Determination of Academic Performance and Academic Consistency by Fuzzy Logic

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***Abstract*—Academic evaluation is becoming an increasingly popular area. In this work, we have developed a software tool using fuzzy logic to find out the academic performance and consistency of students. Traditionally, the academic performance had been measured by the result of a student. However, the new method developed in this work has taken several factors into consideration. The factors are the parameters that influence the academic performance and consistency of students. Such factors have been established by consulting students and data is obtained with the help of online surveys and face to face interviews with students of Electrical and Computer Engineering students from North South University, Dhaka, Bangladesh. Some of the factors that are considered: "Online Assistance", "Part-Time Job", "Number of courses", "Hours spent Studying etc. The data have been used to develop the tool for measuring the academic performance and consistency. The performance is measured with the Fuzzy Inference System (FIS), Adaptive Neuro Fuzzy Inference System (ANFIS). In case of obtaining the academic consistency, the data of different factors are used to generate the clusters using the *k*-means algorithm.**

Keywords—Fuzzy logic, Fuzzy inference system, Adaptive Neuro Fuzzy Inference System, k-means algorithm, Academic Performance, Academic Consistency, Factors.

I. INTRODUCTION

Research on academic evaluation is vital for the improvement in the academic curriculum of a country by finding the loop holes and the features which can be added to upgrade the academic system. Even more, it can help general people in overcoming the difficulty of figuring out which factors influence the academic performance and consistency of a student. If an application can be introduced where academicians and students can put their numerical scaled value for factors, they could be able to find their own academic performance and academic consistency. Normally, people evaluate academic performance by their current average grade point or result, however, such a procedure is imprecise in many ways. It does not hold factors like personal issues of a person which can have a massive impact on their academic performance. In this work, such issues are taken into consideration to improve the precision of academic evaluation with the help of Fuzzy logic.

Academic evaluation is an interesting field of application for fuzzy logic since, fuzzy logic provides an output of some certain degree by taking in an imprecise input. Therefore, by taking the advantage of this property of fuzzy logic, it can be used to measure academic performance and consistency of students. In this work we have used both FIS and ANFIS.

The FIS is the abbreviation for Fuzzy Inference System, which is made of rules. The rules consist of the fuzzy "If-Then" logic rules, membership function and the explanation of the fuzzy inference techniques from elementary rules to obtain the result. The FIS operates on fuzzy values which is yielded from the conversion of the actual value of the input using the fuzzification process through its membership function, where the fuzzy values has ranges from 0 to 1.

The basic rules can be generated from a human or an automatic system. There are various kinds of FIS like the Takagi-Sugeno method, the Mamdani-min implication and Tsukamoto. However, in this research, the Mamdani technique has been chosen specifically, for the rule generation, Fig. 1 shows a detailed structure of the FIS. The procedure of application of FIS in this work is briefly demonstrated in the Methodology section.

ANFIS, also known as adaptive neuro fuzzy system requires the adaptation to learning, using fuzzy logic. In our project, the ANFIS has been trained with the raw data obtained and it will generate output membership function based on the inputs using the SUGENO implication to test our system.

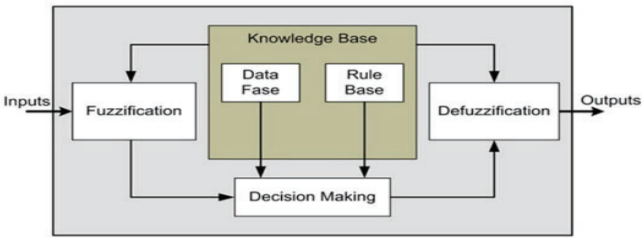

Fig. 1. Structure of the fuzzy inference system (FIS)

In order to find a group of data which has similar properties to one another, the clustering algorithm is the best approach. One of the best clustering techniques is the k-means algorithm. It stores k centroids, which defines the clusters. A specific point is said to be in a cluster if it contains properties similar to a specific cluster and is closer to that cluster's centroid than any other cluster's centroid.

In our work, we use FIS and ANFIS to measure academic performance where different groups of consistent students are found by applying k-means algorithm. The grouping found by k-means will aid in predicting a new student's performance.

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II. Related Works

Fuzzy logic has been applied before in previous researches [2, 4-8] related to academic evaluation. In this work, some related works have been reviewed and the drawbacks of the pervious researches have been identified. We try to address those drawbacks in this paper. A brief explanation of the past researches have been mentioned below.

In [3], the authors proposed a New Fuzzy Expert System (NFES) for evaluating students' academic performance. The authors could not replace the current traditional techniques for evaluating students' performance rather they just strengthened the present system by providing additional information. The research had few limitations. The limitation can be explained using the following example: Let us consider two students, Student A and Student B. If Student A scores 50 marks in semester 1 and 60 marks in semester 2 whereas Student B scores 60 marks in semester 1 and then scores 50 marks in semester 2, then the average score of both students appears to be same using the traditional calculation. But in the proposed classical method in [3], student A is considered to be unsuccessful. On the other hand, our proposed method successfully concludes that Student A's performance has improved and Student B's performance deteriorated.

Parwinder Kaur et al. [1] anticipated a fuzzy system to evaluate students' performance by considering 5 input variables which were teaching factors, university system, university environment, family factors and personal factors. The factors had been further subdivided into 36 sub-factors. After data collection, the values were mapped into the input of fuzzy variables and as a result, fuzzy outputs were obtained. They had used only FIS to form 243 "if then" rules using the knowledge base of the fuzzy expert system and applied Mamdani min implication method to obtain the output by matching the user inputs with the fuzzy rules in the knowledge base. Once the fuzzy outputs had been obtained, they were defuzzified using centroid and other methods.

Overall, the number of parameters considered for academic evaluation in the past papers are few. This is because, with time, resources have increased to help students gain knowledge and information easily. The sources of interruption in academics of students have also increased such as social media and smartphone. Such distraction can lower the performance of a student. Playing fields and outdoor recreation have decreased, especially in developing countries for which students do not get the opportunity for physical activities and outdoor recreation which affects their mental health.

In this research, 10 relative parameters have been introduced to determine the academic performance of a student. The consistency of students has also been determined using k-means algorithm. This is done by establishing six different parameters, such as, grade point of Secondary School Assessment (S.S.C), average grade point of Higher Secondary School Assessment (H.S.C), grade point of the last three semesters completed and the current cumulative grade point average of the students.

The aim of this work is to provide a system to student and academicians to evaluate the academic performance and consistency by their own.

For the determination of the academic performance, 50 rules have been developed which are based on real life scenarios. 50 rules are established using the FIS system. Moreover, the dataset is trained using 10 inputs and one output from which the academic performance is obtained. The resultant academic performance from the FIS and ANFIS is then compared with one another and, it has been further compared with the actual CGPA of the student. This is done to validate the output of the ANFIS and FIS.

To find the consistency of students, k-means algorithm has been applied. After cluster analysis, different groups of consistent students is found, and then the identical parameters are used again, which are used earlier for analyzing students' performance, to make the proposed research more effective. Hence, we have compared our FIS Method and students' original CGPA with the performance of students having a different level of consistency. This is done, since, according to the proposed method, if a student is found consistent after the cluster analysis, then the student's performance and CGPA should be very good as well. If all these are properly matched, then, we can say that the proposed method in this work, is providing more accurate predictions.

III. Research Methodology

To determine the academic performance and to check the consistency of the students, different steps are taken. At first, data is collected through an online questionnaire and face to face interviews with students. Parameters for both academic performance and academic consistency is established simultaneously. Using the parameters of the academic performance, FIS and ANFIS application have been developed, the FIS has been used to generate rules and in case of the ANFIS, the data set has been trained to provide the academic performance. For the academic consistency, k-means algorithm is used to make clusters of different academic consistency. Fig. 2 provides a flowchart of the steps involved in the methodology.

In the research methodology, the data collected is mentioned in section A. In section B, namely data analysis, the process of establishing parameters for academic performance and consistency are demonstrated. Section C describes the rule generation for the FIS application using tables of data and graph. Section D briefly explains the training of data set obtained for the ANFIS application. K-means clustering is explained in section E, it provides a brief description on measuring the centroid for each input and output, the determination of student cluster and comparison the FIS output with the actual data.

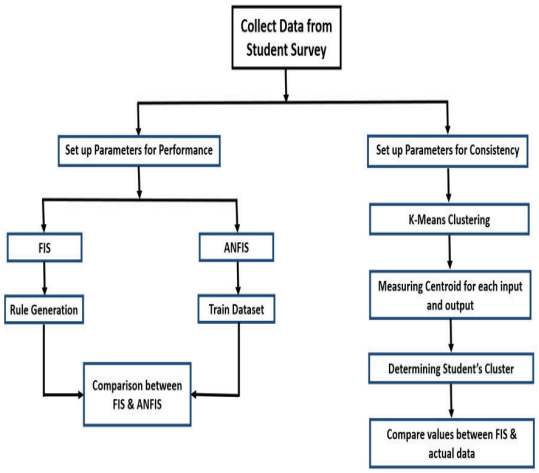

Fig. 2. Flowchart of the research methodology

A. Data Collection

Data collection is required for finding the factors or parameters which could influence the academic performance of the students. Since, the research is done on university students for which the data is collected on the students from the Electrical and Computer Engineering department of North South University, Dhaka, Bangladesh. The data has been collected in two common ways for 170 students. First, we make face to face communication with students to collect information who have completed at least 3 semesters. Secondly, the data is collected by means of online question survey where the answers to each of the question are given in a range of multiple choices from which students could have good flexibility in choosing an option.

In case of academic performance, multiple factors, shown in Fig. 3, had been taken into account, namely, the average attendance of students, the online assistance that students had taken regarding their academic courses, the average number of courses taken by students per semester, the average hours spent in social media and in part time jobs, the number of hours put into studying, the teaching expectation of students, the competency in English of the students, the depression level and the current CGPA of the students. Different factors have been taken into account and they are each given different degrees by means of some value which are named as VERY HIGH, HIGH, MODERATE, LOW and VERY LOW as mentioned in Table-II.

For academic consistency, the results of SSC/O'Level, HSC/A'Level, the GPA of each of the last three semesters and the current CGPA of the student have been considered. Fig. 4 describes the system.

After the completion of the survey, the outputs and the results of each student were recorded in an excel sheet. In the excel sheet, each column indicated the parameters or attributes and the rows held the values of each attribute.

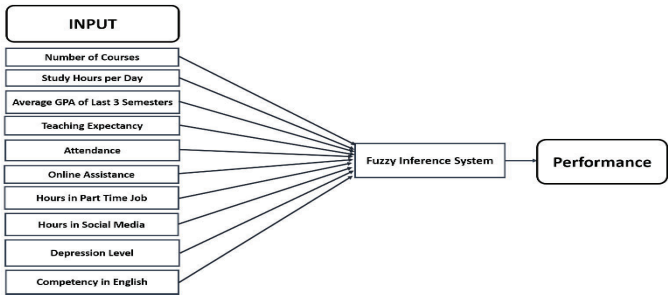

Fig. 3. Factors taken as input for the evaluation of academic performance

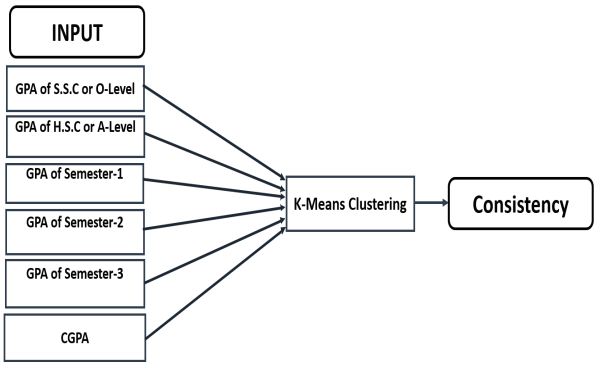

Fig. 4. Mapping inputs for consistency

B. Data Analysis

This step is a follow up of the data collection process. From this process, we identify the factors that have an impact on the student performance and the academic consistency of the student and we try to determine how each factor varies.

The factors or parameters which have been taken into consideration for evaluating the academic performance had gone through the process of data analysis. The number of courses taken in a semester by a student, does have an effect on their grade as it has a direct relation with the pressure of studies and the number of hours for studying increases proportionately. Such parameter also has an impact on the average GPA of the past 3 semesters completed. Moving on, attendance per class, English competency of a student as to how well the student can deliver their work in English and understand the faculty's lecture also, can reflect on their class performance. When students fail to understand a certain topic in class then they can take assistance from the online tutorials which help them in understanding a certain topic. Hours in part job include the time spent in taking private tuition classes of intermediate and elementary level students, running online businesses or freelancing, to earn pocket money. Hours in social media include time spent behind social media like Facebook, Snapchat, Instagram or any other social media applications. The factor, teaching expectancy, means whether the teacher's method of teaching met the expectation of the student of the courses which they had done in the last three semesters. Lastly, the depression level considers the stress level of a student which occurs in a student due to the immense pressure of studies, family issues, romantic or emotional relationships, etc. which affect the mental

state of a person, thereby, the student loses focus and concentration on their academics. Such factors have a direct impact on the result as they all consume time and energy which are the essential items for studying.

Since, it is a norm to evaluate the performance of a student by means of their academic result, in other word, CGPA of an undergraduate student. That is why the academic performance has been scaled from '0.0' to '4.0' according to the CGPA scale.

In case of assessing the academic consistency of a student, fewer factors have been examined in comparison to evaluate the academic performance. The parameters include the GPA of SSC/Ordinary Level, GPA of Higher Secondary school or Advanced level, GPA of the last three semester completed and, the current CGPA of the student. After performing the k-means algorithm, the clusters of different level of consistent students is found. We have tried to take some other factors into consideration to determine consistency such as the number of credits passed so far, the number of GED courses that had been taken for the last 3 semesters etc. But, it is found that if student-A completed 100 credits and has CGPA 3.0 and student-B has completed 50 credits and has CGPA 3.0, the level of consistency is not the same for both students. Since, student B's CGPA may fall after 100 credits. Thereby, that may result in an inaccurate calculation of academic consistency. So, data has been taken from 3rd and 4th year students only who had completed the same number of credit hours.

C. Rule Formation & FIS for Academic Performance

In this step, to build the fuzzy knowledge base mentioned in Fig. 1, 50 "if-then" rules have been generated using the membership values for each of the input parameters (Table-II). The inputs are based on real life scenarios which are normally faced by students.

The rule formation has been done by taking multiple linguistic variables as given in Table II. A student can perform in a certain scenario as given in Fig. 5. We consider five level of output for performance.

TABLE I. LINGUISTIC VARIABLES

VH	VERY HIGH
H	HIGH
VHF	VERY HELPFUL
HF	HELPFUL
M	MODERATE
UHF	UNHELPFUL
L	LOW
VL	VERY LOW
NA	NOT APPLICABLE

TABLE II. LINGUISTIC VARIABLES AND THEIR MEMBERSHIP VALUES FOR FIS

Name of The Inputs	Name of the Linguistic Variables And their Membership Ranges				
Number of Courses	LOW (1,1,2,2)	MODERATE (1.5,2,3,4)	HIGH (3.5,4,5,6)		
Hours of Study/Day	VERY LOW (0,0.5,1.5)	LOW (1,2,2.5)	MODERATE (2,3,3.5)	HIGH (3,4,5)	VERY HIGH (4.5,6,8)
Average GPA of last 3 semesters	VERY LOW (1,1.5,2)	LOW (2,2.25,2.5)	MODERATE (2.4,2.7,3)	HIGH (3,3.25,3.5)	VERY HIGH (3.5,3.75,4)
Teaching Expectancy	LOW (0,1,2,4)	MODERATE (3,4.5,6)	HIGH (5,6,8,10)		
Attendance	VERY LOW (0.5,0.55,0.6)	LOW (0.6,0.65,0.7)	MODERATE (0.65,0.7,0.75)	HIGH (0.7,0.75,0.8)	VERY HIGH (0.8,0.9,0.95,1)
Online Assistance	UNHELPFUL (0,1.5,3)	HELPFUL (3,4,6)	VERY HELPFUL (5,7,8.5,10)		
Hours in Part Time Job/Week	VERY LOW (0,1.5,2.5,4)	LOW (3,4.5,5.5,7)	MODERATE (7,9.5,10.5,12)	HIGH (12,13.5,14.5,16)	VERY HIGH (0.8,0.9,0.95,1)
Hours in Social Media/Day	LOW (0,1.5,3)	MODERATE (3,3.5,4.5,5)	HIGH (5,6.5,8)		
Depression Level	LOW (0,0.5,1,2)	MODERATE (2,2.5,3)	HIGH (3,3.5,4,5)		
Competency in English	VERY LOW (0,1.5,3)	LOW (3,4,5)	MODERATE (5,5.8,6.5)	HIGH (6.5,7,7.5)	VERY HIGH (7.5,8.5,10)

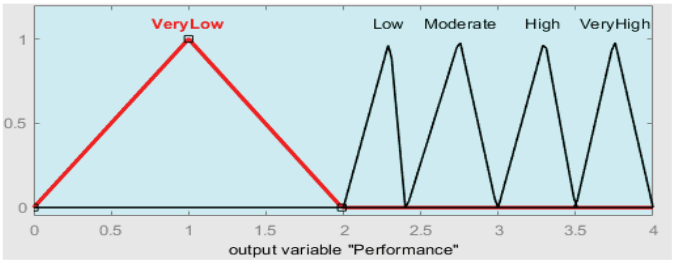

Fig. 5. Output membership function in FIS

For the rule formation, real life cases are taken into account. Some of the rules are given as below:

I. If number of courses were L, the number of study hours is L, average GPA is L, Teaching Expectation is M, attendance is M, online assistance is HF, Hours spent behind part-time job is M, hours spent behind social media is L, the depression level is L, the English competency is M THEN performance is L

II. If number of courses were L, the number of study hours is M, average GPA is L, Teaching Expectation is M, attendance is H, online assistance is HF, Hours spent behind part-time job is VL, hours spent behind social media is L, the depression level is L, the English competency is M THEN performance is M

III. If number of courses were L, the number of study hours is H, average GPA is M, Teaching Expectation is M, attendance is H, online assistance is VHF, Hours spent behind part-time job is VL, hours spent behind social media is L, the depression level is L, the English competency is M THEN performance is H

IV. If number of courses were L, the number of study hours is VH, average GPA is H, Teaching Expectation is H, attendance is VH, online assistance is HF, Hours spent behind part-time job is L, hours spent behind social media is M, the depression level is M, the English competency is H THEN performance is H

V. If number of courses were L, the number of study hours is VL, average GPA is VH, Teaching Expectation is H, attendance is H, online assistance is VHF, Hours spent behind part-time job is M, hours spent behind social media is M, the depression level is L, the English competency is VH THEN performance is VH

VI. If number of courses were L, the number of study hours is VH, average GPA is H, Teaching Expectation is H, attendance is VH, online assistance is VHF, Hours spent behind part-time job is L, hours spent behind social media is L, the depression level is M, the English competency is H THEN performance is VH

VII. If number of courses were L, the number of study hours is M, average GPA is M, Teaching Expectation is L, attendance is M, online assistance is NA, Hours spent behind part-time job is M, hours spent behind social media is M, the depression level is M, the English competency is M THEN performance is L

VIII. If number of courses were L, the number of study hours is M, average GPA is M, Teaching Expectation is M, attendance is VH, online assistance is HF, Hours spent behind part-time job is VL, hours spent behind social media is M, the depression level is H, the English competency is M THEN performance is M

IX. If number of courses were L, the number of study hours is H, average GPA is H, Teaching Expectation is M, attendance is H, online assistance is VHF, Hours spent behind part-time job is VL, hours spent behind social media is M, the depression level is M, the English competency is M THEN performance is VH

X. If number of courses were L, the number of study hours is VH, average GPA is H, Teaching Expectation is H, attendance is H, online assistance is HF, Hours spent behind part-time job is M, hours spent behind social media is M, the depression level is L, the English competency is M THEN performance is VH

The result from the application of FIS is the determination of the student performance based on the rules loaded into the system, i.e, in the FIS editor. With the assistance of the rules, it produces the academic performance. In order to find the authenticity of the performance, it is then compared with the actual CGPA of the student.

As for the FIS application, 50 rules have been generated which are added into the FIS editor. The result of the rules has been seen in a surface view manner (Fig. 6).

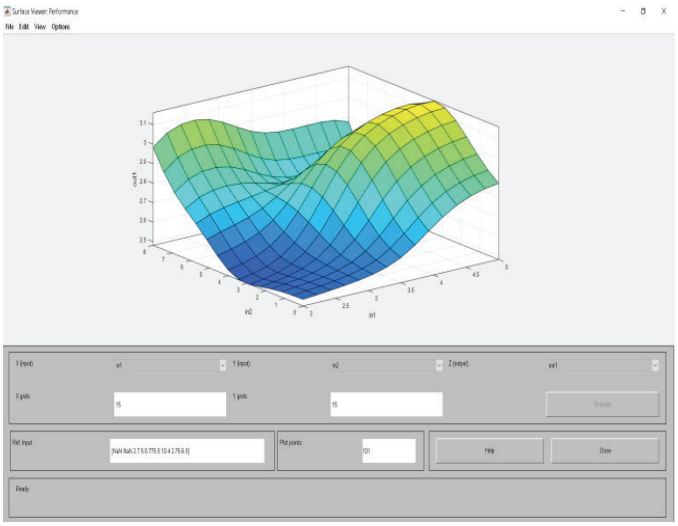

Fig. 6. Surface View for FIS on Academic Performance

D. ANFIS for Academic Performance

In the ANFIS editor, 170 dataset is loaded, where, each of which has 10 input parameters. Based on this dataset, the ANFIS tool generates rules and an output.

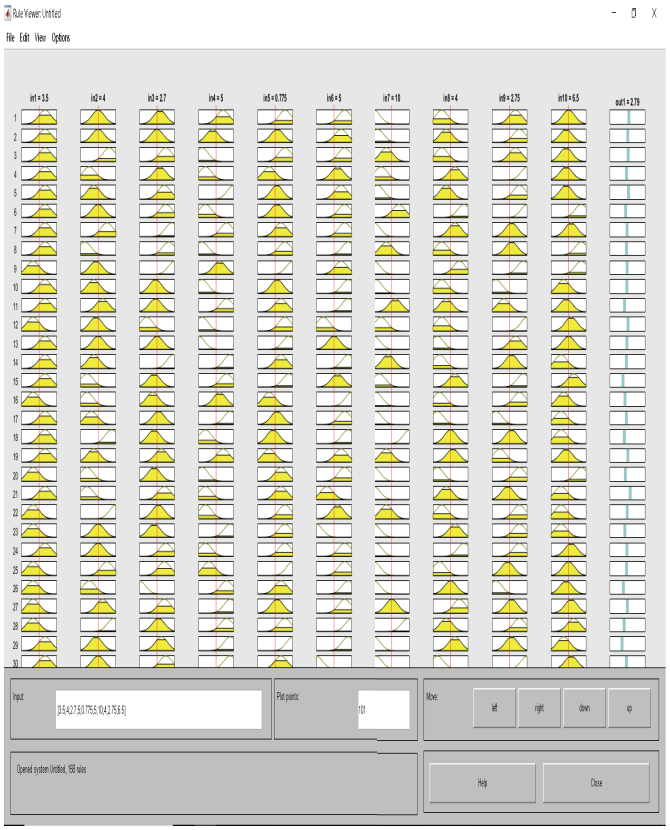

Fig. 7. Rule View of ANFIS for Academic Performance

Fig. 7 represents the output "Performance" of a particular student.

E. K-Means Algorithm applied for Consistency

The correct choice of k in the K-Means is often ambiguous. Moreover, the errors in the resulting cluster depends on the value of k where a rate change of k without any penalization could increase the number of clusters. It is nearly impossible to find out the zero error, but when a zero error occurs every data point will be an individual cluster. In [7] the authors used 'Mean Squared Error' formula to determine the value of k for making a cluster of students with a good, fair, and very good result based on their one semester grades.

In our case, to define the optimal value of k the 'Elbow Method' [9] has been used. This method describes the number of clusters on the basis of the ratio of variance. More precisely, by plotting the ratio of variance against the number of clusters on a graph, the primary cluster will include significantly more data but at certain point, the minimal pick will drop and it will give an edge. However, "elbow" cannot always be recognized unambiguously.

It is found that in this case after k=7 variance, it does not vary to a great extent. Therefore, 7 clusters have been made using the academic result of 170 students as shown in Table III.

TABLE III. DATA FOR THE K-MEANS ALGORITHM

Original coordinates		
Cluster	Number of Students	Average Distance
Cluster-1	17	19.5281977
Cluster-2	16	32.7180065
Cluster-3	29	39.9906157
Cluster-4	31	22.3361215
Cluster-5	31	18.7276023
Cluster-6	41	22.0384618
Cluster-7	5	20.4389154
Overall	170	25.2584839

The column 'Number of Students', of Table III, respresents the number of students that belong to different clusters, e.g., to Cluster-1, Cluster-2 and so on. The column, 'Average Distance', represents the distances btween the centroid and the the points that belong to the cluster.

IV. RESULT ANALYSIS

A. Comparison between ANFIS and FIS on Academic Performance

To compare the academic performance of a student using ANFIS and FIS application, the data is loaded into the ANFIS editor. In the ANFIS editor, the training file contains the data on which sub-clustering has taken place. After 8 epoch (iterations) on the data loaded, it gives an error of 0.000001. From this error value, it can be concluded that the training of the ANFIS is optimum and the output that will result from the ANFIS application will be almost accurate.

TABLE IV. COMPARISON OF FIS AND ANFIS

Student No	Number of Courses	Hours of Study/Day	Average GPA of Last 3 Semesters	Teaching Expectation	Attendance	Online Assistance	Hours in Part Time Job/Week	Hours in Social Media/Day	Depression Level	Competency in English	Performance in FIS	Performance in ANFIS	Actual CGPA of that Student
1	3	7	2.15	8	0.9	8	0	2	2.5	7.5	2.25556	2.3	2.3
2	4	1.5	2.7	6	0.9	7	1	4	4	6	2.83217	2.89	2.89
3	5	6.5	2.8	10	0.85	8	20	5	4	6	2.53215	2.56	2.56
4	2	2	3.7	2	0.85	7	0	1	3.5	7	3.54253	3.5	3.5
5	2	6.5	2	2	0.8	10	6	6	3	5	2.05632	2.06	2.06
6	4	1.5	3.7	2	0.9	2	9	3	4	6	3.71	3.68	3.68
7	5	3.5	2.9	3	1	8	16	8	3	8	3.135	3.1	3.1
8	3	2	1.5	8	0.85	9	0	4	1	6	1.8269	1.78	1.78
9	4	1.5	2.5	8	0.95	6	3	5	4.5	7.5	2.3729	2.37	2.37
10	5	4.5	2	7	0.9	1	0	1	3.5	5.5	3.0234	3.04	3.04

In Table IV, data of 10 students can be seen where each student has values for 10 inputs. Both the output from the FIS application and the ANFIS application is compared with the actual CGPA.

ANFIS generates the output using the SUGENO implication, thereby, the output is computationally efficient. On the other hand, the FIS application is generating the output using the MAMDANI-Min implication. That is why the output of the FIS application is intuitive. But both FIS and ANFIS produce an output that is close to the actual output.

For instance, Student-8 in Table IV is already in probation which means that student-8 has an 'Average GPA of last 3 semesters' is 1.5, but the student had taken 3 courses in that semester, although enough help had been taken from teachers and online resources but, due to the lack of hours spent behind studies per day and because moderate number of courses had been taken, the performance did not improve that much which can be seen from his 'Actual CGPA'. This FIS system also yields similar output from its knowledge base. Therefore, if that student has a desire to improve his performance, then it can be checked by varying the numerical values of the other input variable to see which combination of input variables matches the expected performance.

The Sugeno implication method could have been used for the rule generation in the FIS application. However, as it is known that the Mamdani-min implication is more suited for human-input values; that is why the FIS application has been used in this system.

B. Finding the Consistency

The clusters of different types of consistent and inconsistent students are found in this research. The consistency is then compared with the performance of a student found using the FIS/ANFIS application developed in this work and the actual performance obtained from the CGPA of the student.

TABLE V. CLUSTERS OF DIFFERENT TYPES OF CONSISTENT STUDENTS

Cluster	SSC	HSC	GPA-1	GPA-2	GPA-3	CGPA
Cluster-1	4.976470588	4.911764706	3.588235294	3.552941	3.624118	3.611176
Cluster-2	4.855625	3.715	2.975	3.05	3.03125	2.973125
Cluster-3	4.906551724	4.68	2.351724138	2.282759	2.37069	2.312069
Cluster-4	4.986129032	4.936774194	3.409677419	3.422581	3.454839	3.376774
Cluster-5	4.962741935	4.948387097	2.841935484	3.503226	2.927097	2.780645
Cluster-6	4.969512195	4.913902439	2.968292683	2.890244	2.936585	2.897805
Cluster-7	4.08	3.28	2.8	2.78	3.01	2.74

Table V represents the centroid for each input provided. Now, if there is a new student with all six previous information, then Euclidean distance of information of the new student to other cluster's centroid will be measured and the student will be assigned to the cluster with minimum centroid distance.

TABLE VI. SHOWING CLUSTERS OF EACH INDIVIDUAL STUDENT

Cluster ID	Student No	SSC	HSC	GPA-1	GPA-2	GPA-3	CGPA
3	1	4.94	4.9	2.1	2.1	2.1	2.3
5	2	5	5	2.5	2.1	2.6	2.3
5	3	5	5	3.1	2.8	3	3
5	4	4.63	4.7	2.4	2.5	2.6	2.6
5	5	5	4.9	2.8	3.2	3.6	2.92
4	6	5	5	3.6	3.5	3.5	3.66
3	7	5	4.2	2.3	2.3	2.55	2.5
5	8	5	4.8	2.5	3.2	2.6	3.02
4	9	5	5	3.6	3.7	3.3	3.67
3	10	5	5	1.7	1.9	1.8	2.5
5	11	5	5	2.7	3	3.2	3
5	12	5	5	3.1	2.9	3	3.1
5	13	5	5	3.2	2.7	3	3.08
4	14	5	5	3.3	3.3	3.65	3.43
5	15	4.75	5	2.8	2.6	2.7	2.7
5	16	4.81	5	2.7	2.3	3.15	2.78
5	17	5	5	2.9	3.2	2.65	2.97
5	18	5	5	2.5	2.9	3	2.89
4	19	5	5	3.1	3.2	3.7	3.1
4	20	5	5	3.6	3.7	3.65	3.61
5	21	5	5	2.8	2.9	2.9	2.31
4	22	5	4.9	3.3	3.4	3.3	3.46
4	23	5	4.9	3.4	3.2	3.2	3.02
5	24	5	5	2.5	2.6	2.5	2.5
4	25	5	5	3.3	3.3	3.3	3.71
3	75	5	4.5	2.9	2.4	2.6	2.59
1	145	5	5	3.3	3.7	3.6	3.51

By applying the k -means clustering algorithm, with a value of k=7, it is found in Table III, that number of students is 17 and 31 in cluster 1 and 4 respectively.Cluster-1 and cluster-4 represent "Very Consistent Students". In cluster-2 and cluster-6, there are 16 students and 41 students respectively, that fall among the clusters of "Consistent Students". Cluster-3 contains 29 students, Cluster-5 consist of 31 students and Cluster-7 has 5 students. Those three clusters have "Inconsistent Students".

Table VI represents the clusters to which each student belongs to, which has been obtained by running the k-means algorithm on the academic results of 170 students. To give an example, it has been previously determined that cluster 3, 5 and 7 belong to inconsistent students. In Table VI Student number-15 has a GPA of 4.75,5, 2.8 ,2.6, 2.7 in S.S.C, H.S.C, SEM-1, SEM-2, SEM-3 respectively and CGPA 2.7. Thereby, that student should be found in any of the inconsistent clusters. In Table VI it is found that Student number-15 belongs to Cluster-5 which has already been determined after implementing the k-means algorithm that Cluster-5 belongs to inconsistent students.

Data from random students are then selected from different clusters. This is done to check if a student is found in either of the clusters namely, 'Very Consistent', 'Consistent' or 'Inconsistent Cluster'. Then we figure out as to what will be his performance in FIS/ANFIS.

TABLE VII. VALIDATING OUR FIS BY COMPARING CONSISTENT AND INCONSISTENT STUDENTS' DATA

Student belongs from which cluster	Centroid of 3 Semesters GPA			Actual GPA of 3 Semesters			Centroid of CGPA	Result in Our Method	Actual CGPA
	GPA-1	GPA-2	GPA-3	GPA-1	GPA-2	GPA-3			
1	3.588235	3.552941	3.624118	3.3	3.7	3.6	3.61117	3.5023	3.51
2	2.975	3.05	3.03125	2.9	3.8	2.6	2.973125	2.68796	2.7
3	2.3517	2.28275	2.370689	2	2.3	2.6	2.3120689	2.3158	2.29
4	3.409677	3.422580	3.4548387	3	3.2	3.4	3.37677	3.2001	3.11
5	2.841935	3.503225	2.92709	3	3.2	3.2	2.780645	3.01587	3
6	2.96829	2.89024	2.936585	3.4	3.2	3.4	2.8978	2.394562	2.4
7	2.8	2.78	3.01	2.9	2.7	2.7	2.74	2.7582	2.68

From Table V it is found that Student number-145 belongs to Cluster-1, which is labelled as "Very Consistent". As a result, Student number-145 should have a performance as 'HIGH' or 'VERY HIGH' according to this method. Eventually, the inputs of that student has been loaded in the system and it is found that the output comes to 3.5023 which falls into "VERY HIGH" range in this method as shown in Fig. 5. The result has also been compared to the actual CGPA of the student to check the authenticity.

Similarly, student number-75 from Table-6, has the following results in his S.S.C, H.S.C, GPA in 3rd to last semester, GPA in 2nd to last semester and last semester, 4.94, 4.47,1.9, 1.73,1.9 respectively. His current CGPA is 1.98. In our cluster analysis, he falls into cluster no-3 which has been defined before as "Inconsistent" cluster by analyzing centroid values for all the inputs in Table VII. Now, his given values has been entered for our FIS method. Though his number of courses are LOW, Attendance is MODERATE, he does not have any part time job, but, his other parameters do not fall on parts. That is why his CGPA is 1.93 and his performance in our method is 1.9523 which we have delimited as Very Low performance.

Thus, also from this approach, it is found that the proposed system is useful as its outcome equals the expected result.

V. CONCLUSION AND FUTURE WORK

Students can use this application to easily determine their performance and consistency. They will be able to understand the factors that could affect their academic consistency and performance. Students will be able to comprehend as to which

factors they need to improve to enhance their performance or consistency or both. Academicians and parents can also use this application as a guidance for themselves. They can use this application to help their kids and students to perform better in their studies and keep them in good consistency level. Teachers and parents will be able to understand as to which factors they need to emphasize for the betterment of their students and children. It can also be used to improve the education system by enhancing the quality of the factors mentioned in the application and help them to come up with better ideas to improve the education sector in a country or institution.

We have made a two-way approach using several factors to make sure our proposed Fuzzy Inference System is predicting a student's performance and consistency accurately. Though we have tried to cover all the useful parameters, however, there are still some parameters such as relationship status, the parental guidance should have been taken into consideration. Although data for such parameters are difficult to obtain as they are considered as personal information and people in general, feel uncomfortable to disclose such information. However, such factors are important for students, parents and academicians.

Even though, this system evaluates a student based on our specified education system, it can be used on any other university or college student as well.

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