\sum(\mu(x) * (z))}{\sum \mu(x)}$$

Figure (7) FUZZY OUTPUT FORMULA

z: Center points of output membership function
μ(x): The strengths of output fuzzy variables

3. Outputs and tests results

The proposed fuzzy rule base model were tested for different levels of computer science students from the University of Sulaimani. The online test package designed with three levels of test for JAVA exams (Beginner, Intermediate, and Advance).Test times: (for Beginner = 20 minute, Intermediate = 35 minute, and Advance = 45 minute).

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Students can log into the online exam and choose any level to test. Table (1) shows the output results:

Id	User Name	Result	Time	Level	Low	Acc.	Good	V. Good	Output
124	faruq2010	66	3:30	Beginner	0.00	0.47	0.11	0.00	58.84
125	faruq2010	23	3:10	Intermediate	0.50	0.00	0.00	0.00	25.00
126	faruq2010	0	3:6	Advance	1.00	0.00	0.00	0.00	25.00
127	Ahmed_ali	78	18:7	Beginner	0.19	0.40	0.09	0.00	49.17
128	Ahmed_ali	60	18:0	Intermediate	0.00	0.51	0.09	0.00	57.92
129	Ahmed_ali	50	30:0	Advance	0.00	0.06	0.56	0.00	73.18
130	Aree2000	40	3:3	Beginner	0.50	0.00	0.00	0.00	25.00
131	Aree2000	50	27:8	Intermediate	0.03	0.69	0.00	0.00	53.85
132	Aree2000	40	27:3	Advance	0.08	0.49	0.41	0.00	60.95
133	Shwan_Hamid	80	18:9	Beginner	0.16	0.41	0.25	0.00	55.24
134	Shwan_Hamid	80	30:7	Intermediate	0.00	0.16	0.41	0.25	75.67
135	Shwan_Hamid	90	30:2	Advance	0.00	0.00	0.00	0.72	90.00
136	Zana123	100	16:0	Beginner	0.00	0.00	1.00	0.00	75.00
137	Zana123	100	24:0	Intermediate	0.00	0.00	0.00	0.62	90.00
138	Zana123	90	21:6	Advance	0.00	0.00	0.00	0.53	90.00
139	Jamal55	20	16:9	Beginner	1.00	0.00	0.00	0.00	25.00
140	Jamal55	30	15:6	Intermediate	0.73	0.06	0.00	0.00	27.13
141	Jamal55	20	30:0	Advance	0.47	0.27	0.00	0.00	35.96
142	Hawkar_22	22	9:0	Beginner	0.68	0.00	0.00	0.00	25.00
143	Hawkar_22	10	15:7	Intermediate	0.68	0.00	0.00	0.00	25.00
144	Hawkar_22	0	0:0	Advance	1.00	0.00	0.00	0.00	25.00
145	Jwana_sul	50	9:5	Beginner	0.76	0.00	0.00	0.00	25.00
146	Jwana_sul	0	0:0	Intermediate	1.00	0.00	0.00	0.00	25.00
147	Jwana_sul	0	0:0	Advance	1.00	0.00	0.00	0.00	25.00
148	anwerad	80	19:2	Beginner	0.16	0.41	0.25	0.00	55.24
149	anwerad	90	30:0	Intermediate	0.00	0.00	0.08	0.50	87.93
150	anwerad	80	27:8	Advance	0.00	0.00	0.42	0.42	82.50
151	mohammedali	100	19:0	Beginner	0.00	0.00	1.00	0.00	75.00
152	mohammedali	100	33:0	Intermediate	0.00	0.00	0.00	1.00	90.00
153	mohammedali	90	27:7	Advance	0.00	0.00	0.00	0.84	90.00

TABLE 1
OUTPUT FOR LEVEL OF STUDENT'S KNOWLEDGE

The User Name column represents the student log in name. The result (student score), Time (test time), Level (student knowledge level) columns are the data for input variables of the system. Finally the columns (low,acc., Good, V. Good) represents the data that inference from applying the fuzzy rules for student level of knowledge. The final output induced by the system in defuzzification module for each student, presented in column Output.

4. Conclusion

From this research work, we concluded that employing fuzzy rule-based system for the process of student knowledge evaluation in online tests will introduce a magnificent and reliable technique for the assessment process. The validation of multiple conditions and criteria in the inference system will improve the performance of the expert estimation. The proposed model can be applied to any subject in online tests.

5. References

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