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Student Graduation Prediction System In The Mbkm Program Using The Mamdani Fuzzy Method

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Abstract
This study aims to develop a graduation prediction system for the MBKM Program using the Fuzzy mamdani method. The system is designed to process various academic criteria such as GPA, internship experience, and other supporting documents to provide an accurate projection of graduation probability. The implementation was carried out using data from 61 students of the Informatics Engineering Department at Universitas Malikussaleh. The Fuzzy mamdani method was applied through stages of fuzzification, rule formation, fuzzy inference, and defuzzification to produce the final prediction. The test results show that this method is effective in handling uncertainty and provides a high prediction accuracy, where 67% of students were predicted to graduate, and 33% were not. This system can be used by academic staff to evaluate student performance and provide more precise guidance, as well as to help students plan their studies to achieve graduation in the MBKM Program.
Keywords: Graduation Prediction, MBKM Program, Fuzzy mamdani, Fuzzification, Defuzzification, Decision Support System

Introduction
According to the Ministry of Education and Culture (Kemendikbud), the Certified Internship Program of Kampus Merdeka (MBKM), which was initiated by the Ministry of Education and Culture, is an important initiative in the higher education system in Indonesia. This program aims to help students develop their skills and abilities through practical experiences outside the academic environment. MBKM is designed to prepare students to be more ready to face the workforce and society by enhancing practical skills, creativity, and critical thinking abilities [1]..

In its implementation, the graduation requirements for the MBKM program are numerous and time-consuming. The variety of programs offered adds complexity to the completion process for students. This requires students to put in more effort to meet all the requirements and undergo various programs to ensure their graduation from the MBKM program.
Considering these challenges, an application is needed to assist in predicting student graduation based on administrative information such as academic grades, certificates obtained, and internship experiences. This application aims to provide guidance or projection regarding students' chances of graduating from the MBKM program based on their performance and achievements throughout the program. For instance, a study conducted by Alwendi titled "Analysis of Student Satisfaction Levels and Their Influence on Course Outcomes Using Fuzzy Logic" showed that applying fuzzy logic with the Mamdani method was effective in evaluating lecturers' research activities at Universitas Graha Nusantara Padangsidimpuan, using inputs such as accredited articles and international and national journals. The study results indicated that fuzzy logic could be used for predicting lecturers' performance evaluations, although the system developed only evaluated performance generally without providing more detailed information [2].

According to Napitupulu, the Fuzzy Mamdani method is well-known for its ability to handle uncertainty and subjectivity, which is very relevant in the context of predicting student graduation in the MBKM program. By using the Fuzzy Mamdani method, the application will process various inputs to generate more accurate predictions of graduation, providing benefits to students [3].

The benefits of using this graduation prediction application are significant. It can help students understand which aspects they need to improve in order to increase their chances of graduating. Additionally, with more accurate predictions, universities can offer more effective guidance to students in the MBKM program. In the long term, this application will enhance the quality of higher education output. producing graduates who are more ready and competent for the workforce.

Literature Review

1. Kampus Merdeka

Describes the MBKM (Kampus Merdeka) program, which allows students to take courses outside their major and engage in practical off-campus experiences. The program aims to enhance student skills by offering various activities such as certified internships, independent studies, and teaching. These activities are designed to prepare students for real-world challenges and improve their employability. The Kampus Merdeka program, launched by the Indonesian Ministry of Education, Culture, Research, and Technology (Kemendikbudristek), offers various activities aimed at enhancing students' skills and experiences. These activities include: Certified Internships, where students gain hands-on work experience; Independent Study, allowing students to conduct research or projects in their field of study; Teaching Campus, enabling students to teach in underprivileged areas; Indonesian International Student Mobility Awards (IISMA), providing opportunities to study abroad; Domestic Student Exchange, facilitating exchanges between universities within Indonesia; Thematic Community Service (KKN), focusing on village development; Humanitarian Projects, engaging students in social projects; Research, allowing students to participate in research projects; and Entrepreneurship, encouraging students to develop and run their own businesses or startups [4].

2. Fuzzy Method

According to Nasution, fuzzy logic is a decision-making tool that handles uncertainty and imprecise information. The Mamdani Fuzzy method is discussed as an approach that processes uncertain data and subjective evaluations, making it suitable for applications like graduation prediction[5]. According to Rizki, the fuzzy implementation process typically involves the following steps: 1) Fuzzification: Converting crisp inputs into fuzzy values, for example, turning air temperature into "cold," "warm," or "hot"; 2) Application of Fuzzy Rules: Using IF-THEN rules to generate fuzzy outputs based on fuzzy inputs, such as "IF the air temperature is hot, THEN the fan speed is high"; 3) Rule Composition: Combining outputs from all rules; and 4) Defuzzification: Converting fuzzy outputs back into crisp values, such as converting "high fan speed" into the fan speed in RPM [6].

1. Fuzzification Formula

In the fuzzification step, crisp inputs are converted into fuzzy values. A common formula for a triangular membership function is:

$$\mu_A(x) - \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right) \tag{2.1}$$

Where:

$\mu_A(x)$ is the degree of membership of element x in fuzzy set A.

a, b, c are parameters of the membership function.

2. Rule Application

There is no specific mathematical formula for this stage, as fuzzy rules are typically created based on expert knowledge in the form of "IF ... THEN ..." statements.

3. Aggregation of Fuzzy Output

To combine the output of each fuzzy rule, a common formula is the max operator:

$$\mu_{\text{output}} = \max(\mu_{\text{rule }1}, \mu_{\text{rule }2}, \ldots, \mu_{\text{rulen}}) \tag{2.2}$$

4. Defuzzification Formula

The defuzzification step converts the fuzzy output into a crisp value. The formula for the centroid method (Center of Area, COA) is:

$$COA = \frac{\sum_{i=1}^{n} \mu_B(x_i) \times x_i}{\sum_{i=1}^{n} \mu_B(x_i)}$$

Where:

COA is the center of area.

$\mu_B(x_i)$ is the degree of membership of the fuzzy output at point x_i.

x_i is the value of the input at point i.

n is the number of points used in the calculation

Materials & Methods

1. Research Phases

The research followed these main steps:

a) Planning and Preparation: Defining research goals, reviewing the literature, and determining the methodology.
b) Data Collection: Gathering historical student data and conducting interviews with stakeholders.
c) Fuzzy Mamdani Algorithm Development: Designing fuzzy sets, formulating fuzzy rules, and implementing the

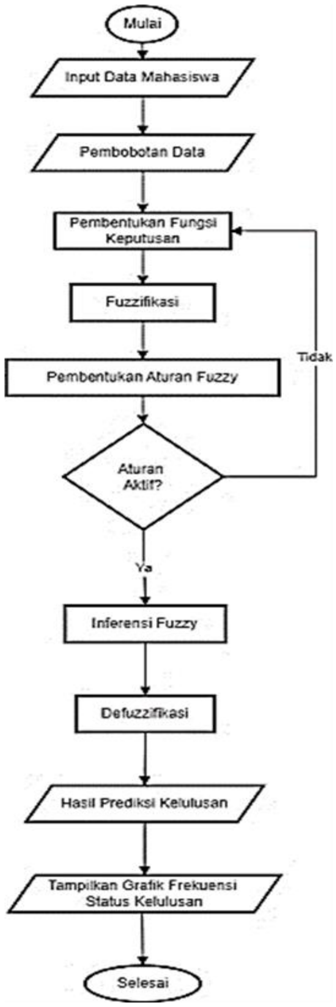
algorithm using MATLAB or Python.

d) Web Application Development: Designing the user interface and integrating the fuzzy algorithm into the web application.

e) Presentation and Evaluation: Compiling the report and revising based on user feedback.

2. System Scheme

This research aims to develop a comprehensive graduation prediction application for students enrolled in the MBKM Program at Universitas Malikussaleh. The application will utilize the Fuzzy Mamdani Method, a well-established approach in decision-making systems, to effectively assess and process a range of factors that influence student graduation outcomes. These factors include GPA, duration of study, internship experience, and participation in extracurricular activities, among others. By implementing this method, the application is expected to provide more accurate and objective predictions, helping students and academic advisors to better understand the likelihood of graduation based on key performance indicators. This tool will also serve as a valuable resource for educational planning and student progress monitoring within the MBKM Program.



Description :

1. **Start**: This is the starting point of the flowchart, indicating the beginning of the process.
2. **Input Student Data**: The first step where student data, such as GPA, internship experience, recommendation letters, and other documents, are entered into the system.
3. **Data Weighting**: Each criterion used in the evaluation (such as GPA, internship experience, and recommendation letters) is assigned a weight according to its importance in the decision-making process.
4. **Decision Function Formation**: At this stage, decision functions or rules used to determine fuzzy outputs are formed based on the criteria and weights previously established.
5. **Fuzzification**: Crisp input values, such as GPA, are converted into fuzzy values using membership functions, allowing uncertainty or ambiguity in the data to be processed.
6. **Fuzzy Rule Formation**: Fuzzy rules (in the form of IF-THEN statements) are created based on the fuzzification results. These rules determine how the fuzzified criteria are combined to produce an output.
7. **Active Rules?**: This decision point checks if there are any active fuzzy rules. If no rules are active, the process returns to "Decision Function Formation" for reevaluation. If there are active rules, the process continues to the fuzzy inference step.
8. **Fuzzy Inference**: The active fuzzy rules are used to determine the fuzzy output based on fuzzy logic operations such as AND (min) or OR (max).
9. **Defuzzification**: The fuzzy values obtained from the inference are then converted back into crisp values, representing the predicted result or graduation classification.
10. **Graduation Prediction Result**: The system generates the final output, which is the prediction of whether the student will graduate, not graduate, or has a high potential to graduate.
11. **Display Graduation Status Frequency Graph**: The graduation prediction result is displayed in a graphical format showing the frequency of graduation statuses (graduate, not graduate, or high potential to graduate) of the students.
12. **End**: This marks the end of the process where all steps have been completed.

Results and Discussion

A. Analysis

The research focuses on implementing the Fuzzy Mamdani method to predict student graduation within the MBKM (Merdeka Belajar Kampus Merdeka) program. The analysis covers the system's requirements, the design model using UML diagrams, and the fuzzy logic application to determine students' graduation status based on various criteria, including GPA, internship experience, recommendation letters, and involvement in student organizations.

The primary objective was to develop a system that can process uncertain data and integrate multiple assessment criteria into one final value to predict the graduation status of students accurately. This systematic approach includes steps like data processing, rule formation, fuzzy inference, and defuzzification to produce meaningful results.

B. Data Used

The dataset consists of students' academic and non-academic records, such as their GPA, internship experience, recommendation letters, scan of identity card (KTP), and participation in student organizations. A sample of 5 student records was selected to demonstrate the manual implementation of the Fuzzy Mamdani method. Below is a sample of the data used:

Table 1. Data used

No	NIM	Name	GPA	Internship Experience	Recommendation Letter	KTP	SPTJM	Organization
1	19001	Aldi Baskoro	4.0	4.5	Yes	Yes	Yes	Very Good
2	19002	Bima Surya	2.0	3.0	No	No	No	Fair
3	19003	Chandra Putra	5.0	5.0	Yes	Yes	Yes	Good
4	19004	Dian Ratnasari	3.0	4.0	Yes	Yes	No	Poor
5	19005	Eka Wijaya	4.0	5.0	No	Yes	Yes	Fair

The Flow Process demonstrates the flow of the system's core processes, such as login, data management, fuzzy parameter updates, graduation predictions, and data visualization. Each process involves interactions between the admin and the system, such as data retrieval, storage, application of fuzzy logic, and the display of prediction results.

- Login: The admin authenticates to access the system.
- Data Management: The admin manages student data (add, update, delete).
- Fuzzy Parameter Updates: The admin updates fuzzy rules and parameters that affect predictions.

- Graduation Prediction: The system retrieves student data and fuzzy parameters, processes them using Fuzzy Mamdani, and displays the results.
- Visualization: The system visualizes prediction results using interactive charts.

C. Implementation Steps

The implementation of the Fuzzy Mamdani method involves several crucial stages that ensure a systematic transformation of input data into meaningful predictions of student graduation status. Each step is designed to handle the uncertainty in data and allow multiple criteria to interact in determining the final output. The steps include fuzzification, rule formation, fuzzy inference, aggregation, and defuzzification.

1. Fuzzification

Fuzzification is the process of converting crisp input values (like GPA, internship experience, recommendation letters, etc.) into fuzzy values (degrees of membership). These fuzzy values represent the extent to which an input belongs to a certain fuzzy set (e.g., "Good GPA," "Average Internship Experience").

For example, consider a student with a GPA of 4.0. The fuzzification process will assign this GPA to different fuzzy sets like "Poor," "Fair," "Good," and "Excellent," using predefined membership functions.

2. Fuzzy Membership Functions:

Poor (B):

$$\mu_B(x) = \begin{cases} 1 & \text{if } x \leq 1.5 \\ \dfrac{2.5 - x}{1} & \text{if } 1.5 < x \leq 2.5 \\ 0 & \text{if } x > 2.5 \end{cases}$$

Good (G):

$$\mu_G(x) = \begin{cases} 0 & \text{if } x \leq 3 \text{ or } x \geq 4.5 \\ \dfrac{x - 3}{0.75} & \text{if } 3 < x \leq 3.75 \\ \dfrac{4.5 - x}{0.75} & \text{if } 3.75 < x < 4.5 \end{cases}$$

Excellent (E):

$$\mu_E(x) = \begin{cases} 0 & \text{if } x \leq 4 \\ \dfrac{x - 4}{1} & \text{if } 4 < x \leq 5 \\ 1 & \text{if } x = 5 \end{cases}$$

- Example Fuzzification for Student 1 (Aldi Baskoro with GPA $= 4.0$):
- Poor: $\mu_B(4.0) = 0$ (since $x > 2.5$)
- Good: $\mu_G(4.0) = \frac{4.5-4}{0.75} = 0.67$
- Excellent: $\mu_E(4.0) = 0$ (since $x \leq 4$)

In addition to GPA, other criteria such as internship experience, recommendation letters, and participation in organizations are fuzzified using similar membership functions.

3. Rule Formation

Rule formation involves creating a set of IF-THEN rules that describe how the fuzzy input values map to a fuzzy output. These rules are based on the input variables like GPA, internship experience, and recommendation letters, and the output is the predicted graduation status.

Example Rules:

- Rule 1: IF GPA is "Excellent" AND Internship Experience is "Outstanding" AND Recommendation Letter is "Present," THEN Graduation is "High Potential to Pass."

- Rule 2: IF GPA is "Good" AND Internship Experience is "Good," THEN Graduation is "Pass."
- Rule 3: IF GPA is "Poor" OR Recommendation Letter is "Not Present," THEN Graduation is "Did Not Pass."

The conditions in each rule use fuzzy logic to handle the uncertainty and imprecision in the input values. The rules will later be used to determine the degree of truth (membership degree) for each condition.

Fuzzy Inference

Fuzzy inference is the process of applying the rules to the fuzzified inputs to calculate the fuzzy output. The goal is to combine the fuzzy sets of the input variables using logical operations like AND (minimum) and OR (maximum) to generate the fuzzy output set.

- AND Operation (MIN): The degree of truth for an AND condition is determined by taking the minimum membership value of the involved fuzzy sets.
- OR Operation (MAX): The degree of truth for an OR condition is determined by taking the maximum membership value of the involved fuzzy sets.
- Example Inference for Student 1 (Aldi Baskoro):
- GPA: $\mathrm{Good}(\mu_G = 0.67)$
- Internship Experience: Swasta Nasional (SN, $\mu_S N = 0.67$)

Recommendation Letter:

Present

$$(\mu_{rec} = 1)$$

Applying Rule 2:

$$\alpha_{\text{Rule 2}} = \min(\mu_G, \mu_S N) = \min(0.67, 0.67) = 0.67$$

Aggregation

Aggregation is the process of combining the fuzzy outputs from all applicable rules to generate a single fuzzy set that represents the overall prediction. This step consolidates the fuzzy output sets from different rules using logical operations (usually MAX).

Example Aggregation for Student 1:

- Rule 2 suggests that the student should "Pass" with a degree of 0.67.
- If other rules (e.g., involving excellent organization participation) contribute to the prediction, the system takes the maximum degree of truth.

Thus, the fuzzy output for Student 1 might include both "Pass" with $\mu = 0.67$ and "High Potential to Pass" with a higher degree from another rule.

Defuzzification

Defuzzification is the final step in which the fuzzy output set is converted back into a crisp value. This crisp value represents the predicted graduation status. The most commonly used defuzzification method is the centroid method, which computes the center of gravity of the fuzzy set.

Centroid Calculation Formula:

$$z^* = \frac{\sum_i \mu_i \times z_i}{\sum_i \mu_i}$$

where z_i is the center of each fuzzy region and μ_i is the corresponding membership degree.

Example Defuzzification for Student 1:

- Suppose the fuzzy output has:
- $\mu = 0.67$ for "Pass" (centroid at $z = 70$)
- $\mu = 1$ for "High Potential to Pass" (centroid at $z = 90$)

- Calculating the area and centroid:

$$\text{Area}_{\text{Pass}} = \frac{(0 + 0.67)}{2} \times 20 = 6.67, \ \text{Centroid} = 63.33$$
$$\text{Area}_{\text{High Potential to Pass}} = \frac{1}{2} \times (100 - 70) \times 1 = 15, \ \text{Centroid} = 85$$

- Total area $= 6.67 + 15 = 21.67$
- Total moment $= (6.67 \times 63.33) + (15 \times 85) = 422.22 + 1275 = 1697.22$
- Final z^* value:

$$z^* = \frac{1697.22}{21.67} = 78.33$$

- Since $z^* \geq 70$, Student 1 is classified as "High Potential to Pass."

The results of the research are presented in tables showing the final crisp value (z∗z^*z∗) and the corresponding graduation classification for each student. Below is a sample of the results:

Table 1. Clasification

No	NIM	Name	Final Score (z∗z^*z∗)	Classification
1	19001	Aldi Baskoro	78.33	High Potential to Pass
2	19002	Bima Surya	35	Did Not Pass
3	19003	Chandra Putra	85	High Potential to Pass
4	19004	Dian Ratnasari	35	Did Not Pass
5	19005	Eka Wijaya	63.33	Pass

The analysis shows that students with higher GPAs, comprehensive internship experiences, and complete documents are more likely to pass or be classified as having "High Potential to Pass." In contrast, students with low GPAs and missing documents tend to fail the program.

For example, Student 1 (Aldi Baskoro) has a GPA of 4.0, good internship experience, and all required documents, resulting in a "High Potential to Pass" classification with a final score of 78.33. On the other hand, Student 2 (Bima Surya), with a GPA of 2.0 and missing documents, is classified as "Did Not Pass" with a final score of 35.

The fuzzy Mamdani method proved effective in handling uncertainties in data, especially in cases where different criteria (e.g., GPA, experience, documents) interact to influence the final prediction. This system provides clear and objective decision-making, which can be beneficial for academic evaluation and student guidance.

Conclusions

The analysis and design of the system implementation began by identifying the system requirements, which included managing student data and key factors influencing graduation, such as gpa, internship experience, recommendation letters, and organizational participation. A survey was conducted through google forms, gathering data from 61 students, covering aspects like mbkm experience and gpa, providing a comprehensive understanding of the student cohort. During the design phase, essential features were identified, and a mysql database was integrated for efficient data storage and retrieval, with an intuitive user interface. The fuzzy mamdani method was implemented by fuzzifying the data, applying fuzzy rules, aggregating outputs, and defuzzifying to predict graduation status. Testing indicated 67% of students were predicted to graduate, while 33% were not. The fuzzy parameters, such as gpa thresholds and document requirements, were dynamically adjustable based on policies. The results demonstrated the effectiveness of the method, showing a higher graduation likelihood for students with a gpa above 3.5, providing valuable insights for academic planning. The system proved effective in handling uncertainties, offering objective decision-making, and shows promise for broader educational applications.

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