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AN Intelligent System for Predicting Students Performance

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***Abstract*:** *One of the causes of the gradual decline of the Nigerian Educational System can be attributed to the inadequacies and flaws in universities admission process. In this paper, we seek to address this problem by predicting the first-year performances of prospective students using Fuzzy Logic based on prior academic achievements presented during admission process. A range of conventional secondary school subjects were used as the input variables in a Mamdani Model. MATLAB fuzzy logic toolbox was used to model the fuzzy rules logic in this study with computer science course (CSC) criteria in the x axis, General studies course (GST) criteria is in y axis, and solution criteria Performance (P) is in z axis. The results show that a student with a model output of CSC=0.857, MTH=0.796, PHY=0.864, GST=0.638, CHM=0.489 model output P=0.446. Output P=0.446 means that the student will most likely perform above the 95th percentile of the Grade Point Average (GPA). The design was successfully tested and implemented.*

Keywords: *Fuzzy Logic, Student Performance, Fuzzy Inference.*

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I. Introduction

The increasing demand for education in Nigeria especially tertiary education has not been without its challenges. Government–owned tertiary institutions as well as those privately owned do not possess the capacity and manpower needed to accommodate the growing number of young school leavers hoping to secure admission into tertiary institutions. [2] [3] [5] [13] posits that predicting and evaluating the academic performances of students has for a long time now been an interesting and important area of research in many academic disciplines. Evaluating students' academic performances or achievement using the cumulative grade point average (CGPA) as a pointer is a typical practice in several tertiary academic environments. A high percentage of fresh students usually find themselves below the minimum grade point required at the end of their first year. [1]. pointed out that having a thorough understanding of a student's prior achievement or knowledge is important and will go a long way in helping academic planners predict the future performance of such student.

[12] stressed the importance of predicting and evaluating the academic performances of students. In his survey carried out in a privately-owned university in Nigeria, the percentages of students below the 2.5 CGPA at the end of the 2007/2008, 2008/2009 and 2009/2010 academic sessions were alarming. This percentage gives a clear view of the declining nature of students' academic performances in our tertiary institutions. Thus predicting and evaluating students' performances cannot be over-emphasized as it is a useful tool for academic planners, educators and students alike, as it gives an actual understanding of students' weaknesses and proffer solutions. The application of fuzzy logic in predicting and evaluating students' academic performances gives effective and attainable solutions as the knowledge of fuzzy logic is suitably required when human evaluation is needed. Furthermore, research has shown that fuzzy logic is a more essential technique to handle imprecision and uncertainty given that evaluating the prior knowledge or past achievements of students with the aim of discovering the risk of students' failure involves dealing with uncertain and imprecise data [5] [8] [17] [21] . Therefore, this project aimed at implementing fuzzy logic in predicting students' academic performances as the fuzzy approach is likely to offer an alternative way of handling imprecise data, especially in decision making.

II. Materials and Method

2.1 Overview of the System

The first step in the proposed model is the establishment of input and output variables. This task is usually done by studying the problem domain. There is infinite number of potential candidates which should be restricted to positive numbers. In this research, the key variables are defined. Input and outputs of proposed

model is given in Table 1 and whole structure of predicting student academic performance system developed in the Matrix Laboratory (MATLAB) as shown in Fig 1.

Inputs variables	Abbreviation	Output variables	Abbreviation
Computer science	CSC		
Mathematics	MTH	Performance	P
Physics	PHY		
General studies	GST		
Chemistry	CHM		

Table 1: Input and output variables

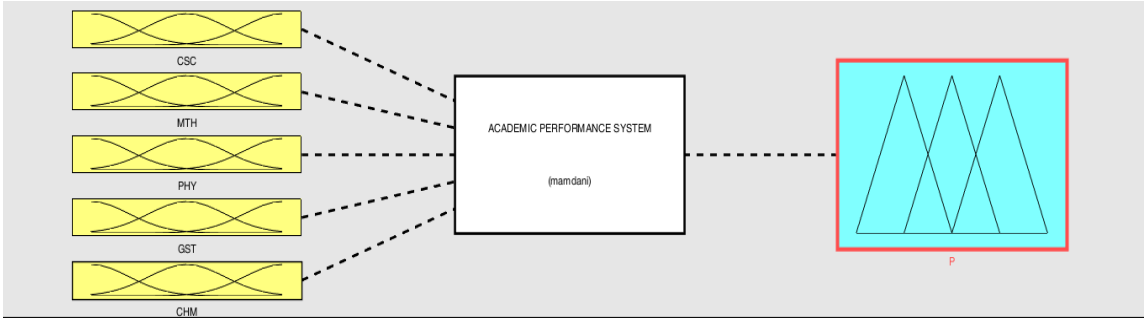

Fig 1: Predicting Student Academic Performance Model using the Mamdani Method.

III. Design Specifications

The three main components of this are given below:

- User interface.
- Decision making inference engine.
- Database (storing the data and fuzzy rules).

A system administrator (or any user) will interact with the predicting student academic performance system using MATLAB Fuzzy module. Inference engine gets commands from user by interface and evaluates these with the help of a database in which rules are deposited.

3.1 Fuzzy sets and fuzzy number

The fuzzy set theory as introduced by Zadeh is a multi-value logic which permits intermediate values to be defined between conventional ones like true/false, low/high, good/bad etc. In a classical set theory, an element may either belong to set or not. In fuzzy set theory, an element has a degree of membership. A degree of membership function can be described as an interval [0, 1]. In this study, a triangular fuzzy number (TFN) was used for prediction computational efficiency. A TFN is shown simply as (a, m, b). "a, m, b" parameter represents the smallest possible value (lower bound), mean value, the largest possible value (upper bound) respectively. $\mu_{\grave{M}}$ is a membership function

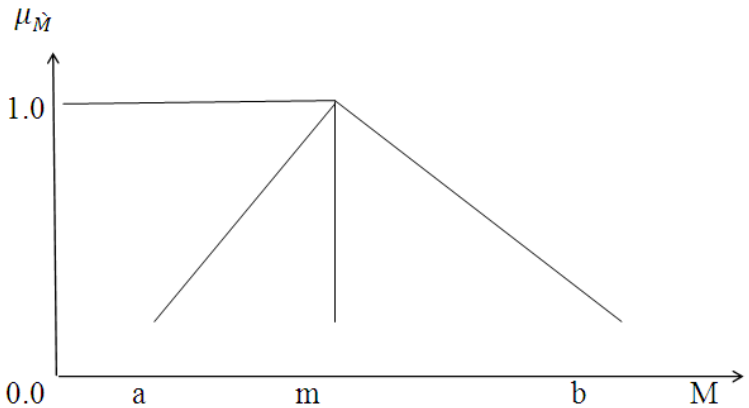

Fig 2: A triangular fuzzy number $\grave{M}$

Membership function of the TFN is presented as follows:

$$\mu_{\grave{M}}(x) = \begin{cases} 0 & x < a \\ \frac{x-a}{m-a} & a \le x \le m \\ \frac{b-x}{b-m} & m \le x \le b \\ 0 & x > b \end{cases} \qquad \text{---------- (3.1)}$$

3.2 Fuzzy Rule Based Model

The general architecture for a rule-based intelligent system and the components of a fuzzy rule-based inference system are shown in this report. The main modules of a fuzzy rule-based system are fuzzification - or fuzzifier module -, fuzzy rules, inference engine and defuzziier.

Step 1. Fuzzification module: It converts a crisp input of the domain of the input variable domain to a grade by fuzzy set. Constructing a fuzzy logic membership functions play a crucial role for fuzzy rule-based models. Triangular membership function was used in many fuzzy logics-based applications. In this study triangular membership functions have been used.

Step 2. Defining fuzzy rules: Fuzzy rules consist of antecedent and consequent in the form of IF-THEN statements. There are a number of rules, and they make a group which forms the basis for inference. The following some fuzzy rules have been taken with the combination of linguistic variable values. Input and output criteria of the model are "computer science (CSC)", "Mathematics-(MTH)", "physics (PHY) "General studies (GST)", "Chemistry (CHM)", and "Performance (P)".

3.3 Fuzzy parameters and their Membership Functions Design

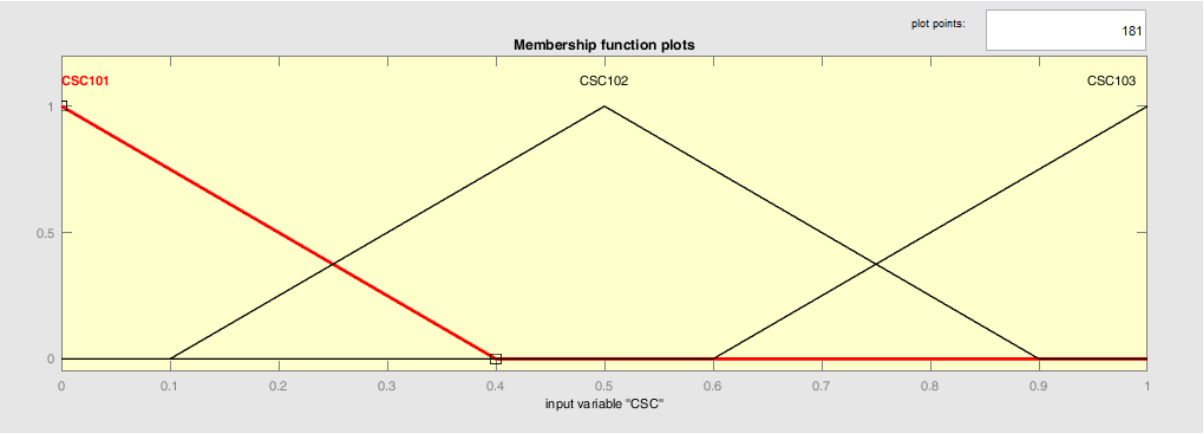

Fig 3: Computer Science Courses Membership

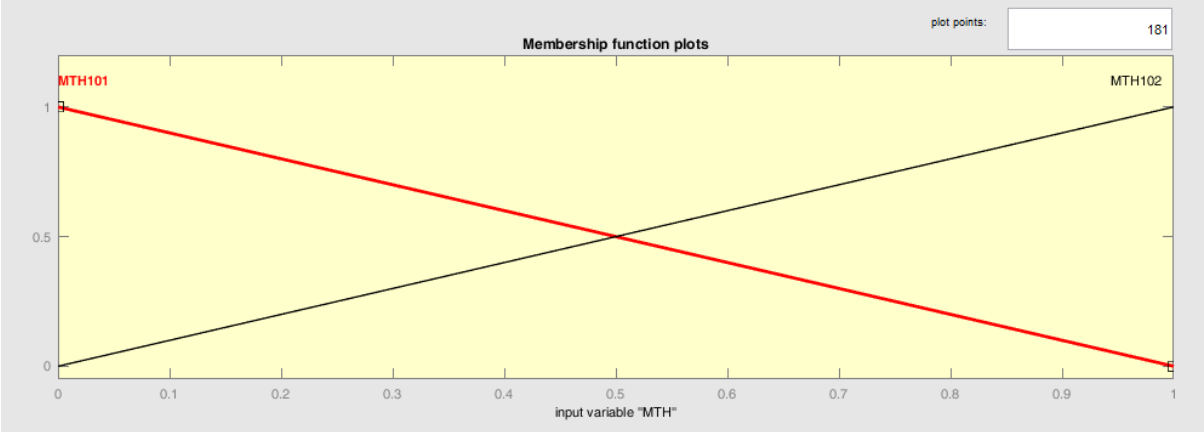

Fig 4: Mathematics Courses Membership

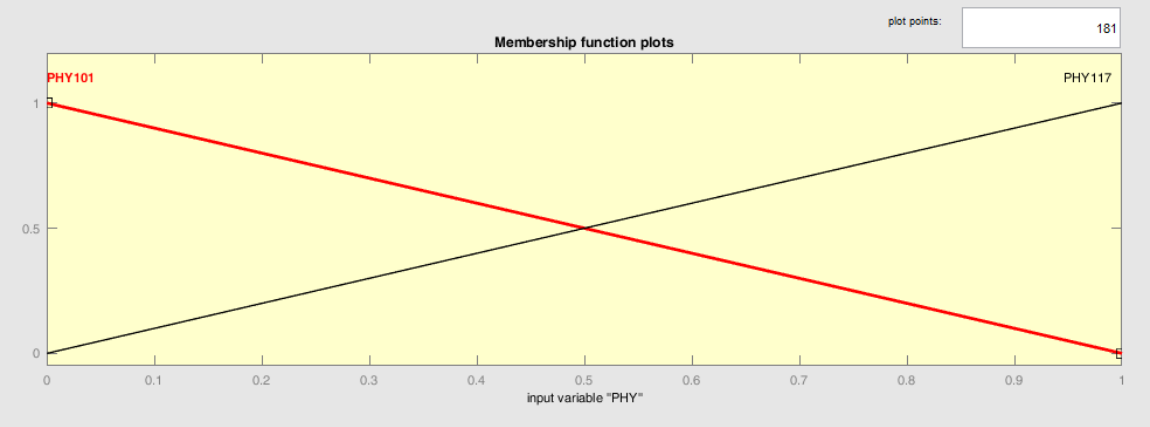

Fig 5: Physics Courses Membership

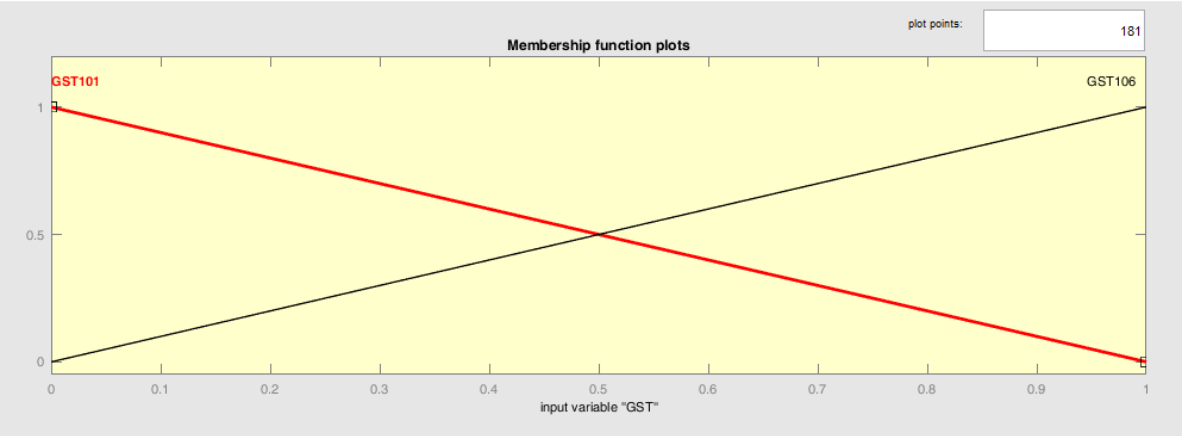

Fig 6: General studies Courses Membership

3.4 Inference Engine and Defuzzification

The basic function of the inference engine is to compute level of belief in output fuzzy sets from the levels of belief in the input fuzzy sets. The output is a single belief value for each output fuzzy set. In this stage, the fuzzy operator is applied in order to gain a single number that represents the result of the antecedent for that rule. The procedure of converting each aggregated fuzzy output set into a single crisp value is called defuzzification. In the prediction of student academic performance system, to find the defuzzification value we use the center of gravity method. The center of gravity equation can be written as follows:

$$y_{op} = \frac{\int_{y_{min}}^{y_{max}} y\mu_{agg}(y)\,dy}{\int_{y_{min}}^{y_{max}} \mu_{agg}(y)\,dy} \qquad \text{---------- (3.2)}$$

IV. Test and Results

The inference mechanism in the fuzzy logic controller resembles that of the human reasoning process. This is where fuzzy logic technology is associated with artificial intelligence. Humans unconsciously use rules in implementing their actions. Fuzzy rules consist of antecedent and consequent in the form of IF-THEN statements. There are a number of rules, and they make a group which forms the basis for inference. The following are some fuzzy rules that have been taken with the combination of linguistic variable values using the software MATLAB.

1. If (CSC is CSC101) and (MTH is MTH101) and (PHY is PHY101) and (GST is GST101) then (P is GOOD) (1)
2. If (CSC is CSC101) and (MTH is MTH101) and (PHY is PHY101) and (GST is GST101) and (CHM is CHM101) then (P is EXCELLENT) (1)
3. If (CSC is CSC101) and (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM101) then (P is GOOD) (1)
4. If (CSC is CSC101) and (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM101) then (P is EXCELLENT) (1)
5. If (CSC is CSC101) and (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM111) then (P is EXCELLENT) (1)
6. If (CSC is CSC102) and (MTH is MTH101) and (PHY is PHY101) and (GST is GST101) then (P is PASS) (1)
7. If (CSC is CSC102) and (MTH is MTH102) and (PHY is PHY117) then (P is PASS) (1)
8. If (CSC is CSC101) and (MTH is MTH101) and (PHY is PHY101) then (P is PASS) (1)
9. If (CSC is CSC103) and (MTH is MTH101) and (PHY is PHY101) and (GST is GST101) and (CHM is CHM101) then (P is EXCELLENT) (1)
10. If (CSC is CSC101) then (P is FAIL) (1)
11. If (CSC is CSC101) and (MTH is MTH101) then (P is FAIL) (1)
12. If (MTH is MTH102) and (PHY is PHY101) and (GST is GST101) then (P is PASS) (1)
13. If (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) then (P is PASS) (1)
14. If (PHY is PHY117) and (GST is GST106) then (P is FAIL) (1)
15. If (MTH is MTH101) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM111) then (P is GOOD) (1)
16. If (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM111) then (P is GOOD) (1)
17. If (CSC is CSC103) and (MTH is MTH102) and (PHY is PHY117) and (GST is GST106) and (CHM is CHM111) then (P is EXCELLENT) (1)
18. If (PHY is PHY101) and (GST is GST101) and (CHM is CHM101) then (P is PASS) (1)

Fig 7: Fuzzy rules dev0lop in MATLAB

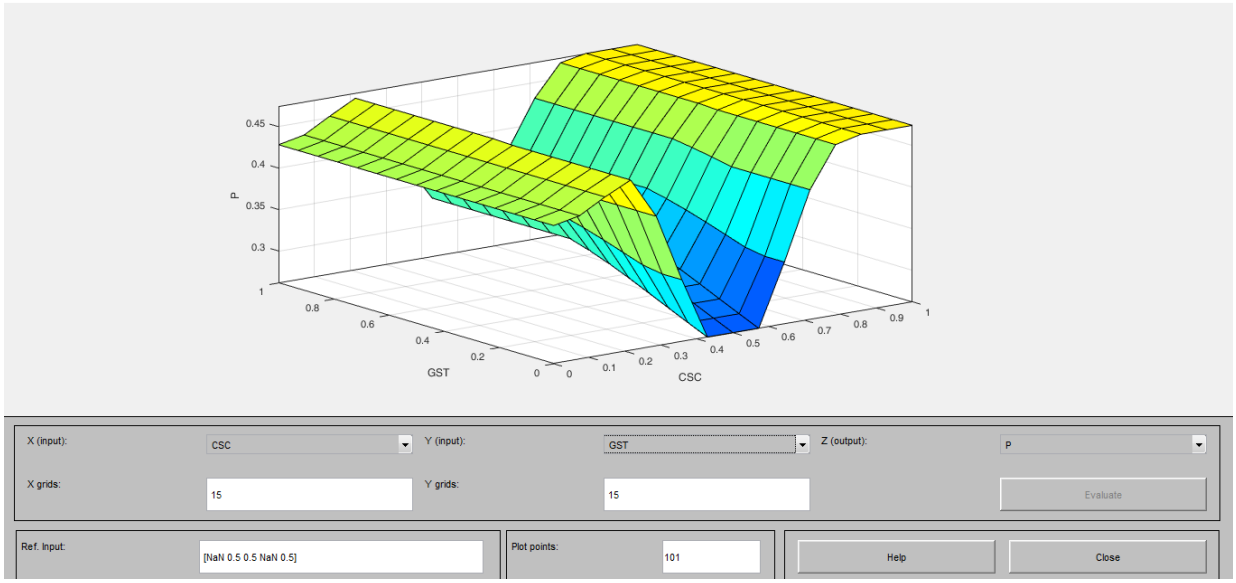

Fig 8: Input variables Computer Science Courses (CSC), General Studies course (GST) vs. output variable Performance (P).

It can be seen that computer science course (CSC) criteria is in x axis, General studies course (GST) criteria is in y axis, and solution criteria Performance (P) is in z axis as shown in Figure 8.

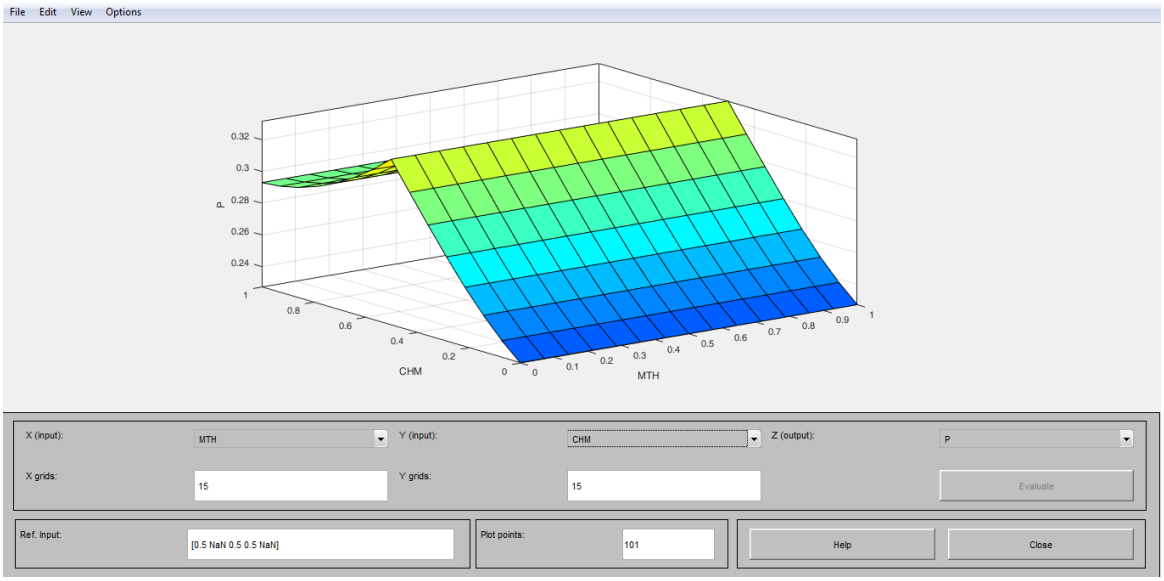

Fig 9: Input variables Mathematics Courses (MTH), chemistry course (CHM) vs. output variable Performance (P)

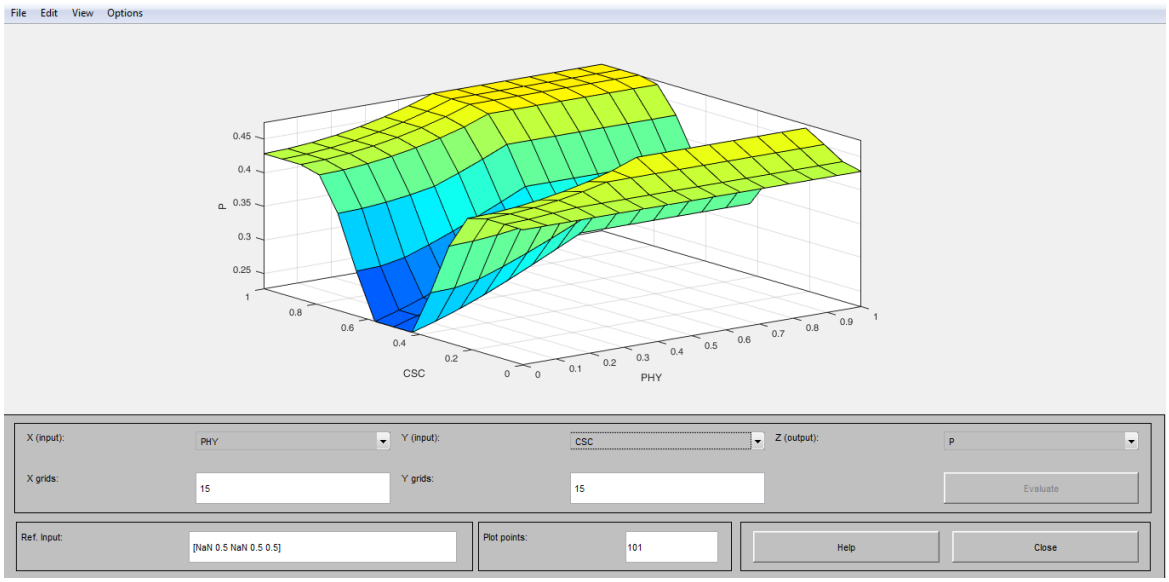

Fig 10: Input variables Physics Courses (PHY), Computer science course (CHM) vs. output variable Performance(P).

As shown in Fig 9 Physics Course (PHY) criteria is in x axis, Computer Science course (CHM) criteria is in y axis, and solution criteria Performance (P) is in z axis.

A 100-level student registered the following first semester courses on his/her portal, and when his final semester examination result was out, and he went to check his performance. According to the proposed model, a sample solution is given in Fig 11 When CSC=0.857, MTH=0.796, PHY=0.864, GST=0.638, CHM=0.489 model output P=0.446. Output P=0.446 means that the student had a good performance. Using the CGPA scale of 5.0, the student performance shows that he/she in first class (4.5) range approximately.

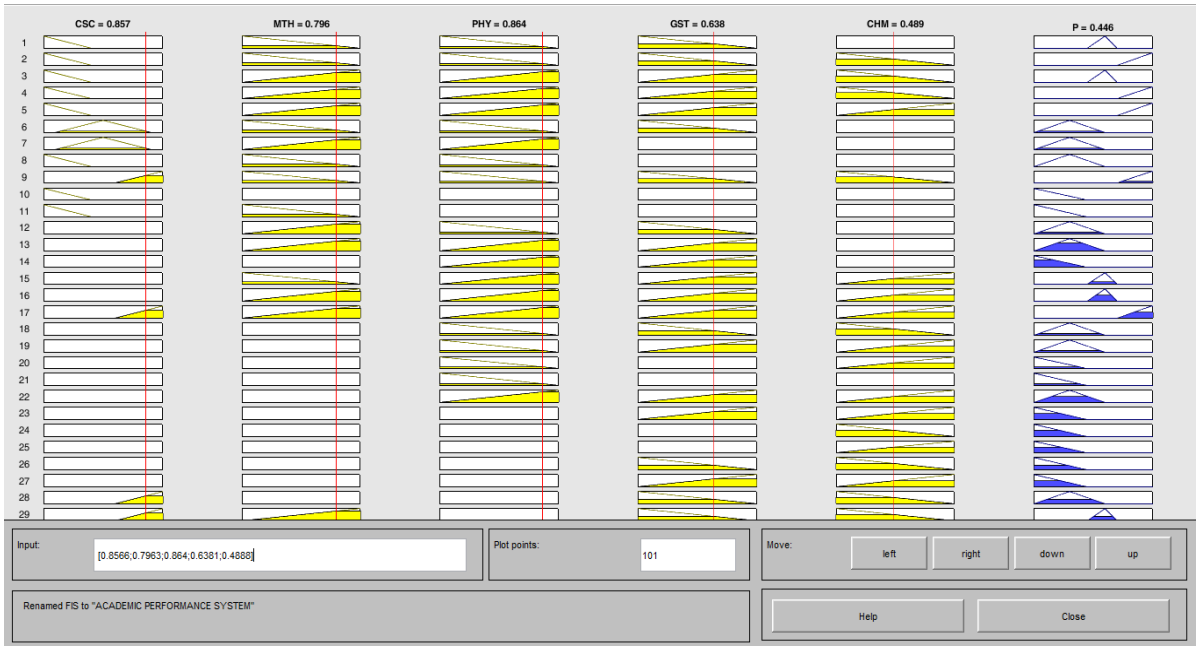

Fig 11: Fuzzy Rule Viewer for Predicting Student Academic Performance

V. Conclusion and Recommendations

In conclusion, a fuzzy logic system was developed for predicting the first semester performance of students based on the following subjects: “Computer science" "Mathematics" "Physics" "Chemistry" and "General studies". Based on our numerical experiments, we conclude that the MATLAB - trained fuzzy logic system exhibits more consistent behavior and illustrate better classification results than the other classifiers. Furthermore, we have shown the main features of our software tool to illustrate its functionalities and the experimental set up process. Our tool is still under development but our first results shows it can be used to gain

considerable insights about student progress and recommend possible actions such as further study or additional learning activities, resources and learning tasks.

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