UNIVERSITI MALAYA

WID3007 FUZZY LOGIC:

GROUP ASSIGNMENT

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Background

In terms of educational evaluation, standard grading systems may fall short of measuring students' overall achievement. To solve this shortcoming, fuzzy logic systems provide a flexible and understandable method that takes into account the inherent uncertainty and vagueness in human judgment. This project examines the design and implementation of a Mamdani Fuzzy Logic System for assessing student programming performance.

Problem statement

The conventional grading system often relies on rigid thresholds and fails to accommodate the multifaceted nature of student performance. This can lead to an incomplete understanding of a student's abilities, especially in complex subjects like programming. The problem is to develop a more nuanced and adaptive evaluation system that considers both quantitative metrics (such as overall marks) and qualitative factors (such as attendance) to provide a comprehensive programming performance assessment.

Objective

The primary objective is to create a Fuzzy Logic System that can effectively evaluate student programming performance based on input variables like overall marks and attendance. The system should be able to handle uncertainties and variations in student performance, providing a more realistic and personalized assessment compared to traditional grading systems.

Design and Implementation

Input and Output

Inputs:

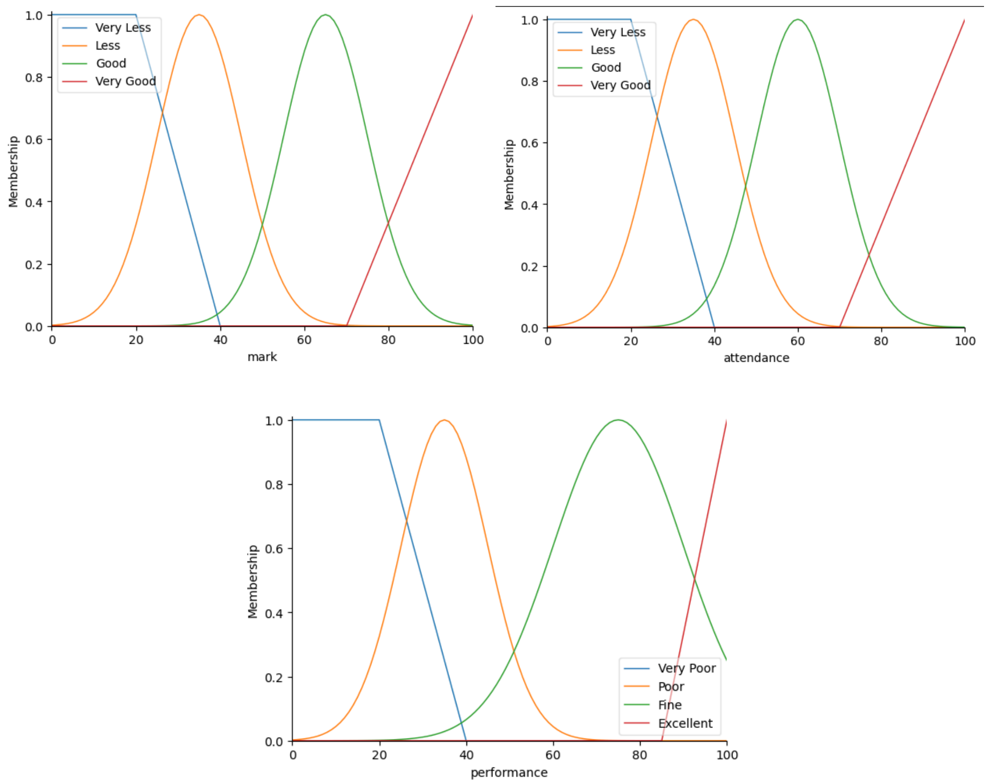
1. Student's Overall Mark (mark):
    - Universe: 0-100
    - Fuzzy sets: Very Less, Less, Good, Very Good
2. Student's Attendance (attendance):
    - Universe: 0-100
    - Fuzzy sets: Very Less, Less, Good, Very Good

Output:

1. Programming Performance (performance):
    - Universe: 0-100
    - Fuzzy sets: Very Poor, Poor, Fine, Excellent

Fuzzification

The fuzzification of programming performance was achieved by using both input variables and membership functions in the fuzzy sets. Fuzzification of input variables, namely ‘mark’ and 'attendance’, as well as the output variable ‘performance’. The universe discourse for the ‘mark’ variable is established from 0 to 100, reflecting the range of possible values for student performance. Linguistic labels are then assigned to capture qualitative assessments, including ‘Very Less’, ‘Less’, ‘Good’, and ‘Very Good’. Each linguistic label is associated with a specific membership function that characterises the degree of membership based on the input value.



The membership functions chosen exhibit diverse shapes to accommodate different performance levels. For instance, 'Very Less' and 'Very Good' are modelled using trapezoidal membership functions, allowing for gradual transitions between membership and non-membership. Conversely, 'Less' and 'Good' are represented by Gaussian membership functions with distinct means (35 and 65) and standard deviations (10), capturing a more centralised and concentrated degree of membership.

The fuzzification process involves evaluating these membership functions for a given input value. As an illustrative example, consider a student's 'mark' value of 45. The degree of membership for 'Very Less' is calculated using the trapezoidal membership function, and similarly, the degrees of membership for 'Less,' 'Good,' and 'Very Good' are determined through the respective Gaussian and trapezoidal functions.

It's essential to note that similar fuzzification processes are applied to the 'attendance' variable, reflecting student attendance levels, and the 'performance' variable, representing the overall performance assessment.

Knowledge Based

In the development of a Fuzzy Logic System (FLS), we formulated a set of knowledge-based fuzzy rules to establish relationships between input variables ('mark' and 'attendance') and the output variable ('performance'). Activation of a rule prompted an AND operation among the inputs, and this iterative process established the output membership functions for each rule. A fuzzy rule, characterised by a simple If-Then structure with conditions and conclusions, exemplifies this approach.

The rules follow a basic structure of "if-then," where the "if" part combines linguistic labels from input variables, and the "then" part assigns a linguistic label to the output variable. For example, "if the mark is 'Very Less' and attendance is 'Very Less,' then the performance is 'Very Poor'".

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----------------------------------------
IF mark[Very Less] AND attendance[Very Less] THEN performance[Very Poor]
----------------------------------------
IF mark[Less] AND attendance[Less] THEN performance[Poor]
----------------------------------------
IF mark[Good] AND attendance[Good] THEN performance[Fine]
----------------------------------------
IF mark[Very Good] AND attendance[Very Good] THEN performance[Excellent]
----------------------------------------
IF mark[Good] AND attendance[Very Less] THEN performance[Very Poor]
----------------------------------------
IF mark[Good] AND attendance[Less] THEN performance[Poor]
----------------------------------------
IF mark[Very Good] AND attendance[Less] THEN performance[Poor]
----------------------------------------
IF mark[Very Less] AND attendance[Good] THEN performance[Very Poor]
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IF mark[Less] AND attendance[Good] THEN performance[Poor]
----------------------------------------
IF mark[Very Less] AND attendance[Very Good] THEN performance[Very Poor]
----------------------------------------
IF mark[Less] AND attendance[Very Good] THEN performance[Poor]
----------------------------------------
IF mark[Very Good] AND attendance[Very Less] THEN performance[Very Poor]
```

Figure 2.0: Fuzzy Rules of Programming Performances

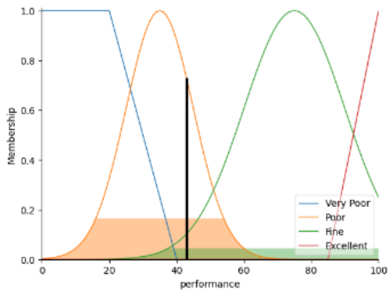
Defuzzification

In the Mamdani-type fuzzy logic system designed for programming performance, the defuzzification process is a crucial step that transforms the aggregated fuzzy output into a crisp, actionable decision. Following the fuzzy inference and aggregation of rules, which result in a fuzzy set representing the overall performance, defuzzification provides a method to convert this fuzzy set into a clear and interpretable numerical value.

In the Mamdani method, this is achieved using methods like centroid defuzzification. The centroid represents the centre of mass of the fuzzy output distribution and is computed to obtain a representative crisp value for the output variable 'performance.

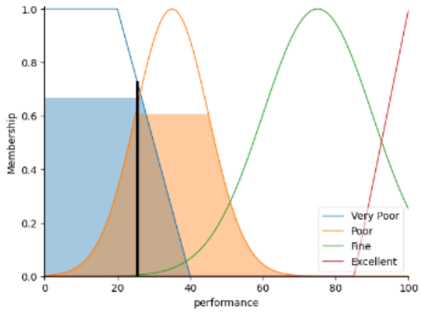
Assuming the student achieves the following:

1. Overall mark = 54%, Attendance = 85%



Student's Programming Performance: 43.06%

2. Overall mark = 90% , Attendance = 25%



Student's Programming Performance: 25.53%

The defuzzification process follows the Mamdani method, with the area between the input and output axes of the membership function shaded to reflect the accuracy of the rules.

System Testing

The FLS is being tested with real data on students' attendance and marks in a programming class. The data consists of hashed matric numbers, occurrence, attendance, and marks. Below are the performance results from testing on real data:

Overall Performance

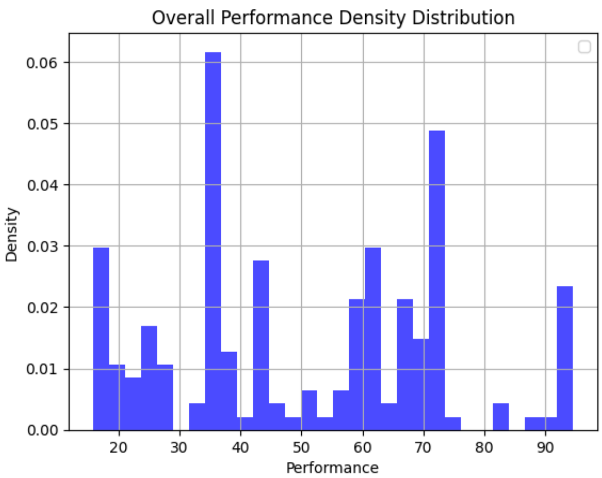


Figure 3.0: Density against Performance

Performance by Occurence (Classes)

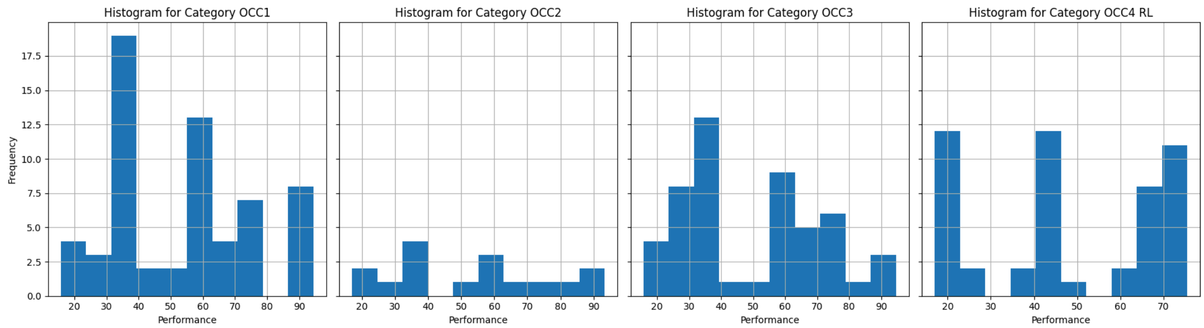


Figure 3.1: Histogram of Frequency against Performance

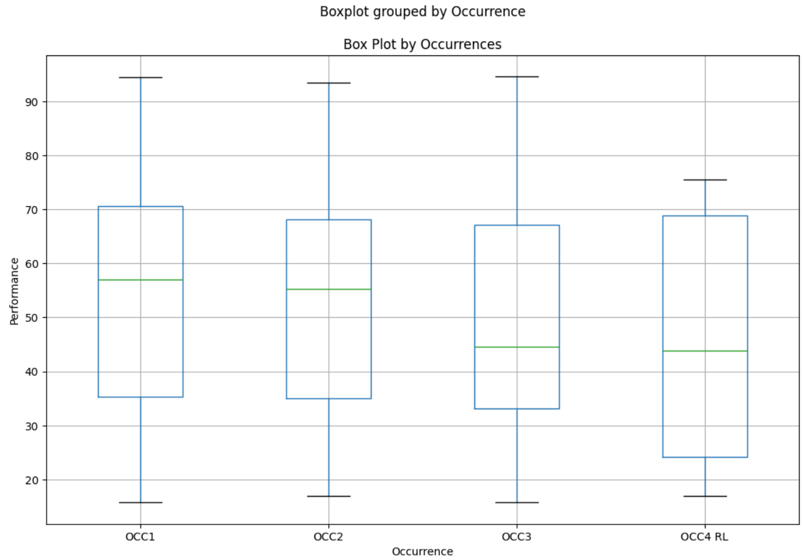


Figure 3.2: Boxplot grouped by Occurence