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Fuzzified System for Learner Behavior Analysis

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Abstract: Identification of learning behavior is an important challenge in the education system. Learning behavior depends on many factors like learner's interest, skill, hobbies, perception, attitude, aptitude and emotions etc. It is a dynamic parameter in the learning environment. Analysis of learning behavior helps for selecting teaching pedagogy as per learner's need and interest. To develop a personalized e-learning system it is crucial to identify the learning behavior of learners to provide the best learning experience. Through this research, we develop a fuzzified system for learner's behavior analysis. The performance of the system is analyzed using an artificial neural network.

Keywords: AI, E-learning, FCM, Machine Learning, Rule Based System.

Abbreviations: FCM: Fuzzy Cognitive Map, AI: Artificial Intelligence, ROC: Receiver operating characteristic.

I. INTRODUCTION

Artificial intelligence means specially developed intelligent machine or computer system which learn from experience. It is technique to solve complex problem without explicitly program. With the AI implementation we can develop machine which can think, work and react like human being. It is simulation process include learning, reasoning and intelligent decision making. AI based software are developed which having simulation, perception, learning, decision making, reasoning and knowledge representation capabilities.

Earlier researchers suggest theoretical approach for personalize e-learning system to improve learner performance. Study mainly focus on importance of student behavior analysis in classroom learning and teaching methodology. Where as in intelligent e-learning system are developed without considering their learning behavior which is the important factor in any e-learning systems [8]. Expert system based techniques are used for personalize education. Machine learning algorithms are used for identify ability of learner but no interactive system is developed to teach learner as per his/her ability and interest [9]. According to literature review AI system is able to adapt individual learning related requirements of a student. It can help to build meaningful learning experience for the students [12].

AI based grading and student knowledge assessment techniques help to save teachers time and getting accurate results. AI based Adaptive learning system helps to identify students learning requirements, more focus on specific important topic, repetitions of the concepts which students not understood or having confusion among concepts [10]. AI helps learner to bridge learning gap and acquire knowledge from his/her own peace [14]. AI helps to monitor student progress. AI-based systems are significantly changed its way of information interaction and integration so in future role of teacher will be changed [1]. Fuzzy system, Neural Network, Genetic algorithm and deep learning are some AI based techniques for solving complex problems [11].

II. LITERATURE REVIEW

Adaptive Neuro-Fuzzy inference system useful for providing e-learning material as per learner's need and knowledge level. Ontology based e-learning system to design concept and determine relationship between concepts by implementing Fuzzy Cognitive Map technique. Different linguistic variables are used to categorize learner as per their knowledge level [4]. Uncertainty in learning style of learner is identifying using fuzzy logic. Researchers evaluate learner style by analyzing learners profile information and web interface parameters. Fuzzy rules are designed on parameters and Fuzzy inference engine along with Gaussian membership function is used to categorized learner into active, medium active, medium reflective and reflective. Applicability of model is tested on various e-learning environments [5]. AI techniques helps for data driven analysis for decision making. Adaptive learning approach is used to recommend different learning modules as per learners' requirement. Fuzzy Rules are designed to decide appropriate course for learner as per their domain knowledge and skill set prediction by analyzing learner's database [6]. Fuzzy based machine learning system is implemented using association rule mining to identify learning style of learner. Apriori algorithm is implemented to identify knowledge level of learners with respect to learning object complexity level and learners knowledge [7].

III. OBJECTIVES

1. Development of fuzzy rule based system for identification of learning behavior of learner.
2. Testing accuracy of system using Artificial Neural Network.

Fuzzy System: There are some problems where we can't decide exact solution with value as true or false. To handle such a situations or problems fuzzy system is useful. Fuzzy system is a mathematical techniques which gives output between 0 and 1. Fuzzy logic works on level of possibilities of input to achieve definite output. Fuzzy logic based system can work on imprecise, distorted and noisy data [2]. Fuzzy logic is gives new intuitive approach without the extensive complexity. Fuzzy logic is based on human communication and based on quantitative approach used in daily language, so it is very easy to use and understand [3].

Fuzzy logic is a computing technique which is based on amount of truth rather than the binary result true or false (1 or 0) on which the modern computer is based. Concept of Fuzzy logic based on fuzzy set theory. It was originally developed from infinite-valued logic. Thus there is correspondence between classical logic and fuzzy logic concepts. In fuzzy logic we deals with linguistic variables and linguistic modifiers. Fuzzy rule based system is an expression of type IF (antecedent) THEN (consequent). A system which represent knowledge using such rules is called as rule-based system.

IV. COMPONENTS OF RULE- BASED SYSTEM

Working Memory: It consist of facts about a domain. These facts are considered while generating rule base. It is storage medium for rule base.

Rule Base: It stores several IF-THEN rules based on working memory. Conflict resolution policies are used for selection of appropriate rule. Conflict resolution policies like data ordering, specificity, and refractoriness of data as well as some data mining techniques like association, clustering techniques are used for creating rule based [13]. It is iterative process works until getting expected results.

Inference Engine: It is the process of generating new information from rule based system and working memory to solve specific problem.

Fuzzification: It is process of making a crisp set to fuzzy. To handle uncertainty, imprecision, ambiguity or vagueness of the variable is probably fuzzy and represented by a membership function.

Defuzzification: It is inverse process of fuzzification. It help to reduce fuzzy set to crisp single valued result, converting fuzzy matrix to crisp matrix and making fuzzy member to the crisp member. There are several defuzzification methods like centroid method, max membership method, weighted average method, mean-max membership, center of sum, center of largest area, maxima etc.

V. RESEARCH METHODOLOGY

Basically learning behavior is categorized as slow learner and fast learner. We can identify learning behavior by judging learners performance in reading, listening, aptitude, remembering capacity, hobbies, interest, study methodology etc.

(a) Data collection: Learners data is collected using Moodle online portal. Total 60 IIIrd year UG students of computer science/application are consider as sample for this research. Learner's database is created by using following modules.

– Personal Information: Learners data is collected using online questionnaire to collect demographic information like name, age, gender, Xth, XIIth, Ist year, IInd year percentage, Number of backlogs, attendance percentage, study material, total study hours in a week etc.

– E-Reading: Text material is provided on online portal allow student to read carefully. MCQ test is provided to identify reading score of learner.

– E-Listening: Audio/Video lecture is provided on online portal and allow student to listen carefully. Restrict student to attempt MCQ test to identify listening score.

– Aptitude: Online test is provided to identify score of aptitude test.

(b) Data Preprocessing: Learners Data is extracted from .csv file. Ms-Excel macros are used for data cleaning and preprocessing.

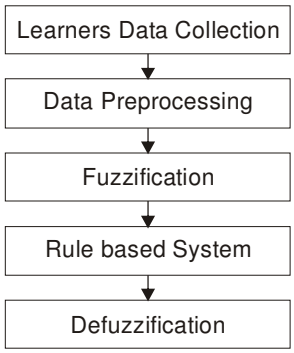

Fig. 1. Proposed fuzzified Rule Based System.

(c) Decision support system using Fuzzy Mamdani Approach: Fuzzy inference system is a popular technique based on fuzzy set theory. Working memory stores all fact related to input. IF-THEN rules are designed to drive conclusion from facts.

(d) FIS Design: Basic fuzzy design consist of components a rule base, comprising fuzzy rules, a database which defines fuzzy rules, reasoning mechanism that performs inference procedure. FIS is design from learners academic information and test score etc.

Fuzzy Rule Based System is designed for learners using Mamdani Approach. Here researcher consider ten inputs as X, XII, Ist year_percentage, IInd year_percentage, No_of_Backlogs, Attendance, Study Hours, TestI, TestII, TestIII etc. According to learning behavior output is divided into two classes as slow learner and fast learner. Input variables and respective membership functions shown in following Fig. 2.

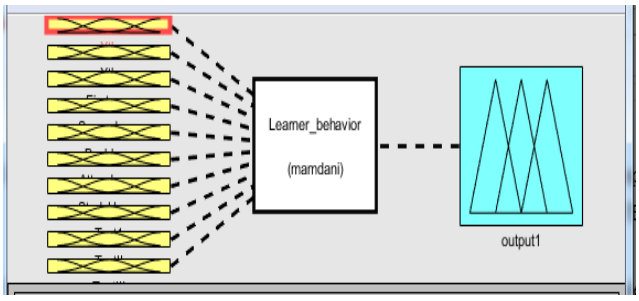

Fig. 2. Input Variables- Membership Functions.

Since the trade-off between simplicity and concept capture ability is quite good, triangular membership function is used in the present work. The knowledge conceived from professors with more than 5 years of experience in teaching field. Result of K-means algorithm and expert's knowledge is used to build the Fuzzy inference rules of DSS. The knowledge base contains a Database and a Rule base. The data-base provides the essential data for fuzzification, rule-base and defuzzification modules. It comprises the membership functions representing meanings of linguistic values of input and output variables in addition to labels, shapes and domain-ranges.

Input variables X^{th} Marks and XII^{th} Marks with four membership functions Average, Good, Very good, Excellent are shown in following Fig. 3 and 4 respectively, whereas details ranges are mentioned in Table 2.

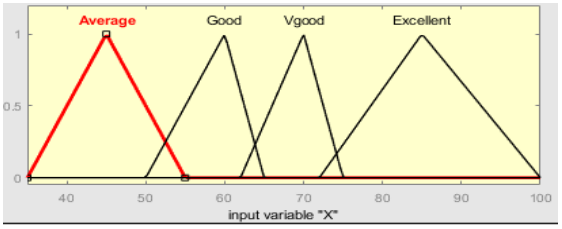

Fig. 3. Input Variable: X^{th} Marks.

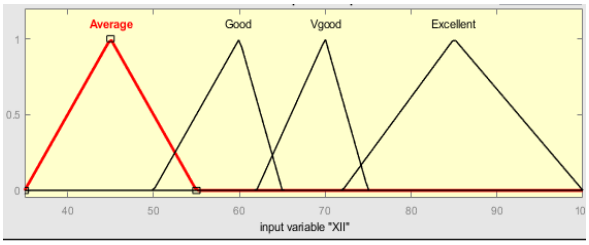

Fig. 4. Input Variable: XII^{th} Marks.

Input variables I^{st} Year Marks and II^{nd} Year Marks with four membership functions Average, Good, Vgood, Excellent are shown in following Figs. 5 and 6 respectively, whereas details ranges are mentioned in Table 3.

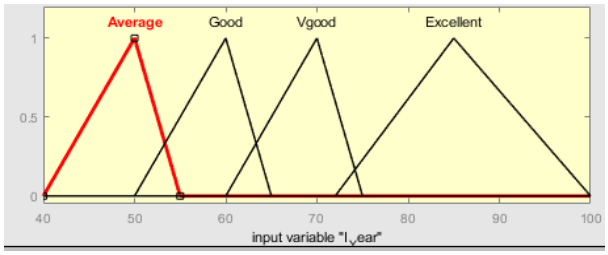

Fig. 5. Input Variable: I^{st} Year Marks.

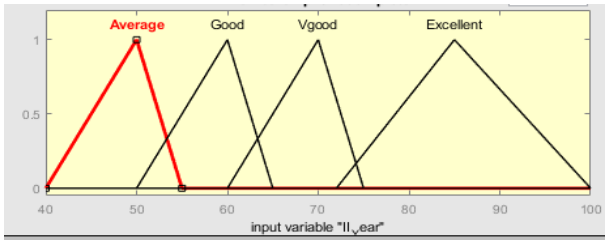

Fig. 6 Input Variable: II^{st} Year Marks.

Input variable Backlogs with three membership functions Very good, Good, Average are shown in following Fig. 7 whereas details ranges are mentioned in Table 4.

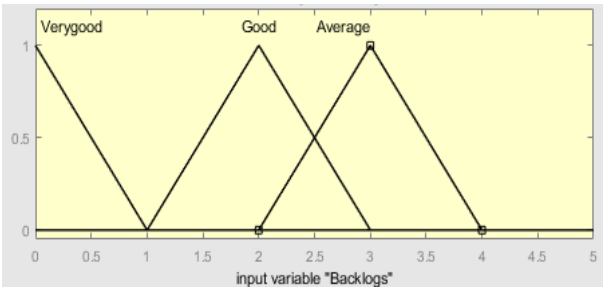

Fig. 7. Input Variable: Backlogs.

Input variable Attendance with three membership functions Low, Medium, High are shown in following Fig. 8 whereas details ranges are mentioned in Table 5.

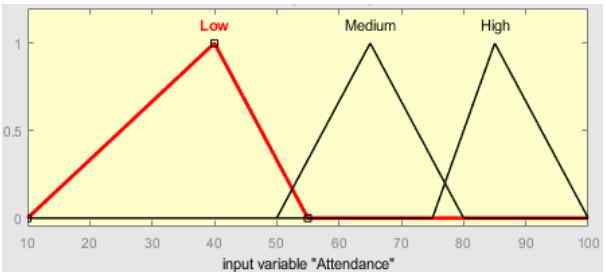

Fig. 8. Input Variable: Attendance.

Input variable Study Hours with three membership functions Less, Medium, High are shown in following Fig. 9 whereas details ranges are mentioned in Table 6.

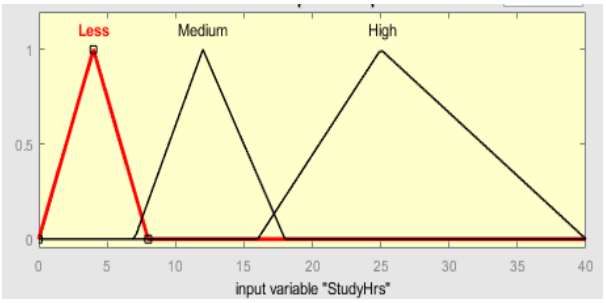

Fig. 9. Input Variable: Study Hours.

Input variables Test I, II, III with four membership functions Average, Good, Very Good and Excellent are shown in following Figs. 10, 11, 12 respectively whereas details ranges are mentioned in Table 7 .

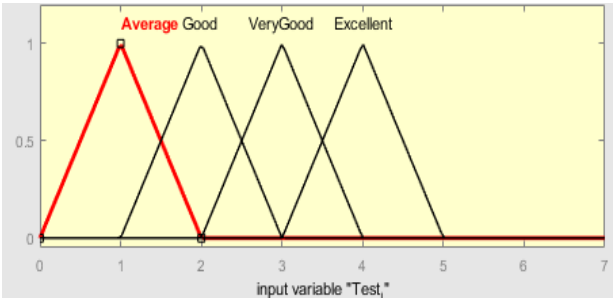

Fig. 10. Input Variable: Test I.

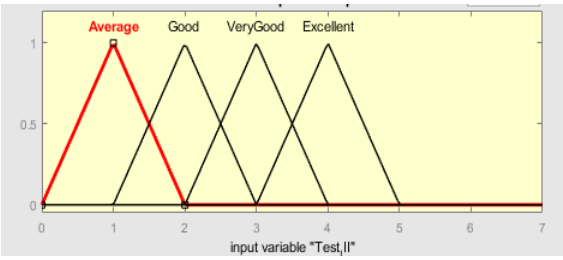

Fig. 11. Input Variable: Test II.

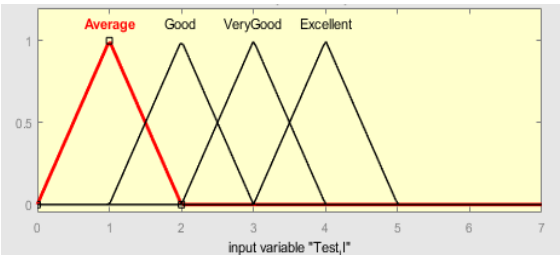

Fig. 12. Input Variable: Test III.

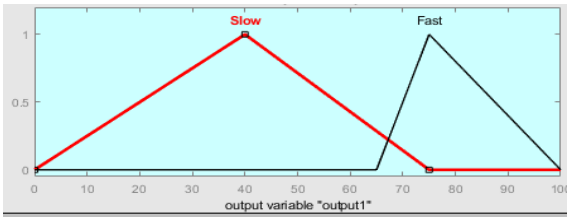

Fig. 13. Output Variable: Learner Type.

Table 1: Input and Output Variables.

S. No.	Variable Type	Name of Variable	Range of Variable	No. of Membership Functions
1.	Input	X^{th}	35 to 100	4
2.	Input	XII^{th}	35 to 100	4
3.	Input	I^{st} Year	40 to 100	4
4.	Input	II^{nd} Year	40 to 100	4
5.	Input	Backlogs	0 to 5	3
6.	Input	Attendance	10 to 100	3
7.	Input	StudyHours	0 to 40	3
8.	Input	Test I	0 to 7	4
9.	Input	Test II	0 to 7	4
10.	Input	Test III	0 to 7	4
11.	Output	Learner Type	0 to 100	2

Table 2: Membership function for Input X^{th} and XII^{th} marks.

Name of the Input Variable	Membership Functions	Ranges
X^{th} Marks and XII^{th} Marks	$\mu_{Average(x)}$	x<=35, 0 (x-35)/45-35, 35<x<45 (55-x)/55-45, 45<x<55 x>=55, 0
	$\mu_{Good(x)}$	x<=50, 0 (x-50)/60-50, 50<x<60 (65-x)/65-60, 60<x<65 x>=65, 0
	$\mu_{VeryGood(x)}$	x<=62, 0 (x-62)/70-62, 62<x<70 (75-x)/75-70, 70<x<75 x>=75, 0
	$\mu_{Excellent(x)}$	x<=72, 0 (x-72)/85-72, 72<x<85 (100-x)/100-85, 85<x<100 X=100, 0

Table 3: Membership function for Input I^{st} and II^{nd} year marks.

Name of the Input Variable	Membership Functions	Ranges
I^{st}Year Marks and II^{nd}Year Marks	$\mu_{Average(x)}$	x<=40, 0 (x-50)/50-40, 40<x<50 (55-x)/55-45, 50<x<55 x>=55, 0
	$\mu_{Good(x)}$	x<=50, 0 (x-50)/60-50, 50<x<60 (65-x)/65-60, 60<x<65 x>=65, 0
	$\mu_{Vgood(x)}$	x<=60, 0 (x-60)/70-60, 60<x<70 (75-x)/75-70, 70<x<75 x>=75, 0
	$\mu_{Excellent(x)}$	x<=70, 0 (x-70)/85-70,70<x<85 (100-x)/100-85, 85<x<100 x=100, 0

Table 4: Membership function for Input variable backlogs.

Name of the Input Variable	Membership Functions	Ranges
Backlogs	$\mu_{Verygood(x)}$	x<=-1, 0 (x-0)/0-1, -1<x<0 (1-x)/1-0, 0<x<1 X = 1, 0
	$\mu_{Good(x)}$	x<=1, 0 (x-1)/2-1, 1<x<2 (3-x)/3-2, 2<x<3 x>=3, 0
	$\mu_{Average(x)}$	x<=2, 0 (x-3)/3-2, 2<x<3 (4-x)/4-3, 3<x<4 x>=4 ,0

Table 5: Membership function for Input variable Attendance.

Name of the Input Variable	Membership Functions	Ranges
Attendance	$\mu_{Low(x)}$	x<=10, 0 (x-10)/40-10, 10<x<40 (40-x)/55-0, 40<x<55 x>=55, 0
	$\mu_{Medium(x)}$	x<=50, 0 (x-50)/65-50, 50<x<65 (80-x)/80-65, 65<x<80 x>=80, 0
	$\mu_{High(x)}$	x<=75, 0 (x-85)/85-75, 75<x<85 (100-x)/100-85, 85<x<100 X = 100, 0

Table 6: Membership function for Input variable Study Hours.

Name of the Input Variable	Membership Functions	Ranges
Study Hours	$\mu_{Less(x)}$	x<=0, 0 (x-4)/4-0, 0<x<4 (8-x)/8-4, 4<x<8 x>=8, 0
	$\mu_{Medium(x)}$	x<=7, 0 (x-12)/12-7, 7<x<12 (18-x)/18-12, 12<x<18 x>=18, 0
	$\mu_{High(x)}$	x<=16, 0 (x-25)/25-16, 16<x<25 (40-x)/400-2, 25<x<40 X = 40, 0

Table 7: Membership function for Input variable Test I, II and III.

Name of the Input Variable	Membership Functions	Ranges
Test I, II and III	$\mu_{Average(x)}$	x<=0, 0 (x-1)/1-0, 0<x<1 (2-x)/2-1, 1<x<2 x>=2, 0
	$\mu_{Good(x)}$	x<=1, 0 (x-2)/2-1, 1<x<2 (3-x)/3-2, 2<x<3 x>=3, 0
	$\mu_{VeryGood(x)}$	x<=2, 0 (x-3)/3-2, 2<x<3 (4-x)/4-3, 3<x<4 x>=4, 0
	$\mu_{Excellent(x)}$	x<=3, 0 (x-4)/4-3, 3<x<4 (5-x)/5-4, 4<x<5 x=5, 0

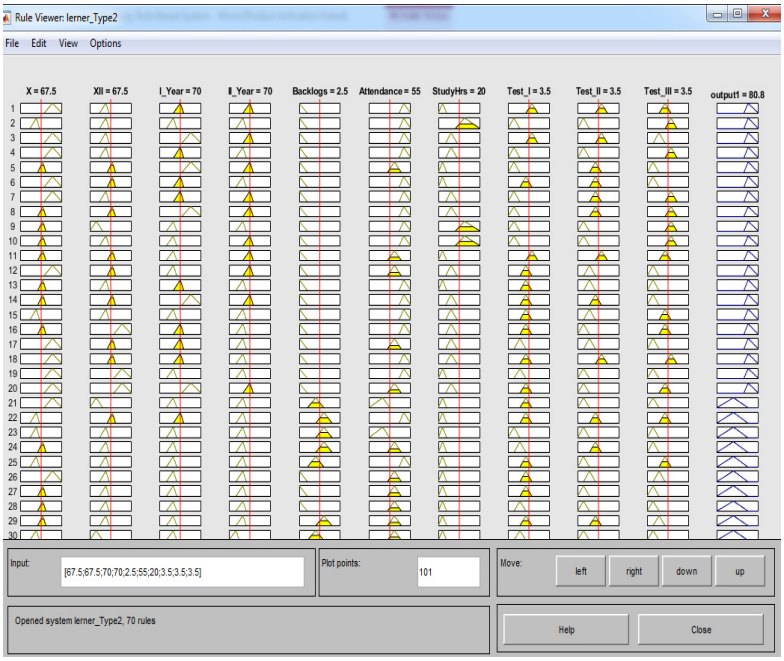

Fig. 14. Fuzzy Rules for learning behavior analysis.

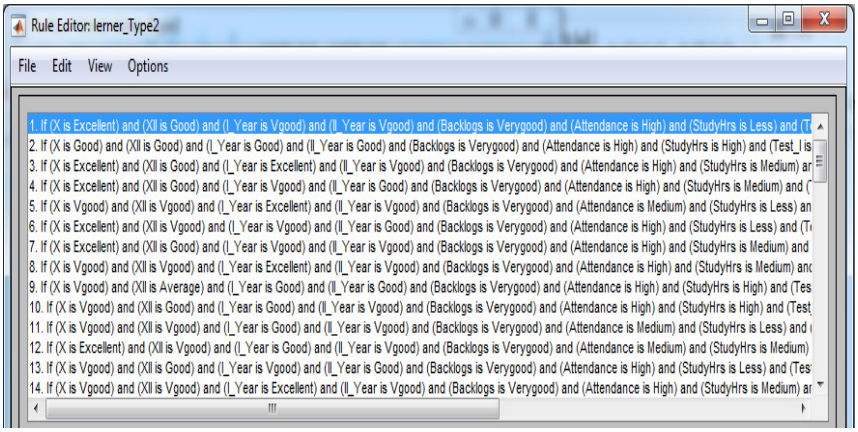

Fig. 15. FIS with 70 rules.

Students categorized into slow and fast learner and result of FIS model shown in following Table 8.

Table 8: Result of FIS Model.

Student Name	Xth	XII	Ist year	IInd year	Backlogs	Attendance	Study hours	T1	T2	T3	Value	Behavior
Aanam Shaikh	76.4	55	65	60	2	94	17	4	2	1	38.33	SLOW
Amar	81	59	72	62	0	75	2	4	4	3	80.00	FAST
Anchali	68.3	55.2	65	64	0	98	34	1	1	4	38.33	SLOW
Anjali	86	58	84	71	0	92	20	4	4	2	80.00	FAST
Apoorva	82	50	73	68	0	75	10	1	1	4	38.33	SLOW
Azeem	75	73	80	75	0	70	5	1	3	1	40.71	SLOW
Hrishikesh	86	76	73	70	0	90	2	3	3	1	81.42	FAST
Manish	79.2	54	69	67	0	80	18	1	3	4	50.00	SLOW
Megha	69	66	75	65	0	82	14	1	3	4	81.69	FAST
Monika	72.92	47.89	65	64	0	92	20	1	1	4	38.33	SLOW
Muskan	65	62	72	70	0	98	16	4	1	3	50.00	SLOW
Pooja	74.8	47	60	59	2	50	1	3	1	1	38.33	SLOW
Prasad	84.83	69.77	74.8	72.3	0	86	6	1	3	1	38.33	SLOW
Pratik	56.45	51.56	58.43	51.23	3	40	1	1	1	1	38.33	SLOW
Utkarsha	69.4	56.4	66	68.2	0	80.2	25	1	1	3	38.33	SLOW
Vishal	56	71	70	61	1	75	3	3	3	3	50.00	SLOW
Ravina	70.8	57	62	59	2	55	4	2	3	1	38.33	SLOW
Gouri	52	59.77	53.45	58	1	74	6	3	1	1	38.33	SLOW

VI. TESTING RESULTS

Two Layer Feed forward Network algorithm with sigmoid activation function is used for testing results generated through fuzzified system. Supervised scaled conjugate gradient Back propagation algorithm is used for training neural network with different number of neurons in hidden layer (corresponding Matlab function is train csg) as shown in following Table 9 and Fig. 16. With 5 hidden neurons, 21 epoch we get of cross entropy performance is 0.0359 and 88.73% accuracy. With 6 hidden neurons, 12 epoch we get cross entropy performance 0.0110 and 87.73% accuracy. With 10 hidden neurons, 40 epoach model is ovefitted.

Accordingly with 10 hidden neurons, 18 epoch we get cross entropy performance 0.00898 and more accuracy. Training process is controlled using Cross Entropy technique based on a random division of the initial set of data in 3 subsets as 70% training dataset, 15% validation and 15% testing dataset. Plot confusion matrix for testing accuracy of output getting from neural network. Following Fig. 17 and 18 shown ROC with confusion matrix respectively with result of training, validation and testing data. Conjugate gradient algorithm with minimal range at epoch 18 which also leads to more accuracy (99.03%) as per confusion matrix that indicating that there is no further training. Following Fig. 19, 20 shown performance of ANN for training, validation and testing data.

Table 9: Performance evaluation of fuzzy model for accuracy using Two Layer Back propagation algorithm.

No. of hidden neurons	Max. Epoch reached at	Cross Entropy (Performance)	Gradient	Confusion Matrix [Accuracy %]			
				Training	Validation	Testing	Average
5	21	0.0359	0.0562	91.2	100	75	88.73
6	12	0.0110	0.0243	88.2	87.5	87.5	87.73
10	40	2.70e-07	6.2833e-07	100	100	62.5	87.50
10	9	0.0120	0.0283	82.4	87.5	87.5	85.80
10	14	0.0158	0.0467	94.1	100	100	98.03
10	18	0.00898	0.016954	97.1	100	100	99.03

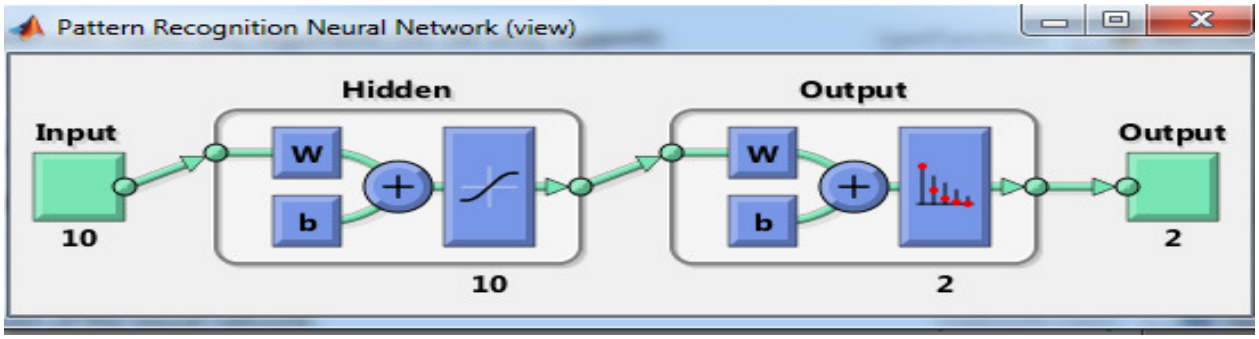

Fig. 16. Two-Layer Feed Forward Neural Network.

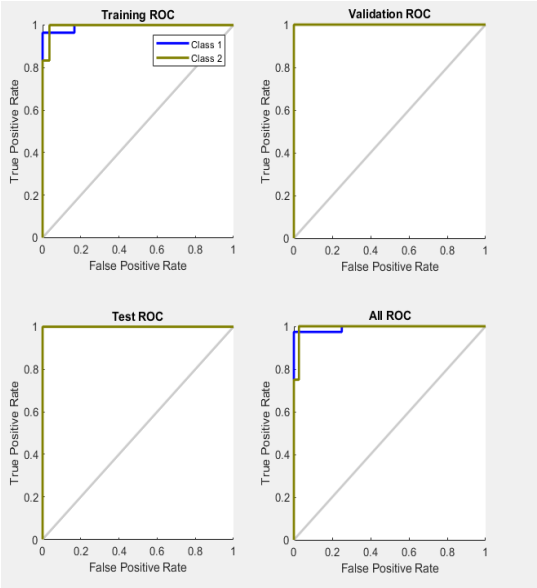

Fig. 17. ROC For ANN Model.

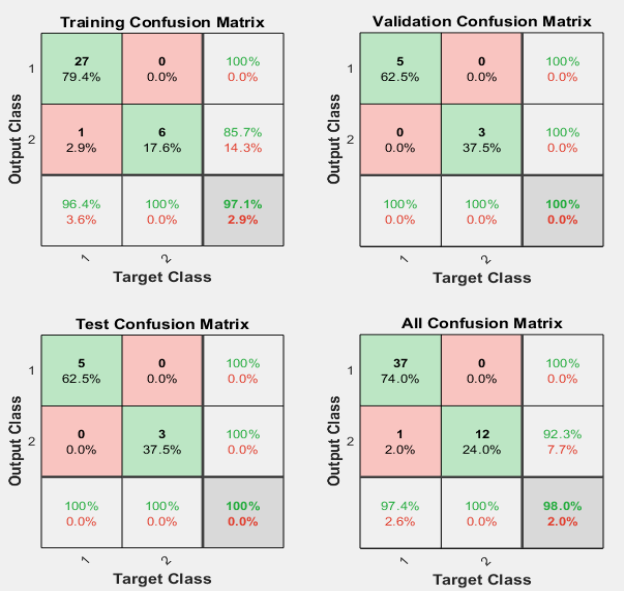

Fig. 18. Confusion Matrix ANN Model.

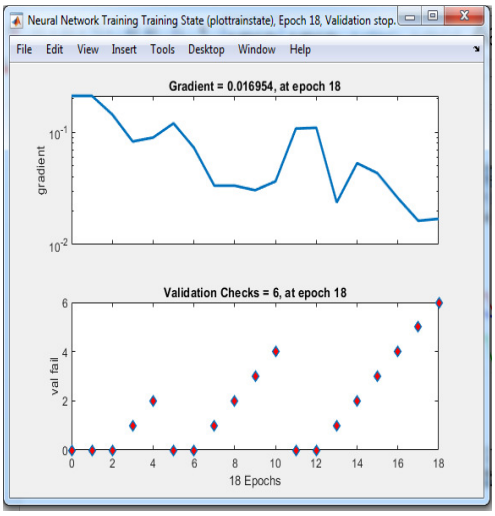

Fig. 19. Performance of selected ANN Model in terms of Gradient, Validation fail parameters.

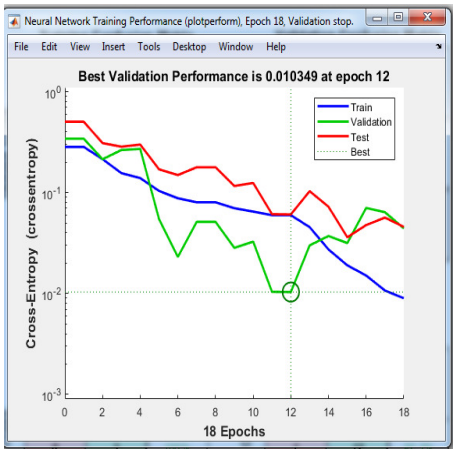

Fig. 20. Performance of selected ANN Model for training, validation, and testing data**.**

VII. ADVANTAGES

Proposed system is useful for predicting learning behavior of learner and further used to suggest teaching methodology and learning path in e-Learning system.

VIII. CONCLUSION

Learner behavior analysis is crucial factor in personalized learning system for better learning experience. Fuzzy rule based system is developed for learning behavior analysis of learner using Mamadani approach. K-means clustering algorithm and experts knowledge base is used to design rule base help for prediction output of system. Feed Forward Neural network is implemented using conjugate gradient techniques for testing accuracy of system. Developed model gives 99.03% accuracy leads to better result. This system further useful for developing personalized e-learning system according to learner's behavior.

IX. FUTURE SCOPE

This system further useful for developing personalized e-learning system according to learner's behavior.

Conflict of Interest: Artificial Intelligence, Data Mining, Soft Computing, ERP.

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