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COMBINATIONAL FUZZY EXPERT SYSTEM (CFES) FOR ACADEMIC PERFORMANCE APPRAISAL

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Abstract

The Education domain has many challenging data mining applications. The effective monitoring of student's performance is a vital task in superior higher learning. This work presents a novel approach for evaluating performance of research students based on Fuzzy logic reasoning in academic institutions. The issue of Rule Explosion has been eliminated by deploying stage wise fuzzy approach. The proposed Combinational Fuzzy Expert System (CFES) works to resolve the ambiguity in the traditional evaluation systems with fewer and better rule sets. The experimental results obtained using CFES have been compared to the results obtained using traditional evaluation methods. The comparison shows that CFES helps in identifying the students that lie at the overlapping area of two class distributions. Thus it helps the educators to monitor the progress in a better way. Moreover they can guide the students from time to time for regular improvement and achieve better results.

I. Introduction

Assessment in educational institutions refers to the phenomenon of criteria based measurable documenting of the knowledge of the candidates. The traditional methodologies generally used for performance appraisal lacks standardization and may yield ambiguous results like students with a difference of just one mark falling in different categories. Fuzzy logic is a recently introduced concept in the applications of performance appraisal. Fuzzy logic is synonymous to how a human being feels or infer from his

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surroundings. As compared to classical control strategies, which implements point to point control, Fuzzy logic on the other hand involves controlling parameters in ranges [1]. Thus Fuzzy techniques can be easily applied for numerical scores based evaluation in academics and other skills. The following figure 1 depicts the process of Fuzzy logic evaluation comprising of three major steps: Fuzzification, Rule Evaluation and Defuzzification. In Fuzzification the classical real world variable are converted to fuzzy variables using various membership functions. Thereafter, Fuzzy inference rules are evaluated to derive the fuzzy output. Finally the real domain output is obtained in defuzzification for better understanding [2].

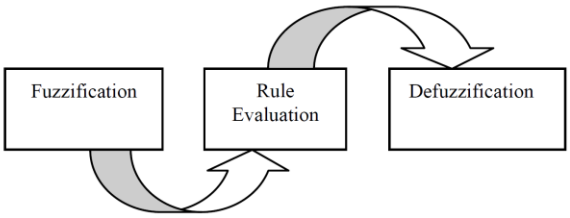

Figure 1. Steps of Evaluation in Fuzzy Logic.

In our work we have explored the pros of the Fuzzy logic based approach for student's performance evaluation. The Fuzzy expert system allows the introduction of external expert knowledge in addition to the information available in the given dataset. Such knowledge that is previously not known helps in dealing with the practical applications involving fuzzy logic.

The rest of the paper is organised as follows: In Section 2 we discuss the various related research works that have been done in the field of performance evaluation. In section 3, the proposed Combinational Fuzzy Expert System (CFES) for student performance appraisal has been elaborated. Section 4 shows the results and analysis of the proposed algorithm on MATLAB tool using Fuzzy toolbox. Section 5 finally concludes the paper along with the future scope of research in the present study.

II. Related Work

Fuzzy logic was first introduced in 1965 at university of California, Berkeley by Professor L. A. Zadeh [1]. But it got well recognized in 1974 when Dr. E. H. Mamdani [2] developed an automatic steam engine controller based

on fuzzy logic. A. Kumari et al. [3] have developed a Fuzzy Logic Inference System (FLIS) for the performance analysis of emerging engineers. Based on Mamdani type FIS, their proposed system fuzzifies the input and output attributes in three linguistic variable (poor, average, good).The results obtained from FLIS are indexed for the purpose of continuous and comprehensive evaluation of students. According to D. Deliktas et al. [4] is multi criteria decision problem including both tangible and intangible factors. They have followed an integrated approach with multi choice goal programming and fuzzy MULTIMOORA. This approach chooses the optimum assignments as per student's ability to enhance the ranking value. The rank of the students and the placement preferences are set as parameters to first and second objective function respectively. S. Deb et al. [5] have put forth a framework of fuzzy logic based Adaptive Behavioral Learning System for better outcomes in learning. In their learning system they have put the students of a class into specific clusters based on the learning ability of individual students. This would enable the educators to customize the teaching methodologies for different clusters which would ensure better understanding of concepts and results of the students.

A. Kharola et al. [6] have given a different model based on fuzzy logic reasoning for performance evaluation of students. Their stage wise evaluation approach considers the academic as well as the personality traits of students. They have obtained better results in evaluation with their fuzzy approach when compared to traditional methods. M. Guruprasad et al. [7] have used an algorithm in visual basics (VB) to develop a fuzzy logic model for evaluating the performances of faculty members in an institution. They have grouped the weighed values for similarities and comparison of the faculty members based the fuzzy values being calculated by the system. A. Shout et al. [8] have explored various aspects of fuzzy logic reasoning using a stage wise approach for building inference systems for fuzzy controllers. Their study brought out the fact a stage wise approach is able to eliminate the problem of rule explosion by combining attributes at various stages. M. H. Wang et al. [9] have developed a mechanism based on strategy of adaptive item selection to obtain the present ability of the student. They have demonstrated how both faculty and students can improve their teaching and learning experiences by utilizing the vital information obtained from the system. N. Arora et al. [10]

have developed an evaluation model based on feed forward probabilistic neural networks. Such networks consumes lesser time in training the network. Their evaluation criteria are mostly based on the qualitative observations.

III. Proposed Methodology

Most of the present day evaluation systems face problem of inadequate data available to them [11]. To address this issue we have used the fuzzy logic approach to design an efficient Combinational Fuzzy Expert System (CFES) for evaluation of performance of students in academic institutions. The aim of our proposed method is not to discard the current classical methods of evaluation but to improve them by providing extra knowledge for better decision making. The architecture of proposed CFES consists of following components:

A. Fuzzification:

Fuzzification refers to converting classical set to fuzzy set to variable degrees. Most of the variables in the real world applications tend to be crisp or classical variables [12]. In order to implement fuzzy logic these crisp variables need to be converted to fuzzy variables and then apply fuzzy inference to that data to obtain the final output. Fuzzification involves following two sub processes:

i. Deriving the input and output variables membership functions.

ii. Using Linguistic variables for representing above variables [6].

In the present CFES for performance appraisal of students, we have considered marks of four exams (Exam 1, 2, 3 and 4), laboratory marks and variable marks representing attendance and other skills. Triangular membership function as shown in Figure 2 has been used to fuzzify these marks into three linguistic variables namely low, medium and high.

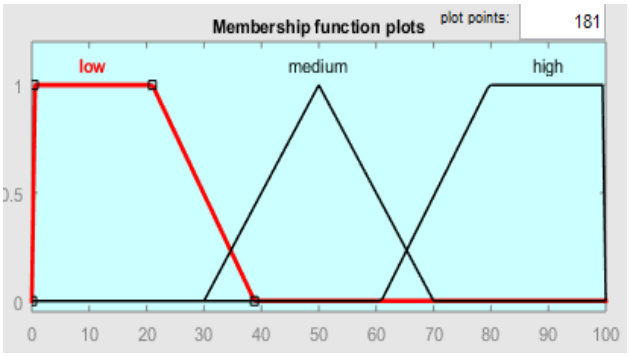

Figure 2. Membership Function.

CFES is a multi-stage appraisal system including three stages of Fuzzification. In stage 1, marks of Exam 1 and Exam 2 are fuzzified together, marks of Exam 3 and Exam 4 are fuzzified together and laboratory and variable marks are fuzzified together. In stage 2, result 1 and result 2 are fuzzified together to obtain the academic result. In stage 3, academic result and result 3 are finally fuzzified together to obtain the final overall result.

B. Rule set Inference:

Fuzzy control rules are the added knowledge of experts in any field of consideration. These are generally the sequences of IF-THEN which describe what output is to be produced in terms of current information input in form of linguistic variables [13]. The rule set used in CFES for Fuzzification till stage 2 are:

i. IF Exam 1 HAS high score AND Exam 2 HAS high score THEN Result 1 WOULD HAVE high score.

ii. IF Exam 1 HAS high score AND Exam 2 HAS medium score THEN Result 1 WOULD HAVE medium score.

iii. IF Exam 1 HAS high score AND Exam 2 HAS low score THEN Result 1 WOULD HAVE medium score.

iv. IF Exam 1 HAS medium score AND Exam 2 HAS high score THEN Result 1 WOULD HAVE high score.

v. IF Exam 1 HAS medium score AND Exam 2 HAS medium score THEN Result 1 WOULD HAVE medium score.

vi. IF Exam 1 HAS medium score AND Exam 2 HAS low score THEN Result 1 WOULD HAVE low score.

vii. IF Exam 1 HAS low score AND Exam 2 HAS high score THEN Result 1 WOULD HAVE medium score.

viii. IF Exam 1 HAS low score AND Exam 2 HAS medium score THEN Result 1 WOULD HAVE low score.

ix. IF Exam 1 HAS low score AND Exam 2 HAS low score THEN Result 1 WOULD HAVE low score.

Similar inference rules are used to fuzzify Exam 3 and Exam 4 and laboratory marks and variable marks to obtain Result 1 and Result 2 respectively. Further the rule set used in CFES for Fuzzification for stage 3 are:

i. IF Academic_Result HAS high score AND Result 3 HAS high score THEN Final_Result WOULD BE excellent.

ii. IF Academic_Result HAS high score AND Result 3 HAS medium score THEN Final_Result WOULD BE above avg.

iii. IF Academic_Result HAS high score AND Result 3 HAS low score THEN Final_Result WOULD BE avg.

iv. IF Academic_Result HAS medium score AND Result 3 HAS high score THEN Final_Result WOULD BE above avg.

v. IF Academic_Result HAS medium score AND Result 3 HAS medium score THEN Final_Result WOULD BE avg.

vi. IF Academic_Result HAS medium score AND Result 3 HAS low score THEN Final_Result WOULD BE below avg.

vii. IF Academic_Result HAS low score AND Result 3 HAS high score THEN Final_Result WOULD BE avg.

viii. IF Academic_Result HAS low score AND Result 3 HAS medium score THEN Final_Result WOULD BE below avg.

ix. IF Academic_Result HAS low score AND Result 3 HAS low score THEN Final_Result WOULD BE poor.

C. Defuzzification:

In this step, fuzzy output is converted into final crisp output. In our proposed CFES approach, minimum operator or AND operation is performed between inputs and maximum or OR operator are done between outputs [14]. Thus we can say that we choose the smaller value among the inputs and the membership function transcends for the corresponding output. Also, the centre of area (Centroid) technique has been used for the final Defuzzification of the output values.

Following Figure 3 represents the block diagram of proposed combinational fuzzy expert system.

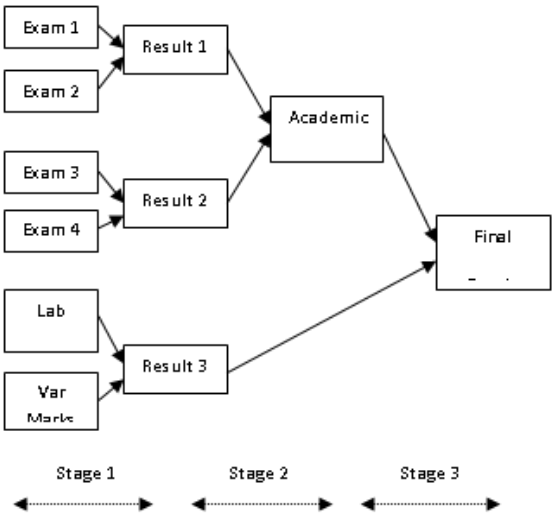

Figure 3. CFES Methodology.

Thus, we can briefly say that the proposed algorithm consists of following steps:

Step 1: Fuzzify the marks obtained in Exam 1 and Exam 2 using triangular membership function to obtain Result 1.

Step 2: Fuzzify the marks obtained in Exam 3 and Exam 4 using triangular membership function to obtain Result 3.

Step 3: Fuzzify the marks obtained in Laboratory Exam and attendance and other skills (variable marks) using triangular membership function to obtain Result 3.

Step 4: Fuzzify Result 1 and Result 2 using triangular membership function to obtain Academic_Result.

Step 5: Fuzzify Academic_Result and Result 3 using triangular membership function to obtain over all Final_Result.

Step 6: Use the inference rules mentioned before to obtain the final fuzzy outputs on specific inputs.

Step 7: Use the centre of area Defuzzification method to derive the final crisp output.

IV. Results and Analysis

The proposed CFES approach for performance evaluation of students in academic institutions has been tested for several rounds of experiments with varying input values for the exams considered.

A. Tool used: Fuzzy Tool box in MATLAB

MATLAB stands for Matrix Laboratory which is a tool that aids for technical computing using high level language. MATLAB is an interactive system that provides integrated programming facility (computation and visualization) in an easy to use environment. MATLAB also provides superior research, analysis and development than its counterparts on grounds of productivity. MATLAB includes many toolboxes for various domains. In our research work we have used the Fuzzy toolbox for the implementation of our proposed algorithm.

B. Results

In the first round of experiments we supply the values of various marks as follows:

Exam 1: 78, Exam 2: 89, Exam 3: 76, Exam 4: 65, Laboratory marks: 90 and Variable marks: 87.

Result 1 obtained after the Fuzzification of marks of exam 1 and exam 2 can be represented in the rule viewer of MATLAB in Figure 4 as:

Figure 4. Result 1 output.

Similarly Result 2 is obtained to be 80.0 after the Fuzzification of marks of exam 3 and exam 4. Result 3 is obtained to be 82.1 after the Fuzzification of marks of Lab exam and variable marks corresponding to attendance and other skills .Thereafter Result 1 and Result 2 are fuzzified together to obtain the Academic result as 83.8. Finally the proposed fuzzy inference system is applied to the Academic result and result 3 to obtain the final result (86.7) as follows in Figure 5:

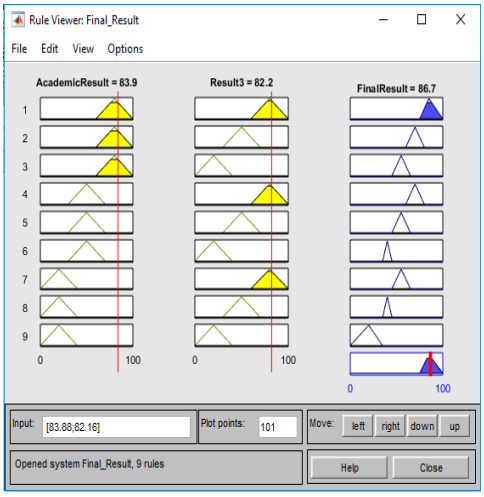

Figure 5. Final Result output.

The surface view of the final result in MATLAB can be represented as follows in Figure 6.

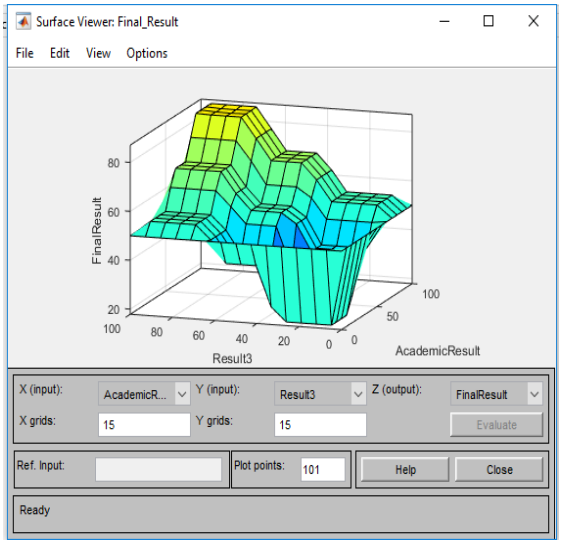

Figure 6. Final Result Surface view.

Similar to above different inputs were given to collect sample of results. The results so obtained have been compared with the traditional results in the same scenario in Table 1.

Table 1. Comparison of results obtained with CFES and Traditional Methods of Evaluation.

Exam1	Exam2	Exam3	Exam4	Lab marks	Variable marks	CFES Result	Classical Result
90	94	86	88	76	89	**86.72**	**84.83**
78	89	76	65	90	87	**83.69**	**80.83**
78	85	94	64	65	80	**65.63**	**77.67**
54	58	67	70	85	65	**79.79**	**66.5**
65	75	85	56	78	90	**84.84**	**74.83**
74	65	68	54	66	69	**65**	**66**
75	95	89	67	74	80	**84.83**	**80**

Following figure 7 represents the obtained results in graphical form.

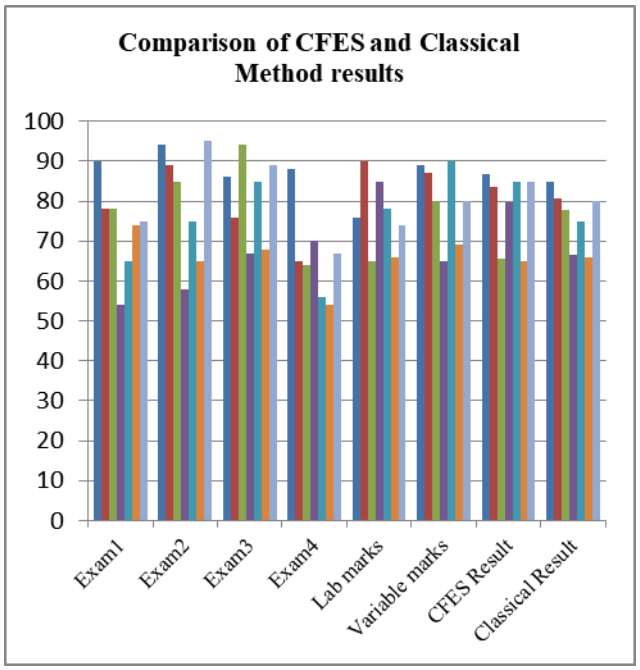

Figure 7. Comparison of CFES and Classical Method Results.

The above graph and Table 1 results show that CFES performs much better than Classical method of evaluation.

V. Conclusion and Future Work

In this work, we proposed a Fuzzy logic based evaluation approach for students in academic institutions. The traditional methods of performance evaluation stick to constant mathematical rules offering least flexibility. Hence they do not provide proper information of how a student is performing. The proposed Combinational Fuzzy Expert System (CFES) follows a step wise fuzzy logic technique to resolve the problem concerning rule explosion. CFES has been evaluated using MATLAB simulation tool with Fuzzy toolbox. Mamdani Fuzzy Decision techniques were used to calculate the active member functions as per the rule table. The final output value was defuzzified using Centre of Area function. This sequence of processing was done for every student in the class using his examination scores in every semester.

The comparison of CFES results with classical results show that CFES performs much better and it also has the provision to add the external expert knowledge for better evaluation. In Future we would try to further improve the CFES evaluation system by incorporating the neural fuzzy logic in the existing CFES system.

References

[1] L. A. Zadeh, The Concept of Linguistic Variable and its application to Approximate Reasoning, Information Sciences, Volume 8, pp. 199-249, 1975.

[2] A. Kaur and A. Kaur, Comparison of Mamdani type and Surgeno type Fuzzy Inference System for AC system, International Journal of Soft Computing and Engineering (IJSCE), 2(2) (2012), 325-329.

[3] N. A. Kumari and D. N. Rao, Indexing Student Performance with Fuzzy Logics Evaluation in Engineering Education, 9(4), ISSN 2394-3386, 2017.

[4] D. Deliktas and O. Ustun, Student Selection and Assignment Methodology based on Multimoora and multi choice goal programming, International Transactions in Operational Research 5(24) (2017), 1173-1195.

[5] S. Deb and P. Bhattacharya, A Framework to enhance the Learning Outcome with Fuzzy Logic ABLS, Advances in Intelligent Systems and Computing, Volume 564, pp. 3-11, 2017.

[6] A. Kharola and S. Kunwar, Student Performance Evaluation: A Fuzzy Logic Reasoning Approach, PM World Journal 4(9) (2015), 1-11.

[7] M. Guruprasad and A. Arora, Fuzzy Logic as a tool for evaluation of performance of Faculty in higher Education Systems, SHS web of Conference by EDP Sciences, 2016.

[8] A. Shout and M. K. Yousif, Employee Performance Appraisal System using Fuzzy logic, International Journal of Computer Science and Information Technology (IJCSIT) 6(4) (2014), 1-19.

[9] M. H. Wang and C. S. Wang, Type 2 Fuzzy Set construction and Application for Adaptive Student Assessment System, I
EEE Internal. Conference on Fuzzy Systems (FUZZ-IEEE), pp. 888-894, 2014.

[10] N. Arora and J. K. Saini, A Fuzzy Probabilistic Neural Network for student Performance Evaluation, International Journal of Innovative Research in Science, 2(9), ISSN 2319-8573, 2013

[11] K. Chrysafiadi and M. Virvou, Evaluating the intergration of Fuzzy logic into the student model of a web learning environment, Elsevier Journal of Expert Systems and Applications 39 (2012), 13127-13134.

[12] L. A. Zadeh, The Concept of Linguistic Variable and its application to Approximate Reasoning, Information Sciences 8 (1975), 199-249.

[13] S. G. Tzafestas and S. Terjakis, Fuzzy Sets and Fuzzy Reasoning: An Introduction, Fuzzy Reasoning in Information and Decision Control Systems, pp. 3-29, 1994

[14] G. Jyothi and P. Parvathi, Fuzzy Expert model of Evaluation of faculty performance in Technical Education Institutions, International Journal of Engineering Research and Applications 4(5) (2014), 41-50.