

Fuzzy Logic based Personalized Learning Navigator for Students

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Abstract

The student performance tracking system using fuzzy logic algorithm is designed to transform online education by addressing the challenges students face in personalized guidance, study scheduling and resource navigation. The objective of this project is to categorize students' marks as good, average, or bad, helping them understand their performance level in each subject. Using fuzzy logic, the marks of the students are categorized by comparing them with predefined membership functions and ranges for each category. Fuzzy logic provides an accurate evaluation of marks compared to manual categorization, considering various degrees of membership rather than fixed thresholds. This approach ensures a precise assessment of students' performance, providing the benefits of automated categorization over traditional manual methods. With the categorized marks the schedule is provided for each subject based on the range they have scored i.e., good, average, or bad providing with improvement in performance evaluation. Additionally, the student can get access to the online platforms offering free course materials relevant to each subject with just one click. It helps the students to track their progress, maintain a personalized timetable for learning and access the free courses in the same place.

Keywords: Progress tracking, self-learning, fuzzy logic, learning platforms

1. Introduction

In recent years, the major problem students have faced is the lack of proper academic guidance with individual attention, which needs improvement in school settings. They can only take notes and receive grades through exams, without receiving personalized attention in each subject [1]. The purpose of the research is to overcome these difficulties by providing a one-stop solution for mark categorization, generating personalized schedules for each category, and offering free online course materials, thereby improving students' academic careers. The challenges faced with other categorization methods, such as manual approaches, are that they are tedious and time-consuming and may produce inaccurate results. The significance of this project is to provide accurate categorization using fuzzy algorithms in machine learning. It includes the membership functions that help to categorize the student marks into three categories: good, average, and bad. The benefits are that the student can personally get access through an account. He can provide the system with the marks, the system generates the category in which the subject falls, with this the system generates a schedule for each category which ranges with more time for poor subjects and relatively less time for good subjects [3].

1.1 Fuzzy Logic

Compared to other mathematical and logical procedures, fuzzy logic is a method for representing and manipulating data that more closely resembles human reasoning. The values become fuzzy, meaning that something may gradually belong to a set, rather than being strictly crisp (i.e., precise). Fuzzy sets, which are sets whose elements have degrees of membership, are used in this logic to describe and control this type of uncertainty[4]. Fuzzy logic uses this foundation to enable programming and mathematical calculations that resemble certain types of human thought [5].

Fuzzy logic may also be used in intelligent tutoring systems to introduce human-like thinking and decision-making, giving people individualized real-time help and direction [6].

1.2 Python

The fuzzy logic implemented in the project is written in Python. It is a general-purpose programming language that supports multiple paradigms, including structured, object-oriented, and functional programming. It defines the membership function with the range of marks for

each category. It connects with the frontend HTML code which gets the inputs from the user. This input is passed to the python containing fuzzy code for categorization.

1.3 Flask

The flask is a web framework written in Python. It acts as a middleman connecting the Python code in the backend and the HTML script in the frontend. It handles the web requests, responses, and form submission. It renders the HTML template using the jinja2 template engine. The code written in Python is passed to the HTML code with the jinja template and is routed back in the Python code by importing all the Flask libraries.

2. Related Work

The challenges students face in accurately evaluating their performance highlight the potential benefits of integrating self-assessment practices. This study relates to the project by emphasizing the need for accurate performance evaluation methods. Using fuzzy logic aims to bridge the gap between subjective self-assessment and objective performance categorization, providing a more reliable and adaptive method for evaluating student marks and enhancing learning outcomes.[1]

In order to improve learning outcomes, the study investigates techniques for evaluating interactivity in online learning environments. It is relevant to the work because it highlights the value of efficient teaching strategies and resources. The initiative advances knowledge management in e-learning environments by using fuzzy logic for performance categorization, which is in line with Yamamoto's emphasis on improving learning effectiveness through creative evaluation techniques.[2]

Furthermore, some academics have looked at the incorporation of fuzzy logic systems, which can provide more adaptable and flexible classification algorithms by accommodating the inherent imprecision and uncertainty associated with grading standards. The research on input categorization in education emphasizes the value of using cutting-edge computational tools to provide customized interventions for students based on their academic achievement and well-informed decision-making.[4]

Experts are faced with several decisions and considerations when designing web-courses within online learning instructions or mechanisms in general. These decisions and considerations have an impact on how students perceive instruction, how they construct and process knowledge, how students may be satisfied with this experiment, and how web-based learning courses may improve their academic performance [7].

The research provides a more detailed understanding of student performance by integrating fuzzy logic principles, which allow for the handling of imprecise or uncertain information inherent in educational assessment. This research is relevant to our project as it aligns with our objective of categorizing student marks using fuzzy logic, demonstrating the applicability and effectiveness of fuzzy logic in educational assessment and performance evaluation.[10]

The work investigates the properties and characteristics of different connectives, providing insights into their efficacy and applicability in fuzzy systems. While the project focuses on applying fuzzy logic for categorizing student performance. The work contributes to the theoretical understanding of fuzzy logic operations. The study informs the development of fuzzy logic-based algorithms and systems by elucidating the properties of logical connectives, thereby indirectly benefiting projects like ours that rely on fuzzy logic principles.[11]

3. Proposed Work

The system's primary function is to enable user input, enabling students to submit data like the number of subjects they are taking and the accompanying grades. Based on this information, the system uses complex algorithm like fuzzy logic algorithm to divide participants into three groups according to their performance.

Fuzzy Categorization: The fuzzy algorithm categorizes students' marks into good, average, and poor by considering various input variables such as exam scores, assignment grades, attendance records, and participation levels, each associated with fuzzy sets representing different levels of performance. Membership functions determine the degree of belongingness to each fuzzy set, while fuzzy rules define the relationships between input variables and output categories. Through fuzzy inference, the algorithm combines input variables and fuzzy rules to determine the degree to which each output category applies to the

student's performance. Defuzzification then converts the fuzzy output into a precise value representing the student's overall performance category, enabling a nuanced interpretation of academic achievement with greater flexibility and accuracy [12].

Based on this categorization, a customized study schedule may be created, carefully assigning study times to each topic to maximize learning objectives. By providing individualized recommendations for online platforms and resources, the system enhances students' learning experiences beyond the confines of traditional classroom training [13]. These resources, which range from conceptual study materials to interactive practice problems, are designed for students in grades 6 through 12.

The system's emphasis on student autonomy and individualized learning is essential to its efficacy. Students may access a multitude of tools and services intended to promote their academic advancement through unique user accounts and an easy-to-use online interface. Additionally, the system is a great tool for parents and teachers, giving them information about their children's learning preferences.

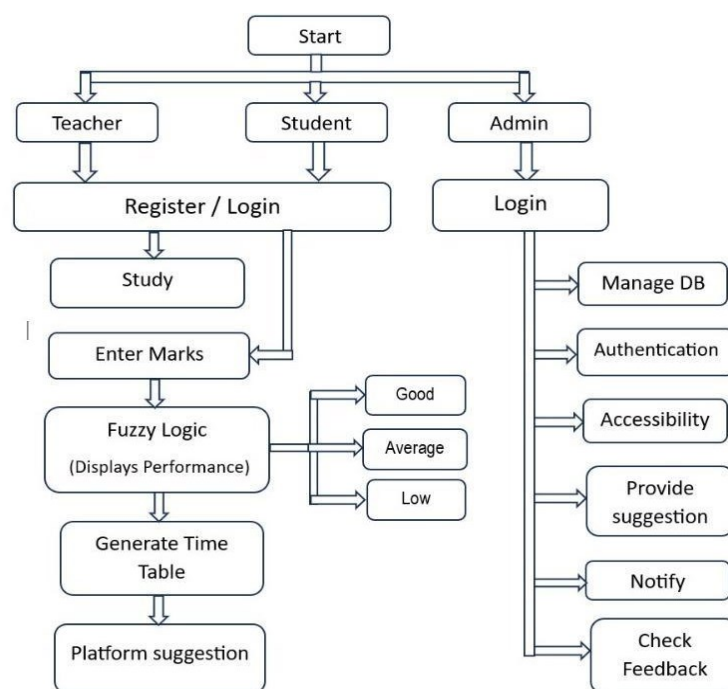


Figure 1. Flow Diagram of the System Architecture

The above flow chart (figure.1) represents the modules involved and the flow of the project from getting input to the platform generation and student details management. It begins with login into account, enter marks, get categorized, generate a timetable, study. If course materials needed, they can use the suggested links for each class and subjects and study with materials.

3.1 Fuzzy Algorithm

The fuzzy logic for student mark categorization, involves categorizing the student marks into good, average, and bad by fuzzifying the input to convert it into fuzzy set which is passed onto membership function to compare and categorize, defuzzify to convert the value into precise output i.e., accurate output among the three categories. The algorithm is given below.

```
# Get the marks for each student

for i in range(num_students):

    marks = int(input(f'Enter marks for student {i+1}: '))

    student_marks.append(marks)

# Membership functions for marks

marks_poor = mf.trapmf(x_marks, [0, 0, 40, 50])

marks_avg = mf.trimf(x_marks, [40, 50, 60])

marks_good = mf.trapmf(x_marks, [50, 60, 100, 100])

# Membership functions for performance

performance_poor = mf.trapmf(y_performance, [0, 0, 30, 50])

performance_avg = mf.trimf(y_performance, [30, 50, 70])

performance_good = mf.trapmf(y_performance, [50, 70, 100, 100])
```

```

# Function to categorize marks

def categorize_marks(marks):

    # Fuzzification

    marks_fit_poor = fuzz.interp_membership(x_marks, marks_poor, marks)

    marks_fit_avg = fuzz.interp_membership(x_marks, marks_avg, marks)

    marks_fit_good = fuzz.interp_membership(x_marks, marks_good, marks)

    # Rules

    rule1 = np.fmin(marks_fit_poor, performance_poor)

    rule2 = np.fmin(marks_fit_avg, performance_avg)

    rule3 = np.fmin(marks_fit_good, performance_good)

    # Aggregation

    aggregated = np.fmax(rule1, np.fmax(rule2, rule3))

    # Defuzzification

    defuzzified = fuzz.defuzz(y_performance, aggregated, 'centroid')

    result = fuzz.interp_membership(y_performance, aggregated, defuzzified)

```

3.1.1 Membership Function

Membership functions are used for classifying student marks into performance categories such as good, average, and poor because they quantify the extent to which an element belongs to a fuzzy set-in fuzzy logic system. To enable fuzzy inference and the making of judgments based on ambiguous input, they assign degrees of membership to marks within a range.

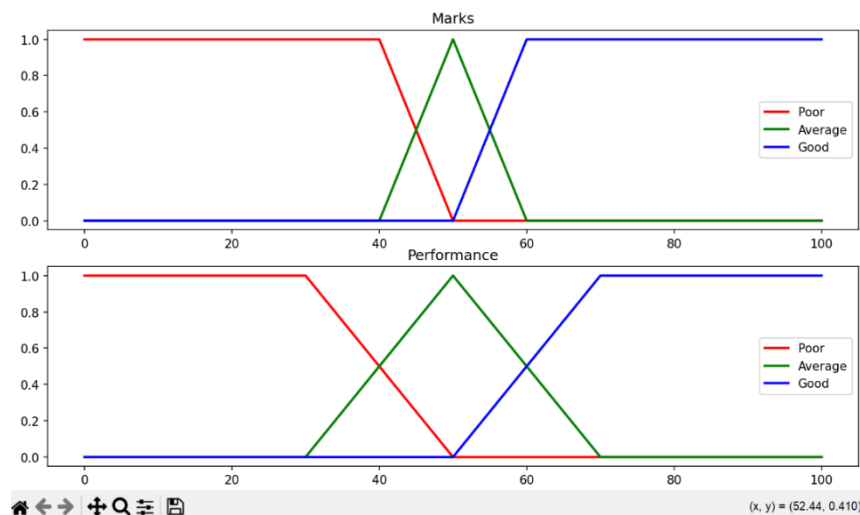
The membership function used here is the triangular function. It uses three parameters: the lower limit, peak, and upper limit, creating a triangular shape on a graph. This function allows for a flexible categorization, where marks around the peak have the highest membership

in a category, while those near the limits have lower membership. Each line starts from lower point, rise and reach the peak value and lowers to the lower limit for each category which checks for the input marks where it lies around the peak value.

3.2 Categorization of Marks

Table 1. Categorization of Marks using Fuzzy Logic

Category	Range Of Marks
Good	76-100
Average	51-75
Bad	0-50



x-axis: student mark

y-axis: range of truthfulness

Figure 2. Membership Function Graph for the Marks and their Performance

The graph represents the range of marks and their performance using the triangular membership function to plot them in the graph with x-axis showing the marks and y-axis showing the range of truthfulness between 0 and 1. This graph is generated for a sample input of marks 34, 55 and 90 and is represented in triangular form.

4. Experiment Research

Software Requirements

- HTML, CSS, Javascript (Front end)
- Python (Fuzzy algorithm)
- Flask (Backend)
- PyTorch

Front End

- HTML

HTML is a markup language which elements and tags to create a web page. It interacts with the user and gets input. It interacts with the backend fuzzy code(Python) with Flask framework. It renders the input using the Jinja2 template.

- CSS

Cascading Style Sheets(CSS) is a style sheet language used to decorate and handle the styling of the markup language like HTML, XML.

- JavaScript

JS is a programming language that's helps to create the webpage more interactive, it helps in form handling, validation and responsive design.

Backend

- Python

Python is a programming language which is used to write the fuzzy code for categorization and table generation. It interacts with HTML through Flask. The libraries of PyTorch are imported for the implementation of fuzzy logic.

The Personalized learning navigator contains a landing page where the student can sign up if he is a new user, login if he has an account already. This page navigates to the student home page where he can get his marks categorized, scheduled timetable and online course

access. This front end is developed using HTML, CSS and Javascript for elements like buttons, decorating the page and interactive page with login, logout access respectively. The student mark categorization is performed with the fuzzy logic. The online courses are available as links in the platform suggestion page.

The research aims to evaluate the effectiveness of individualized learning in an educational setting. By employing established threshold values to divide marks into good, average, and bad categories (Figure.6) based on input from students' academic performance, the research allows for a thorough comprehension of individual success levels. The research aims to provide customized study plans for improved learning outcomes by creating timetables(Figure.7) based on students' categorization grades. Additionally, the research provides free online learning platforms(Figure.8) for students to learn from one place.

The modules with their explanation are as follows

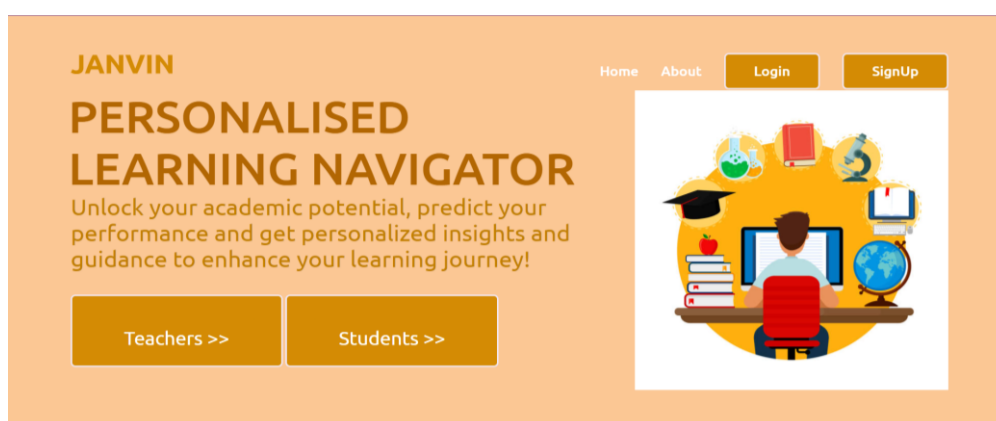


Figure 3. Home Page of the Website Containing about and Login Page.

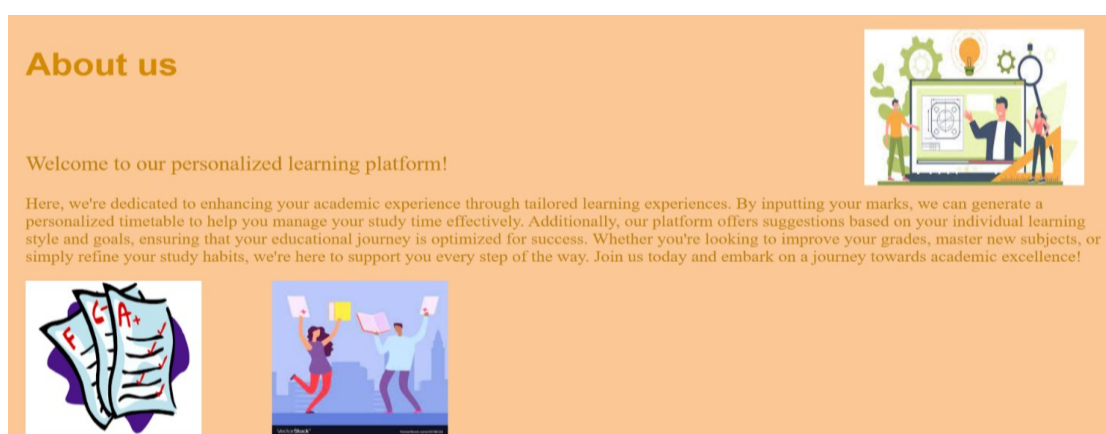


Figure 4. About Page

Reset it here.'"/>

Figure 5. Login Page of Our Website

Figure 6. Student Home Page

The above page is the student home page which navigates from the login page. It contains the details of the student such as their marks, their progress, study timetable and the online platforms available to study for free.

Figure 7. Getting the Input from the Student – Number of Subjects, its Mark and Classify the Marks based as Good, Average, Poor.

This page gets the marks as input from the user, classify them as good, average, or poor. It navigates to the timetable generation page.

JANVIN
Home Mark Platform Logout

Student Timetable for a week

Mathematics Marks:

Science Marks:

English Marks:

Day	Mathematics	Science	English
Monday		Study 1 hour	Study 2 hours
Tuesday	Study 1 hour		Study 2 hours
Wednesday		Study 1 hour	Study 2 hours
Thursday	Study 1 hour		Study 2 hours
Friday		Study 1 hour	Study 2 hours
Saturday	Study 1 hour		Study 2 hours
Sunday		Study 1 hour	Study 2 hours

03 April 2024
Wednesday

Figure 8. Timetable Generated based on the Inputted Marks and its Classification

The above generated timetable(fig.7) is based on the input marks from the user for a week. It helps to navigate to the platforms available to learn for free online.

Home Timetable Logout	
Classes	Platform URL
6th standard	link for platforms
7th standard	link for platforms
8th standard	link for platforms
9th standard	link for platforms
10th standard	link for platforms
11th standard	link for platforms
12th standard	link for platforms

Figure 9. Suggested Platforms to Study using the Links for Specific Standard

The learning platforms which are available for free online for classes between 6 and 12(fig.8) are available in this page through a link. By clicking the link, it navigates to the specific links for specific class.

Home Timetable Classes	
Classes	Courses available
doubtnut.com	Mathematics
unacademy.com	English, Mathematics, Science science, Social, Environmental Science, Commerce,Competitive Exams
learnflix.com	English, Mathematics, Physics, Chemistry, Social science, Aptitude
khancademy.com	English, Mathematics, Physics, Chemistry,Biology, Board preparation

Figure 10. Online Learning Platform Links for Class 7, Mentioning the Subject Available.

This page contains the free online courses for each subject for class 7(fig.9). By clicking the link, it navigates to the specific platform and the student can access the contents available in the link.

5. Comparison Chart

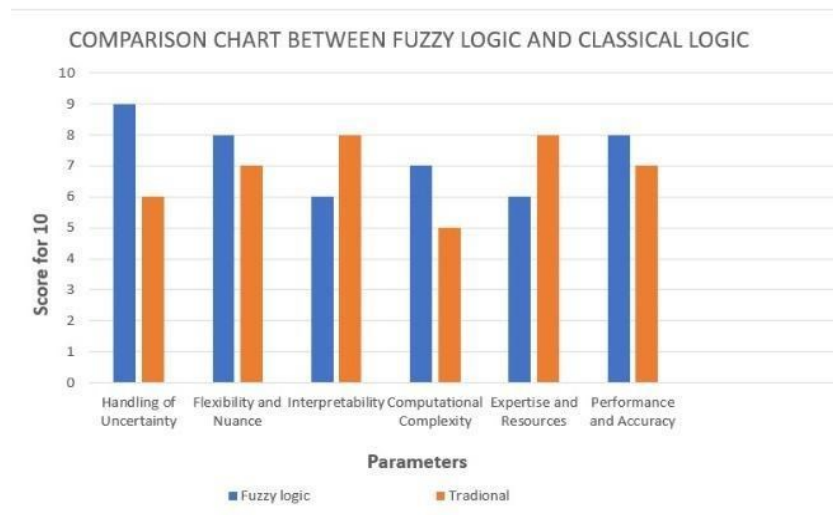


Figure 11. Comparison between Fuzzy Logic and Classical Method of Handling the Student Data, Classification, Computational and Performance of the Logic.

The comparison between fuzzy logic and conventional approaches is made in terms of certain parameters applicable to their use in a particular setting, such as determining student achievement levels. Several elements that should be considered while comparing fuzzy logic with conventional approaches are listed on the x-axis. Examples of these variables include managing uncertainty, flexibility, interpretability, computational complexity, knowledge and resources, performance, and accuracy. The scores allocated to each factor for both fuzzy logic and conventional approaches are shown on the y-axis. These scores reflect the evaluation or rating of each method's performance in the relevant factors. Higher scores indicate better performance, while lower scores indicate worse performance. Different colors are used to distinguish between fuzzy logic and traditional methods. The legend provides a key to the colors used in the graph, indicating which color represents fuzzy logic and which represents traditional methods.

6. Conclusion and Future Work

The suggested website for individualized learning is a good example of innovation in the field of education. Its innovative method offers a holistic solution by creating individualized schedules based on subject categorization and curating learning platforms, all inside a single, centralized platform instead of just classifying subjects. This website caters to the various requirements of learners by providing customized study plans and suggested reading lists, encouraging self-directed learning and independence. This all-in-one platform, in contrast to conventional approaches, maximizes learning results while streamlining the learning process and providing ease and efficiency. Students may now confidently begin their educational journeys with the resources and assistance they need to reach their full potential and achieve academic success. By adding new features and improving current functionality, the project hopes to substantially improve the system's capabilities in the future. Expanding the input categorization method to include into account more than simply number marks is one area of attention. To give a more thorough assessment of student performance and requirements, this may involve combining qualitative data such as student comments, learning preferences, and extracurricular activities. Furthermore, to enhance the precision and level of detail in categorization outcomes, the system will investigate the use of sophisticated machine learning methods, such deep learning models. Additionally, efforts will be focused on improving the recommendation engine to offer more context-aware and tailored recommendations for study

materials and learning tools. To better grasp the semantic context of learning materials, textual information may be analyzed using natural language processing algorithms. Furthermore, the system's user interface and user experience design will be continuously improved to guarantee accessibility and usability for a wide variety of users, such as parents, teachers, and students. Lastly, the system's efficacy will be rigorously assessed and validated in the future via user studies and practical implementation in educational settings. The main objective of these studies will be to determine the system's influence on student engagement, learning results, and the general educational experience.

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