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Design and Development of Soft Computing Model for Teaching Staff Performance Evaluation

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Abstract

The evaluation of teacher's performance is especially important for the academic institutions. Academic institutes use Performance Based Appraisal System to evaluate teaching staffs which involves awarding scores in terms of numerical values. Academic administrators often face challenges when trying to evaluate a staff's performance. The most appropriate ways of handling imprecise data is to use Fuzzy Logic Reasoning which reflects the way of human-thinking. So Fuzzy Set Theory - an area under the umbrella of Soft Computing, approach is followed in the presented work. This approach of performance evaluation allows the organization to exercise professional judgment in evaluating employees. In this paper, a soft computing model for academic performance evaluation of the teachers is presented.

Keywords: Soft Computing .

Introduction

A highly reliable and effective performance evaluation rule is essential in decision making environments [17]. The Performance Based Appraisal System (PBAS) provides teachers with meaningful appraisals that encourage professional learning and growth. Performance evaluation usually consists of several components in which each involved a number of judgments often based on imprecise data. Arithmetical and statistical methods have been used for aggregating information from these assessment components. The performance of the staff involves the measurement of teaching-learning activities, professional development activities and research contributions, which are actually fuzzy concepts, can be captured in fuzzy terms. Application of the Fuzzy Set Theory in evaluation systems can improve evaluation results [2] [4].

Problem Statement

In reality, evaluation techniques engage in handling cases like subjectivity, fuzziness and imprecise information. It is often difficult to quantify performance dimensions. The current method of evaluating performance using arithmetical and statistical techniques does not necessarily offer the best way to evaluate human performance [3]. Since the judgment may involve approximated data and linguistic terminology, therefore a method that can handle such kind of data is needed. Academic administrators often face such issues when trying to evaluate a staff's performance. Fuzzy approach can be effectively utilized to handle imprecision and uncertainty [18]. Application of the Fuzzy Reasoning in evaluation systems can improve evaluation results. For this reason, a fuzzy evaluation method is adopted.

Objective

Proper system to motivate the teachers to improve their work performance is the primary aim of this research. The objective of the proposed research is to design and develop a soft computing model for teaching staff performance evaluation using fuzzy logic reasoning [5]. This model incorporates an alternative way of thinking, which allows modeling complex systems using a higher level of abstraction originating from human knowledge and experience. It is expected that this model will handle various kinds of imprecise data to reflect the way people think and make judgments.

Exploration of Fuzzy Theory Approach

Fuzzy Logic is an extension of crisp two-state logic that provides a platform for handling imprecise knowledge. The advantage of fuzziness dealing with imprecision fit ideally into decision systems. The vagueness and uncertainty of human expressions are well modeled in the fuzzy sets and a pseudo-verbal

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representation, similar to an expert's formulation, can be achieved.

Architecture of Fuzzy Inference System (FIS) followed in the proposed research is shown in the figure 1.

- Fuzzification is the process of converting Academic Performance Indicators (API) scores in to fuzzy inputs with the help of membership functions. A membership function is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1.
- Inference engine applies reasoning to compute fuzzy outputs. This can be done by if-then rules which relates multiple input and output variables. Because the rules are based on word descriptions instead of mathematical definitions, any relationship that can be described with linguistic terms can typically be defined by a fuzzy logic. This means that even nonlinear systems can be described and easily controlled with a fuzzy logic.
- Defuzzification is a conversion of internal fuzzy output variables into crisp values that can actually be used. Crisp output denotes overall performance of the employee. The centroid calculation method is used for defuzzification.
- Rule Base is a collection of knowledge in the If-Then format from experts. It describes the relationship between input parameters and output. It is used to display how an output is dependent on any one or two of the inputs.

Structural Design of Soft Computing Model

Present research demonstrates Soft Computing Model for teaching staff performance evaluation by exploiting Fuzzy Reasoning [7] [8]. The model can be viewed as an alternative to the use of addition in aggregating the scores from all categories, and to produce a final score. The factors used for evaluating the performance are considered as input parameters for fuzzification. The study utilizes FIS to deal with the problem associated with rule explosion. The proposed FIS is implemented using Mamdani-type inference. To defuzzify the resulting fuzzy set the center of gravity defuzzification method is selected [10].

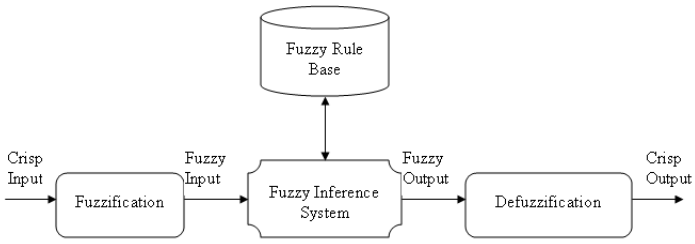

Figure 1: Fuzzy Inference Model

According to U.G.C. Notification the approach adopted for evaluation of teaching staff performance evaluation focuses on Academic Performance Indicators (API) [13]. API focuses on following categories:

- Category 1 : Teaching, Learning and Evaluation related Activities
- Category 2 : Co-curricular, Extension, Professional Development related Activities
- Category 3 : Research, Publications and Academic Contributions

All these categories which influence on teacher's performance are focused in the proposed soft computing model [9] [13]. Nature of activities and corresponding variables assigned in the model for API categories is enlightened in the table 1.

Table 1: API activities and assigned variables

Category	Nature of Activity	Assigned Variable
Category 1 : Teaching, Learning and Evaluation	Lectures, Seminars, tutorials, practical, contact hours undertaken taken as percentage of lectures allocated	C_{1a}
	Lectures or other teaching duties in excess of UGC norms	C_{1b}
	Preparation & Imparting of knowledge / instruction as per curriculum; syllabus enrichment by providing the additional resources to students	C_{1c}
	Use of participatory & innovative teaching learning methodologies; updating of subject	C_{1d}

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	content, course improvement, etc.	
	Examination duties as per allotment.	C_{1e}
Category 2: Co-curricular, Extension, Professional Development Related Activities:	Institutional Co-curricular activities, Positions held/ Leadership role played in organization, Students and Staff Related Socio-Cultural and Sports Programme, Community work	C_{2a}
	Contribution to Corporate life, Institutional Governance responsibilities, Participation in committees, Responsibility for Students Welfare, Counseling and Discipline Organization of Conference/Training	C_{2a}
	Membership in Profession related committees at state and national level, Participation in subject associations, conferences, Participation in short term training courses, Membership in education Committees, Publication of articles in newspapers, magazines	C_{2a}
Category 3: Research, Publications and Academic Contribution	Published Papers in Referred Journals, Non refereed but recognized, indexed and reputed Journals, Full Papers published in Conference Proceedings	C_{3a}
	Other Research Publications, Research	C_{3b}
	Monographs, Text Books, Reference Books, Chapters contributed to edited knowledge, Editing of the proceedings of the Seminar	
	Research Projects, Ongoing and Completed Research Projects, Consultancy Projects	C_{3c}
	Research Guidance	C_{3d}

Development Of Fuzzy Inference System

The system architecture of present research encompasses fuzzification, inference mechanism and defuzzification [12]. MATLAB is used for the application development of present research. All the parameters that affect performance of a teacher are taken in to account. The first step in using fuzzy logic within this model is to identify the parameters that will be fuzzified and to determine their respective range of values. Fuzzifying of variable involves passing the crisp value through each MF attached to that value. The final result of this interaction is the value for each performance parameter. The determination of membership function and fuzzy rules generation relies much on human expert and experience [15] [16].

Preliminary Computations

Performance of a teacher in Teaching, Learning and Evaluation related activities i.e. category 1 is calculated by equation [1].

$$C_1 = C_{1a} + C_{1b} + C_{1c} + C_{1d} + C_{1e} \quad [1]$$

Performance of a teacher in Co-curricular, Extension, Professional Development Related Activities i.e. category 2 is calculated by equation [2]

$$C_2 = C_{2a} + C_{2b} + C_{2c} \quad [2]$$

Performance of a teacher in Research, Publications and Academic Contribution i.e. category 3 is calculated by equation [3]

$$C_3 = C_{3a} + C_{3b} + C_{3c} + C_{3d} \quad [3]$$

Fuzzyfication of API Scores

Fuzzification is the process of determining the degree to which a value belongs in a fuzzy set. Three categories of API which are fuzzy in nature are

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considered as input parameters. We have taken these parameters as linguistic variables that affect the performance of a teacher. The variables represent the gradual transition from Poor to Excellent are called linguistic variables. Table 3 explains input parameters and their range for linguistic variables. Fuzzy intervals are decided by considering maximum and minimum values of input parameter as specified in the UGC notification. Table 2 gives range of API scores for each category

Table 2: Range of API scores

Nature of Activity	Maximum Score	Minimum Score
Category 1	125	75
Category 2	50	15
Category 3	---	---

Minimum requirement for Category-3 varies depending upon the post of the teacher as well as their promotion.

Table 3: Fuzzy Input Parameters and corresponding intervals.

Linguistic Variable	Category 1- Interval	Category 2 - Interval	Category 3 - Interval
Poor	[0 0 30 50]	[0 0 9 13.5]	[0 9 18 27]
Average	[40 55 65 80]	[9 13.5 18 22.5]	[18 27 36 45]
Good	[75 85 90 100]	[18 22.5 27 31.5]	[36 45 54 63]
Very Good	[90 100 105 115]	[27 31.5 36 40.5]	[54 63 72 81]
Excellent	[105 110 125 125]	[36 40.5 50 50]	[72 81 100 100]

In the Fuzzification phase, Membership Function Graph will be used to map the elements of input variable on to numerical values in the interval [0, 1]. Degrees of membership are expressed with membership functions. Fuzzy set membership enables the interpretations of linguistic variables in a very natural and plausible way to formulate and solve various problems. Figure 2, 3 and 4 shows membership functions of input parameters.

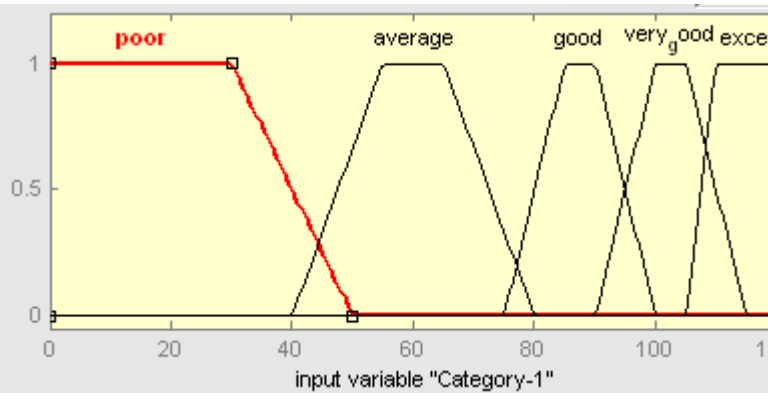

Figure 2: Membership functions for input variable "Category-1"

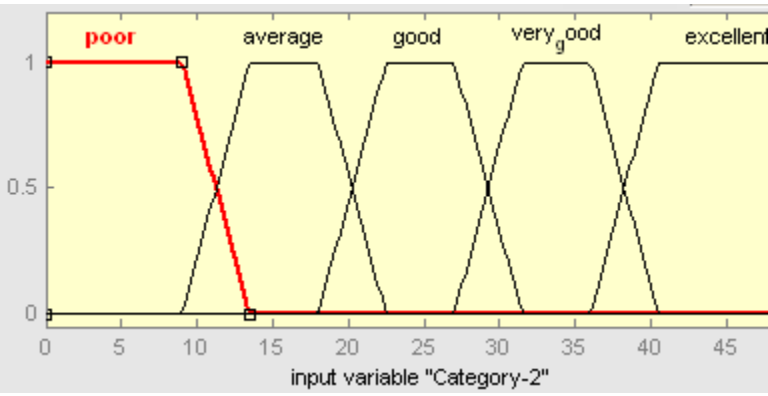

Figure 3: Membership functions for input variable "Category-2"

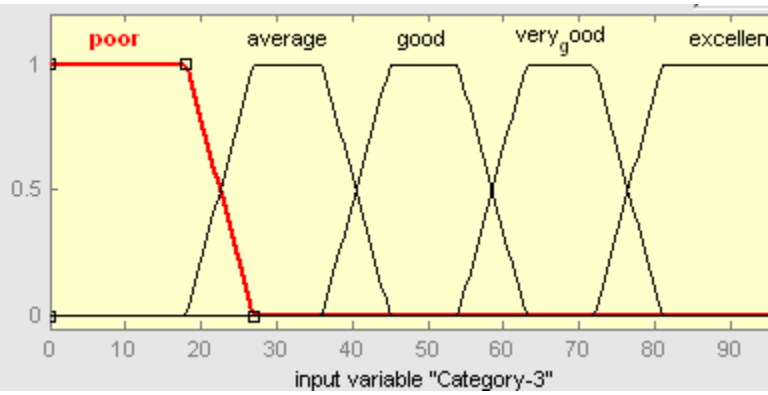

Figure 4: Membership functions for input variable "Category-3"

Fuzzy Rule Base and Inference Mechanism

Rule Base is generated by applying reasoning to evaluate the performance of a teacher. The rules determine input and output membership functions that will be used in inference process [6]. The rule editor is used to define and edit the rules that describe the

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behavior of the system. The membership functions and fuzzy rule bases were developed based on logical reasoning. There are 90 numbers of rules generated in the presented work. These rules are formulated by discussing with the academic experts [1]. Table 4 explains the sample rules collected from rule base which are responsible for the assessment.

Table 4: Fuzzy Rule Base

	Input Parameters			Output
Rule	**Category-1**	**Category-2**	**Category-3**	**Performance**
1	Excellent	Excellent	Excellent	Excellent
2	Excellent	Excellent	Average	Very Good
3	Excellent	Very Good	Very Good	Very Good
4	Excellent	Good	Average	Good
5	Very Good	Excellent	Average	Very Good
6	Very Good	Very Good	Good	Very Good
7	Very Good	Good	Good	Good
8	Very Good	Average	Poor	Average
9	Good	Excellent	Excellent	Very Good
10	Good	Excellent	Average	Good
11	Good	Very Good	Excellent	Very Good
12	Good	Very Good	Poor	Good
13	Average	Very Good	Good	Good
14	Very Good	Good	Average	Average
15	Poor	Good	Poor	Poor

A fuzzy inference engine resembles human reasoning in its use of approximate information and uncertainty to generate decisions [14]. The most commonly used fuzzy inference technique is so-called Mamdani method. It consists of rules, facts and conclusions. The fuzzy production rules connect premises with conclusions, condition with action. In this inference, expert's knowledge and experience were acquired and formulated accordingly to develop the appropriate rule to perform the system.

Defuzzicfication – Computation of Overall Performance

The Defuzzification phase transforms the fuzzy value into crisp value. It involves finding a value that best represents the information contained in the fuzzy set. The Defuzzification process yields the expected value of the variable for a particular execution of a fuzzy model. The output variable is the overall performance of the teacher, which has five linguistic variables. Fuzzy linguistic variables of Overall Performance are shown in Table 5. Figure 5 shows membership functions for output variable "Performance".

Table 5: Linguistic Variables and their range of Overall Performance

Linguistic Variable	Value
Poor	[0 0 45 75]
Average	[55 95 130]
Good	[105 140 175]
Very Good	[150 185 220]
Excellent	[200 230 275 275]

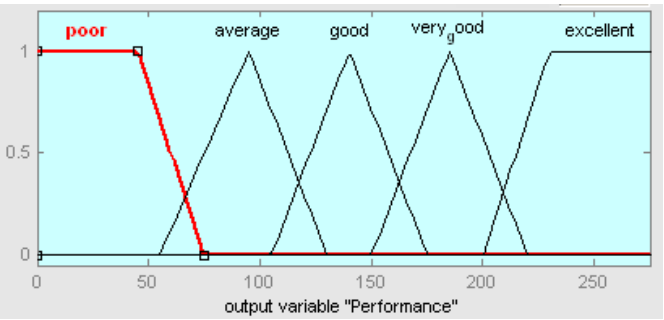

Figure 5: Membership functions for output variable "Performance"

Experimental Result

The Soft Computing Model developed in the present research can be applied to evaluate the overall performance a teaching staff. Sample data were examined and randomly selected for the present study. From the input data, the output variable overall performance of teacher is determined by using the FIS developed in this research. Table 6 presents computation of Overall Performance using Fuzzy model for sample data.

Table 6: Overall Performance by Fuzzy Method

	Input Parameters			Output
	Category-1	**Category-2**	**Category-3**	**Performance**
1	63	25	50	140
2	83.4	32.4	63	185
3	91.4	41.8	81.1	197

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4	110	42.2	86.4	245
5	57.5	21.4	79	140
6	75.5	31.3	65.7	178
7	51.5	19.8	42.8	112
8	77.5	21.9	42.8	120
9	40.2	14.2	60.9	115
10	54.9	16.6	58.8	117
11	30.3	15.3	39	93.2
12	22.9	10.2	14.6	31.7
13	38.2	22.2	40.2	93.1
14	24.3	9.9	20.5	45
15	74	15.8	19.4	92.8

Result provides the difference in the direct value and the values determined by using this fuzzy model. This is due to the weightage given on some important parameters related to API categories and formulation of rules [11]. So the overall performance of a teacher determined by fuzzy model is more realistic than the direct values.

Conclusion

This paper presents design and development of Soft Computing Model for Teaching Staff Performance Evaluation using Fuzzy Approach. A large number of factors affecting the staff's performance were identified and incorporated in the system. The membership functions and fuzzy rule bases were developed based on logical reasoning. This model can be adopted for the evaluation of teacher's performance in order to make good administrative decisions. Application of the fuzzy set theory in evaluation systems can improve evaluation results. For performance assessment and adequate support in decision making this model produced significant bases. This research can be extended to all types of employee assessment.

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