Engineering Applications

https://publish.mersin.edu.tr/index.php/enap

e-ISSN 2979-9201

Development of individualized education system with artificial intelligence Fuzzy logic method

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Cite this study: Kayıran, H. F., & Şahmeran, U. (2022). Development of individualized education system with artificial intelligence Fuzzy logic method. Engineering Applications, 1 (2), 137-144

Keywords
Artificial intelligence
Fuzzy logic
Algorithms
Mathematical modelling

Research Article
Received: 27.09.2022
Revised: 27.10.2022
Accepted: 06.11.2022
Published: 14.11.2022

Abstract

Within the scope of this study, an education system has been developed with mushroom management. Fuzzy logic systems considering the intellectual structure of people it is a collection of improved systems. Taking a 1 or 0 approach to any event instead, it is approached with certain degrees of membership. With Mamdani management, shapes AND OR institutions emerge to cover each different situation. In general; the questions they have shown before are intended to show difficult questions to difficult students with a fast and high accuracy rate, reducing the difficulty of the problem when they go to higher times and low accuracy rates. Graphs have been created for inputs and outputs. The degrees of openness of the inputs and outputs were calculated. Fuzzy logic can be used in different approaches.

1. Introduction

The Fuzzy Logic System can be considered as one of the computational Intelligent (CI) methods that are very complex. In the literature, it is used to represent nonlinear systems and problems that cannot be solved mathematically [1-2]. Artificial intelligence is very important nowadays. Coordinated studies in health, law and other departments, especially in the field of artificial intelligence and mechanics, are academicians by continuing. The topics discussed around artificial intelligence, the components are artificial neural networks, expert systems, fuzzy logic, genetic algorithms. There are many disciplines that adopt artificial intelligence. Some of them are computer engineering, philosophy, cognitive science, electronic sciences [3]. By giving importance to the study of intelligence automation with computers, the foundations of artificial intelligence were laid in the 1950s and 1960s, when the definition of intelligence and artificial intelligence was discussed, artificial intelligence gained usability in every field in the society we live in [4-5]. Artificial intelligence is the process by which the human brain, non-organic systems (computer, program, robot, etc.) Based on its functions. In short, artificial intelligence is a set of systems that think like a human, perceive like a human, interpret like a human, analyze like a human and make decisions like a human after all these stages. Scientists have defined artificial intelligence differently. For example, artificial intelligence is the science of computer programs that simulate intelligent behavior, and artificial intelligence is the science of converting things into machines that require intelligence when done by humans [6-7]. When the literature is scanned, it is possible to come across different studies with artificial intelligence and sub-branches. For example, in a study conducted; Student academic performance estimation was made by artificial intelligence using machine learning algorithms of students. At the end of the study; the decision tree algorithm gives the best accuracy rate with a maximum depth value of 2 for 649 student data. The random forest algorithm gives the best accuracy with 649 student data. The logistic regression algorithm was found to give the best accuracy with 395 student data [8]. In different studies, the importance of the development of artificial intelligence

in the field of food, epidemics and pandemics and its applicability in the field of health have been investigated. The literature findings were shared in the results section [9-11]. Intelligent tutoring systems (ITS) are also becoming more and more important today. ITS are used to stimulate one-to-one personal tutoring. ITS are generally used in large scale distance teaching situations, where there are hundreds of students and one-to-one teaching is impossible. ITS can choose a student's learning route and the content to teach them based on learner models, algorithms, and neural networks [12]. Research on ITS has two basic aims: to develop and test models regarding the cognitive processes involved in instruction, as well as to deliver complex instructional guidance on a one-to-one basis that is better than that obtained with traditional computer-aided programs and close to that of a skilled human tutor [13]. A study observed a huge and statistically significant increase in the learning outcomes with higher course completion rates and learning 2 to 2.5 times higher than students in other platforms and control groups [14]. Our study will be a new perspective to ITS by using fuzzy logic theorem.

2. Fuzzy Logic

In 1965, Fuzzy logic was mentioned in the work by Lotfi Askar Zadeh [15]. The concepts of fuzzy logic and fuzzy sets were first introduced in 1965 by Lotfi A. It is set out in an article published by Zadeh. Later, in his notes published in 1973, Zadeh proposed the idea that fuzzy set theory has a structure that can be modeled on the human decision-making system with the best approximation [16]. In classical logic, the limitations are certain, an element is either a member of a set or it is not. There is a logic of 0 and 1 in classical sets. In fuzzy logic, on the other hand, there is partial membership. In this way, it can operate in vague and approximate situations similar to human logic. Fuzzy logic is currently used in many fields such as the automotive industry, electronic control systems, and home electronics. Especially with the use of electrical appliances, energy has been saved and such tools have been smartened up [17]. An example fuzzy logic diagram is shown in Figure 1.

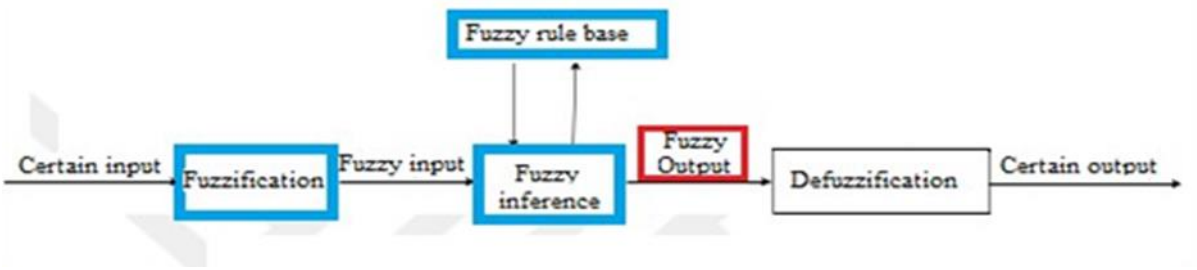

Figure 1. Operation of the fuzzy system fuzzy logic system [18]

3. Material and Method

The Mamdani approach can be considered as a very compatible thought structure with man [19]. The difficulty level of each problem in the study will be calculated by fuzzy logic. Two different inputs will be subjected to the rules and the difficulty level of the problem will give the output. Mamdani inference will be used in the study. When the student starts using the system, he will be shown 10 leveling questions, which are shown to everyone. These questions will be selected by educators and will consist of different difficulties. It is very important to have selective questions. According to the percentage of wrong / right that arise as a result of these questions and the time spent per question on these questions, the questions will begin to be shown to him according to his academic level. With each question it solves, the time and accuracy will be updated according to previous calculations. In this way, it is aimed to gradually increase the student's learning level by increasing the difficulty level. Two different inputs will be subjected to rules and will output the difficulty level of the problem. Mamdani inference will be used in the study. Figure 2 shows the graph of the general formula used in fuzzy logic calculations.

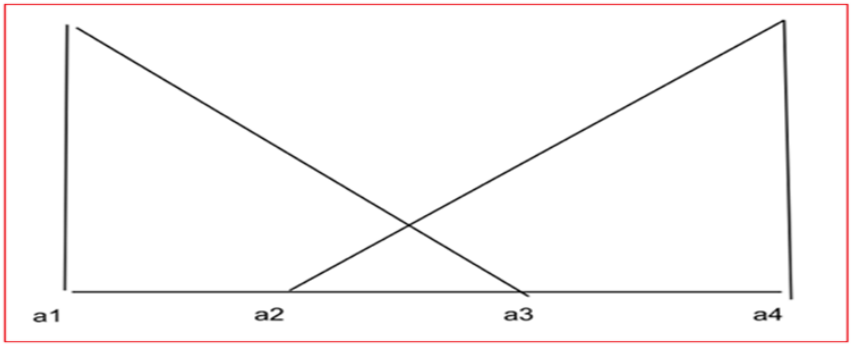

Figure 2. General formula used in fuzzy logic calculations

The formulas used in the study are listed below;

$$0 \qquad x<a1 \tag{1}$$

$$\frac{x-a1}{a3-a1} \qquad a1 \leq x \leq a2 \tag{2}$$

$$1 \qquad x > a4 \tag{3}$$

Inputs are very important in fuzzy logic; the inputs determine the result of the functions. The inputs to be used in this study and their output are as follows:

Inputs: Average time to solve questions (x) and the accuracy rate (y) in the questions solved

Output: Difficulty level of the new questions (z)

x, y and z are time to solve the question, accuracy rate and difficulty of the question.

- Three explanatory variables are defined for the duration fuzzy set X: A1, A2 and A3 (low, medium and high)
- Two explanatory variables are defined for the accuracy rate fuzzy set Y: B1 and B2: (more and less)
- Three explanatory variables are defined for the difficulty fuzzy set Z: C1, C2 and C3: (low, normal and high)

The difficulty level of each problem in the study will be calculated by fuzzy logic. Two different inputs will be subjected to the rules and the difficulty level of the problem will give the output. Mamdani inference will be used in the study. When the student starts using the system, he will be shown 10 leveling questions, which are shown to everyone. These questions will be selected by educators and will consist of different difficulties. It is very important to have selective questions. According to the percentage of wrong / right that arise as a result of these questions and the time spent per question on these questions, the questions will begin to be shown to him according to his academic level. With each question it solves, the time and accuracy will be updated according to previous calculations. In this way, it is aimed to gradually increase the student's learning level by increasing the difficulty level. Fuzzy logic works according to certain rules. These rules use AND and OR functions. If the AND function is used, both conditions must be true. In the OR function, only one of the two conditions is true to give the output. The rules we use for Mamdani inference in this study are as follows:

IF x = A3 OR y = B1 THEN z = C1 IF time very OR low accuracy THEN difficulty low
IF x = A2 AND y = B2 THEN z = C2
IF x = A1 AND B2 THEN z = C3

Fuzzy operations work within the context of these rules. However, even if the verbal expression is as above, of course, these operations should have a numerical representation, only in this way we can make a calculation and obtain a numerical value. Using this numerical value, the difficulty level of the problem will be determined. Graphs are used to achieve this in fuzzy logic. Each rule written above has a separate graph. The membership degree of a value is calculated from the graphs and the numerical value of the output is calculated by using these rules above.

4. Results

The inputs were defined as the time to solve the questions and the accuracy rate of the questions. In the question solving time graph, the Y-axis shows the membership status, while the X-axis gives the time to solve the question in seconds. The graph of the students' question solving speed is given in Figure 3.

In Table 1, the degree of turbidity of the students' problem-solving speed is given.

In the accuracy rate graph, the Y axis shows the membership status, while the X axis gives the accuracy rate in percentage. In Figure 4, a graph of the accuracy rate was given for the questions solved by the students.

Figure 4 will be used to calculate the membership values in the table below. The membership values will be given out of hundred (like 70 instead of 0.7) for the case of simplicity. In Table 2, the degree of fuzziness of the accuracy rate in the questions solved by the students.

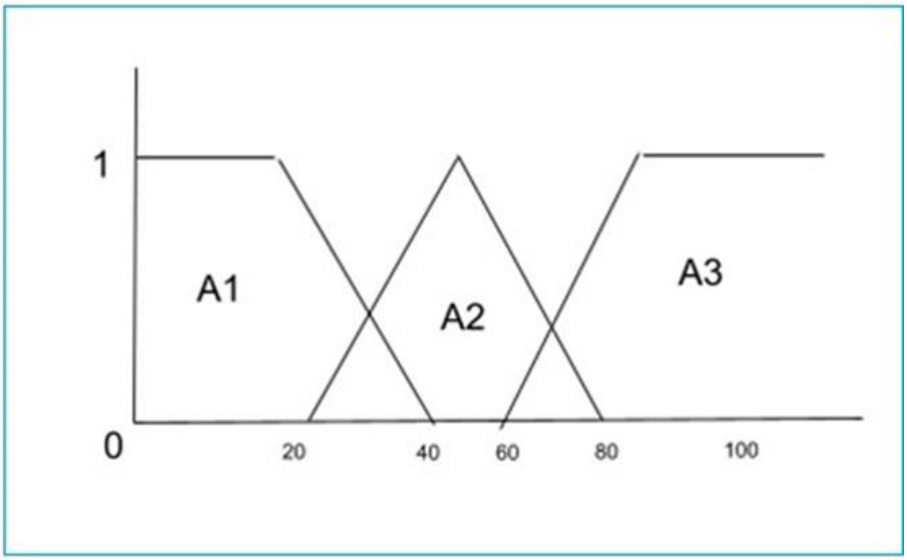

Figure 3. Students' question solving speed graph

Table1. The fuzziness degree of students' problem-solving speed

Time to solve the question (seconds)	Low(A1)	Medium(A2)	High(A3)
0	100	0	0
5	100	0	0
10	100	0	0
15	100	0	0
20	100	0	0
25	75	16,6	0
30	50	33.3	0
35	25	50	0
40	0	66.6	0
45	0	83.3	0
50	0	100	0
55	0	83.3	0
60	0	66.6	0
65	0	50	25
70	0	33.3	50
75	0	16.6	75
80	0	0	100
85	0	0	100
90	0	0	100
95	0	0	100
100	0	0	100

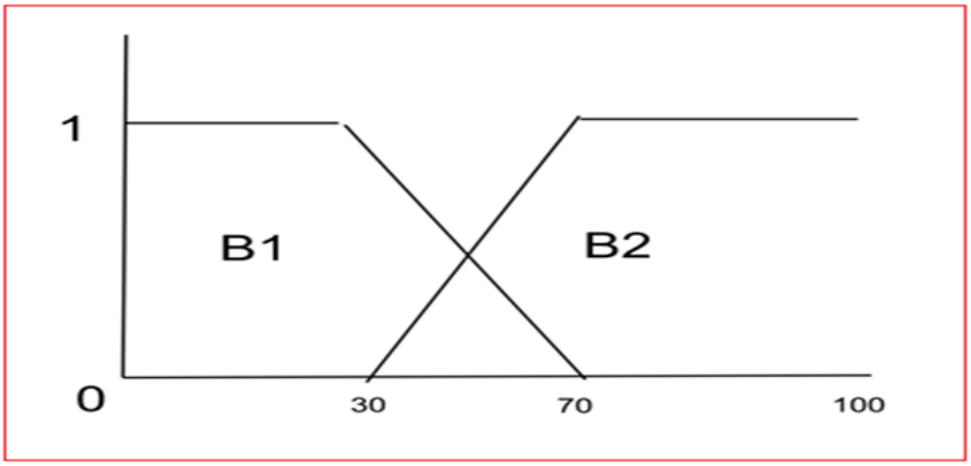

Figure 4. Accuracy rate graph in the questions solved by the students

Table 2. The fuzziness degree of the accuracy rate in the questions solved by the students

Correctness Rate	Low(B1)	High(B2)
0	100	0
5	100	0
10	100	0
15	100	0
20	100	0
25	100	0
30	100	0
35	87.5	12.5
40	75	25
45	62.5	37.5
50	50	50
55	37.5	62.5
60	25	75
65	12.5	87.5
70	0	100
75	0	100
80	0	100
85	0	100
90	0	100
95	0	100
100	0	100

The output is the difficulty level of the problem. In the difficulty level graph, the vertical axis shows the membership status, while the horizontal axis gives the difficulty level in percent. In Figure 5, the difficulty level graph of the questions given by the application as output is given.

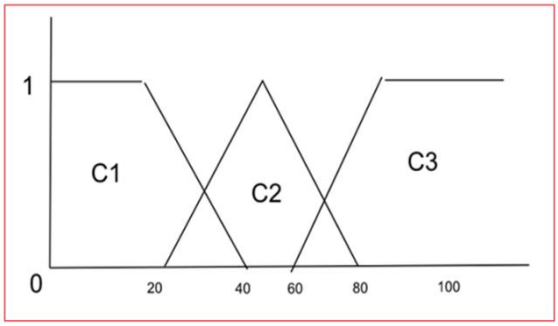

Figure 5. Difficulty level graph of the questions that the application gives as output

The Y axis shows the membership status, and the x axis shows the percentage of difficulty of questions.

Table 3. The degree of fuzziness of the questions that the application gives as output

The percentage of difficulty	Low (C1)	Medium (C2)	Hard (C3)
0	100	0	0
5	100	0	0
10	100	0	0
15	100	0	0
20	100	0	0
25	75	16,6	0
30	50	33.3	0
35	25	50	0
40	0	66.6	0
45	0	83.3	0
50	0	100	0
55	0	83.3	0
60	0	66.6	0
65	0	50	25
70	0	33.3	50
75	0	16.6	75
80	0	0	100
85	0	0	100
90	0	0	100
95	0	0	100
100	0	0	100

The corresponding membership status is looked from the right three columns, and the output is the percentage of difficulty that is obtained from the left column. The process will be explained by example cases. Example cases are given below.

Example Cases

Example 1: The average time per question of a student is 30 seconds and the accuracy rate is 80%.
Looking at the question solving speed table, 30 seconds are seen as A1:50 and A2: 33.3. The higher one A1: 50 is accepted.
The 80% accuracy rate corresponds to B2:100 when looking at the table.
This situation obeys the rule IF x = A1 AND B2 THEN z = C3
Output C3:50 (AND function takes the minimum).
Looking at the value of 50 from the C3 table, questions from the question pool with 70% difficulty will be displayed.

Example 2: The average time per question of a student is 60 seconds and the accuracy rate is 65%.
Looking at the question solving speed table, 60 seconds are seen as A1: 0 and A2: 66.6. The higher one, A2: 66.6 is accepted.
65% accuracy rate corresponds to B2:100 when looking at the accuracy rate able.
This situation obeys the rule IF x = A2 AND B2 THEN z = C2
Output C2:66.6 (AND function takes the minimum).
Looking at the value of 66.6 from the C2 table, questions from the question pool with 60% difficulty will be displayed.

Example 3: The average time per question of a student is 75 seconds and the accuracy rate is 60%.
Looking at the question solving speed table, 60 seconds are seen as A2: 16.6 and A3: 75. The higher one A3: 75 is accepted.
The 60% accuracy rate corresponds to B2:100 when looking at the table.
This situation obeys the rule IF x = A3 OR y = B1 THEN z = C1
Output C1: 100 (OR function takes the maximum).
Looking at the value of 100 from the C1 table, questions from the question pool with question difficulty between 0% and 20% will be displayed.

Example 4: The average time per question of a student is 25 seconds and the accuracy rate is 45%.
Looking at the question solving speed table, 25 seconds are seen as A1: 75 and A2: 16.6. The higher one A1: 75 is accepted.
The accuracy rate for 45% corresponds to B1: 62.5 and B2: 37.5 when looking at the table.
The higher B1: 62.5 is accepted.
This situation obeys the rule IF x = A3 OR y = B1 THEN z = C1
The output is C1: 75 (the OR function takes the maximum).
Looking at the value of 75 from the C1 table, questions from the question pool with a question difficulty of 25% will be displayed.

Example 5: The average time per question of a student is 60 seconds and the accuracy rate is 45%.
Looking at the question solving speed table, 60 seconds is seen as A2: 66.6.
The accuracy rate for 45% corresponds to B1: 62.5 and B2: 37.5 when looking at the table.
The higher one B1: 62.5 is accepted.
This situation obeys the rule IF x = A3 OR y = B1 THEN z = C1
Output C1: 66.6 (OR function takes the maximum).
Looking at the value of 66.6 from the C1 table, questions from the question pool with a question difficulty between 25% and 30% will be displayed.

Example 6: The average time per question of a student is 75 seconds and the accuracy rate is 35%.
Looking at the question solving speed table, 25 seconds are seen as A2: 16.6 and A3: 75. The higher one A3: 75 is accepted.
Looking at the table, the accuracy rate for 35% corresponds to B1:87.5 and B2: 12.5.
The higher B1: 87.5 is accepted.
This situation obeys the rule IF x = A3 OR y = B1 THEN z = C1
Output C1: 87.5 (OR function takes the maximum).
Looking at the value of 87.5 from the C1 table, questions from the question pool with a question difficulty of between 20% and 25% will be displayed.

5. Conclusion

The aim of this study is to create an individualized education system by applying the principle of fuzzy logic so that students can get maximum efficiency and add a new perspective to individual tutoring systems (ITS) by the use of fuzzy logic. The results obtained by the Mamdani method turned out to be feasible. At the end of the study, it was determined that the two important factors indicating that he is academically successful and that he has learned the subject completely are the accuracy rate in the questions and the time to solve the questions. Rules were created with fuzzy logic and these rules were poured into graphs and output was provided. The principle of operation of this program is illustrated by example cases. It has been determined that the program works as requested. With this study, it is believed that it can be used in classrooms, especially for students preparing for high school and university exams. It will also be useful in distance online learning environments, especially since it allows students to study on their own to a certain extent. Even though it may not completely eliminate the need for a real tutor, it will be useful for students who don't have access to tutoring all the time.

Acknowledgement

This study was partly presented at the 4th Advanced Engineering Days [20].

Funding

This research received no external funding.

Author contributions

Hüseyin Fırat Kayıran: Methodology, Validation, Editing. **Ufuk Şahmeran:** Visualization, Writing.

Conflicts of interest

The authors declare no conflicts of interest.

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