CHAPTER 4
FUZZYFICATION MODELING FOR PREDICTION OF PERFORMANCE

This work explains a fuzzy model system (FMS) for student performance evaluation. A suitable fuzzy inference mechanism has been discussed. Work mentioned how fuzzy principal can be applying in student performance prediction. This model shows advantage over the traditional evaluation method. This model can be useful for educational organization, educators, teachers, and students also. Traditional evaluation methods have some boundary points but proposed method taking favor of non-numeric grade and shows how can achieve it using fuzzy logic. Modeling based on the past academic result and on some information they earlier submitted for admission purposes.

4.1. Introduction

Success rate of any educational institute or organization may depend upon the prior evaluation of student’s performance. Normally educational institute uses different method for student’s performance evaluation usually any educational organization use grading system on the basis of academic performance especially higher education. Users can involve other key points to evaluating student performance such as communication skill, marketing skill, leadership skill etc [67].

Performance evaluation can provide information. Information generated by evaluation can be helpful for students, teachers, and educators to take decisions [55]. In corporate field employers highly concern about all mentioned skill. If an educational institute involve other than academic performance for evaluation then it will be beneficial for students as well as organization also. Traditionally student’s performance evaluate done by academic performance like class assignment, model exams, yearly etc. This primary technique involves either numerical value like 6.0 to 8.0, which may call grade point average, or 60% to 80% i.e average percentage.
Some organization also using linguistic terms like pass, fail, supply for performance evaluation. Such kind of evaluation scheme depends upon criteria, which are decided by experienced evaluators. So that evaluation may be approximate. The objective of work is to present a model. Which may be very useful for teachers, organization and students also. It helps to better understanding weak points, which acts as a barrier in student’s progress.

4.2. Method used

This work anticipated a model for students’ evaluation with Fuzzy logic. Fuzzy logic can be described by fuzzy set. It provide reasonable method / technique through input and output process. This input and output process shown in Figure 3.3, inputs crisp values. Fuzzification of the values is done by fuzzyfier. Class of object can define Fuzzy set; there are no strident margins for object [71]. A fuzzy set formed by combination of linguistic variable using linguistic modifier.

Linguistic modifier is link to numerical value and linguistic variable [100]. In work linguistic variable is performance and linguistic modifiers are good, very good, excellent, and outstanding.

Figure 4.1: fuzzy input output model
Basics of any fuzzy set are membership function. It’s a line in plane surface, which define relationship between set and degree of membership [32]. User can obtain degree of membership function, which is actually the degree of truth in which an element belongs to the set [59].

4.3. Methodology

Fuzzy logic technology basically involves main 3 steps as show in Figure 4.1 also.

- Fuzzyfication
- Fuzzy reasoning
- Defuzzification

A. Fuzzification:

Initial step of fuzzy inference system is fuzzification. This step performs transformation of domain where crisp inputs are transformed into fuzzy inputs. Crisp inputs are exact inputs measured by any system [102]. Usually crisp inputs are numeric values that are processed by control system like marks, temperature, pressure, rpm's, etc.

Processed input has it’s own set of membership function (MF). This sets of membership functions exists within a universe of discourse that holds all relevant values that the crisp input can possess. The Figure 4.2 shows the structure of membership functions within a universe of discourse for a crisp input.

![Figure 4.2: MF structure [20].](image)
**Degree of membership:** Degree to which a crisp value is compatible to a membership function, value from 0 to 1, also known as truth value or fuzzy input [32].

**Membership function (MF):** Defines a fuzzy set by mapping crisp values from its domain to the sets associated degree of membership.

**Label:** Descriptive name used to identify a membership function. This work uses poor, good, excellent etc. Whenever forming any MF for input, first have to decide labels for membership function. For example in work for percentage input decided poor, good and excellent labels.

**Scope or domain:** The width of the membership function or the range, over which a membership function is mapped. Any numerically range will be decided by the expertise for input value is domain that assigned to MF. In work percentage <50 is assign poor, >50 and <75 is good , >75 is excellent.

Universe of discourse: range of all possible values, or concepts, applicable to a system variable.

**B. Fuzzy reasoning**

It involves inference mechanism and produce fuzzy output. As mentioned Base of Inference mechanism is degree of membership function is display in Figure 4.1. This work use sample data of 40 students, in which 2 output predictive factors. One is there division in HSSE and second is caste benefits.

Fuzzy output is output membership value [57]. This value denotes the output variable Fuzzy set for rule invoked from the rule base system.

**C. Defuzzyfication**

This step computes the final output. To compute final output aggregating two or more fuzzy output set, this yields a new one. In defuzzification fuzzy set again
converted into crisp result. Defuzzification involves the process of transposing the fuzzy outputs to crisp outputs [33]. There are a variety of methods to achieve this, however this discussion is limited to the process used in work. A method of averaging is utilized here, and is known as the Center of Gravity method or COG, it is a method of calculating centroids of sets. The output membership functions to which the fuzzy outputs are transposed are restricted to being singletons. This is so to limit the degree of calculation intensity in the microcontroller. The fuzzy outputs are transposed to their membership functions similarly as in fuzzification [57]. With COG the singleton values of outputs are calculated using a weighted average. The crisp output is the result and is passed out of the fuzzy inference system for processing elsewhere.

4.4. Proposed model

Performance of any fuzzy logic can be enhanced by expert system, which is very reliable for decision-making. Decision in this model based on fuzzy inference system. In proposed model triangular membership function are used for converting the crisp set i.e (Percentage, Parent’s education, caste) into fuzzy set. Here used triangular MF because it is suitable for performance evaluation. It covers maximum values of Input variable values [101]. Values of fuzzy set and their corresponding membership function shown are below tables and figures. According to this transformed data are shown in Figure 4.3. For data transformation following Table 4.1. For the output work use variable performance. Now form a fuzzy set with linguistic modifier (good, vgood, excellent, outstanding), which is link with numerical value (0 to 6).
Table 4.1: Fuzzy set variables

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Input variable</th>
<th>Detail</th>
<th>Values</th>
<th>Obtainable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>HSS result</td>
<td>Higher secondary school result</td>
<td>First, Second, third</td>
<td>1-3</td>
</tr>
<tr>
<td>2.</td>
<td>Caste</td>
<td>Caste of students</td>
<td>Gen, SC, ST</td>
<td>1-3</td>
</tr>
</tbody>
</table>

Figure 4.3: Transformed data set
Figure 4.4: mf of input1

Figure 4.4 shows membership function of caste (input 1). Input1 classified in 3 categories. Gent, SC, ST. Figure 4.5 shows membership function of HSS result (input 2) categorized in First, second, third. Membership values are used in the fuzzification and defuzzification steps. It is helpful in mapping the non-fuzzy input values to fuzzy linguistic terms and vice versa.

A membership function is used to compute a linguistic term [4]. For instance, membership functions for the linguistic variables are plotted in terms of input variable caste, input variable result and output variable. These are given in Figure 4.4, 4.5 and 4.6 respectively. In fuzzy logic numerical value’s fuzzification cannot perform by only single membership function [42]. A value can belong to multiple sets at the same time. The most common types of membership functions are triangular, trapezoidal, and gaussian shapes [32]. In fuzzy set there are various forms of membership function use triangular for input variable and trapezoidal for output. The type of the membership function can be context dependent and it is generally chosen arbitrarily according to the user experience. Triangular function: defined by a lower limit a, an upper limit b, and a value m, where a < m < b.
To calculate output values have to find out degree of membership function for each corresponding linguistic variable which shown in Figure 4.6. Figure 4.7 depicted Degree of membership function. In a fuzzy set A membership function is defined as $\mu_A : X \rightarrow [0,1]$, on the universe of discourse X. In membership function each element of X is mapped to a value between 0 and 1. This value, called membership value or degree of membership, enumerates the grade of membership of the element in X to the fuzzy set A.
Figure 4.6: mf of output 1
Work obtain 4 fuzzy set of output linguistic variable and apply “union” operation of fuzzy set, produced result shown in Table 4.2. Fuzzy set union operation implemented by maximum function [54].

Table 4.2: Degree of Membership functions for performance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value range</th>
<th>Degree of MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>0≤X≤3</td>
<td>0.5</td>
</tr>
<tr>
<td>Vgood</td>
<td>2≤X≤4</td>
<td>0.8</td>
</tr>
<tr>
<td>Excellent</td>
<td>3≤X≤5</td>
<td>0.9</td>
</tr>
<tr>
<td>Outstanding</td>
<td>4≤X≤6</td>
<td>1.0</td>
</tr>
</tbody>
</table>
4.5. Output

Qualitative inappropriate information can handle using fuzzy logic [4]. For this work calculates membership value of input data by fuzzification process. Transformed sets of values are shown in Figure 4.8 and Figure 4.9. Through defuzzification get output which shown in column G of Figure 4.8 and Figure 4.9. Value of column G calculated as min \{0.97,0\}=0, min \{1,0.9\}=0 etc. Performance grouped in four category outstanding, excellent, vgood and good. In this model calculated performance value is depends upon degree of membership function. With the help of past study membership function groped which is depicted in Table 4.2. Performance generating by fuzzy inference method for input variables are depicted in Figure 4.10. It shows performance =3.84 for percentage 1.76 and caste 1.77(MF value).

![Figure 4.8: Transformed input data after fuzzification](image.png)
The overall performance space is shown through graph in Figure 4.11. This figure will show distinct area of performance with progression from one space percentage to another caste. The variations in decision combined by human evaluator may bring uncertainty in outcome of student’s performance. The fuzzy approach can handle uncertainty effortlessly [85]. It can be determine from Figure 4.11 that academic performance for good and outstanding remains stable it is affected for input range 2-3.
Figure 4.10: performance value

Figure 4.11: surface view of performance

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4.6. Conclusion

This research improves to the validation for having prior knowledge about the academic achievement of all the newly admitted and registered students, at the earliest possible time of their studentship, with a view to determining their strengths and weaknesses. This work represents performance evaluation on the basis of two-factor grade and caste. For work used data of newly admitted and registered students. Modeled input variable using the fuzzy logic technique. It seems that include a subjective variable in fuzzy logic approach. Subjective variable also affects the performance of students. Work presents through the figure 4.10 and 4.11 that performance of any student affect by previous grade and caste also. This model can be applied to predict the performance of all students who are seeking admission for higher education. The technique of fuzzy logic applied in this research shows its capability of handling uncertainty. In future some more predictable variable can be included. Fuzzy logic provides more convenient ways to mapping process, as depicted through diagram [4].