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DEVELOPMENT OF INTERVAL TYPE-2 FUZZY LOGIC FRAMEWORK FOR ACADEMIC STAFF APPRAISAL

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Abstract

In developing countries, government seemed to pay attention to education sector. This is evidenced through massive funds directed to universities system to train lecturers and enhance the efficiency in productivity of the staff in higher institutions. Despite this massive investment on academic staff, performance appraisal systems used in the various institutions create much room for bias, nepotism, unreliable and imprecise. This study outlines the most relevant issues concerning academic staff performance appraisal in university system with particular emphasis on the faculty of science guided by the following objectives; design of a database model to handle both structured and unstructured information of academic staff ,design of interval type -2 fuzzy logic system for academic staff appraisal management ,development of interval type -2 fuzzy logic system for academic staff appraisal management framework and representation of interval type -2 fuzzy logic system for academic staff appraisal management. Primary method of data collection such as observation of archive and questionnaire were deployed to obtain data. These data are stored in knowledgebase and the Interval Type -2 Fuzzy Logic is used to manipulate on it and transforms the data into the fuzzy output.

Keywords*: Performance Appraisal System, Interval Type -2 Fuzzy Logic, Multi source feedback, 360 degree feedback, mathematical method, Knowledge Base*

1. INTRODUCTION

Performance management (PM) system is goal-oriented process that ensures organizational processes are in place to maximize the productivity of employees, teams, and ultimately the organization. It is a major player in accomplishing organizational goals in that it involves measuring and improving the value of the workforce. Performance appraisal (PA) is a formal system of review and evaluation of individual or team task performance. Although performance appraisal is one of the components of performance management, it is vital, because it directly reflects the organization's strategic plan. It evaluates accomplishments and initiates plans for development, goals, and objectives. It has been suggested that utilization of effective performance management systems make companies, organizations and institutions perform strategically better and optimally, in financial and human management than those that invest less in this process. According to [1] there was a basic human tendency to make judgments about those working with, as well as about oneself. However, in the university systems, the annual staff appraisal provides an opportunity for the employee and management to reflect on the achievements on the year gone and think about the year to come. It means to have a closer look at the institutional aims and the definition of a person's responsibilities. The annual staff appraisal is an instrument to enhance the quality of an organizational unit's activities. It also promotes a positive working atmosphere. The collected results and data gathered during the evaluation of appraisal are subsequently an impulse for decision making [2]. According to [3], performance appraisal systems ensure that the behaviour of individuals does not deviate from his own self-confessed identity. According to [4] firms can monitor the development of desired employee attitudes and behaviors through the use of the appraisal mechanisms. However, the appraisal systems in the universities maybe regarded as a structured and formal interaction between the head of various departments and lecturers which usually takes the form of a periodic interview (annual or semi-annual) in which the work performance is assessed and examined to identify strengths and weaknesses and create opportunities for improvement. The main aim of a staff appraisal system is to identify the performance gap in teaching, research, number of conferences and workshops attended etc. This gap occurs when performance does not meet the standards set by the

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institution as acceptable. Secondly, a feedback system is supposed to inform the employee about the quality of his performance [5]. So over the years several methods such as Multi-Source Feedback or 360 Degree Feedback, mathematical method and Fuzzy logic type 1 have been proposed for evaluations of staff performance appraisal [5] and these methods have performed reasonable well to some extent for instance, Fuzzy logic type- 1 has rapidly become one of the most successful of today's technologies for developing sophisticated staff appraisal systems. While other approaches have equations to model real world behaviors, fuzzy design can handle the ambiguities of real-world human language and logic. It provides a method for describing systems inhuman terms and automates the conversion of those system specifications into effective models. Despite having a name which carries the connotation of uncertainty, research has shown that there are limitations in the ability of Type-1 FSs to model and minimize the effect of uncertainties in academic staff records. This is because a fuzzy type-1 is certain in the sense that its membership grades are crisp values. Recently, type-2 Fuzzy Logic System characterized by membership functions that are themselves fuzzy has been attracting interests [6]. This type of membership function does not contain any uncertainty. In other words, there exists a clear membership value for every input data point. If the points on the triangle function are shifted either to the left or to the right, membership function of fuzzy type-2 can be obtained and due to the complexity of the type reduction, the general type-2 FLS becomes computationally intensive.

Fuzzy logic type- 1 (FLT1) system cannot handle inherent uncertainty completely in the membership functions present in the system that will make the system to be more robust, reliable and efficient to use so because of this reason fuzzy logic type-2 (FLT2) model is proposed to address such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information, fuzzy type-2 will be used to develop a robust , reliable and efficient system that can be used for management of staff appraisal information. The aim of this work is to develop an academic staff appraisal management system for Universities using Interval type -2 fuzzy logic with the following objectives:-design a database model to handle both structured and unstructured information about academic staff**,** design of interval type -2 fuzzy logic system for academic staff appraisal management, development of interval type -2 fuzzy logic system for academic staff appraisal management **,**performance evaluation of interval type -2 fuzzy logic system for academic staff appraisal management.

2. REVIEW OF RELATED LITERATURE

In the work of [7] performance appraisal system is used in the organizations to measure the effectiveness and efficiency of their employees. It tends to improve the work performance, communication expectations, determining employee potential and aiding employee counseling. The researchers present the review of some popular performance appraisal techniques along with their pros and cons. Ranking, Graphic Rating Scale, Critical Incident, Narrative Essays, Management by Objectives, Assessment Centers, BARS, 360 Degree and 720 Degree are some performance appraisal techniques. This help to subject each employee into same basic process and rating criteria with the same range of response. The system creates a fixed process of appraisal that allows a certain categories of workers to be more relevance in some position than the other. According to [5] multi-feedback or 360-degree interval type 1 fuzzy logic was developing based on the data collected from a number of stakeholders about individual performance. These stakeholders are the head of units, managers of the institution and human resource persons. In this system, there exist ambiguity in the parameters used in this system and thus the system does not give accurate result. This system helped to establish people of what they think, believe, value or feel about the method of appraisal used for assessments. This system is not user friendly and only design for administrative staff and too rigid to use for the entire organization. In the work done by [1] used checklist methods to collect and analysis the effects of selected human resource management in the organization. This helps to answer the question why the management does not want to carry out the performance appraisal, but it is weak and not reliable for decision making. Questionnaire and interview method was used to appraise and analysis the impacts of appraisal in the development of an institution, this system helped high-performance organizations focus basically on the development and retention of the skills and knowledge of workers, but it seeks not to fit human resource management practices and emergent strategies of organizations goals. In the university Social support from the private companies can boost training and also play a significant role into the level of commitment that is established in the institution. Employees are likely to place greater value on training programs that are highly respected by colleagues, supervisors, and managers. Organizations that is able to create an environment where training is supported and valued by employees will be able to achieve greater commitment outcomes [8]. Management behavior was one of the most notable determinants of successful training programs. Employee commitment was found to be higher in organizations where management allowed access to and candidly supported employee training. This paper develop a framework that will help to determine the relationship between Human Resource Management (HRM), but only limited to a particular industry which cannot be implemented in other organizations. Because of these limitations existing systems, Interval Type 2-Fuzzy Logic is applied to develop a robust and efficient system that can be used to apprise academic staff of universities system in the developing countries.

3. PERFORMANCE APPRAISAL PROCESS

As shown in figure 1, the starting point for the PA process is identifying specific performance goals. An appraisal system probably cannot effectively serve every desired purpose, so management should select the specific goals it believes to be most important and realistically achievable. For example, some firms may want to stress employee development, whereas other organizations may want to focus on pay adjustments. Too many PA systems fail because management expects too much from one method and does not determine specifically what it wants the system to accomplish. The next step in this ongoing cycle continues with establishing performance criteria and communicating these performance expectations to those concerned. Then the work is performed and the supervisor appraises the performance. At the end of the appraisal period, the appraiser and the employee together review work performance and evaluate it against established performance standards. This review helps determine how well employees have met these standards, determines reasons for deficiencies, and develops a plan to correct the problems. At this meeting, goals are set for the next evaluation period, and the cycle repeated [5]

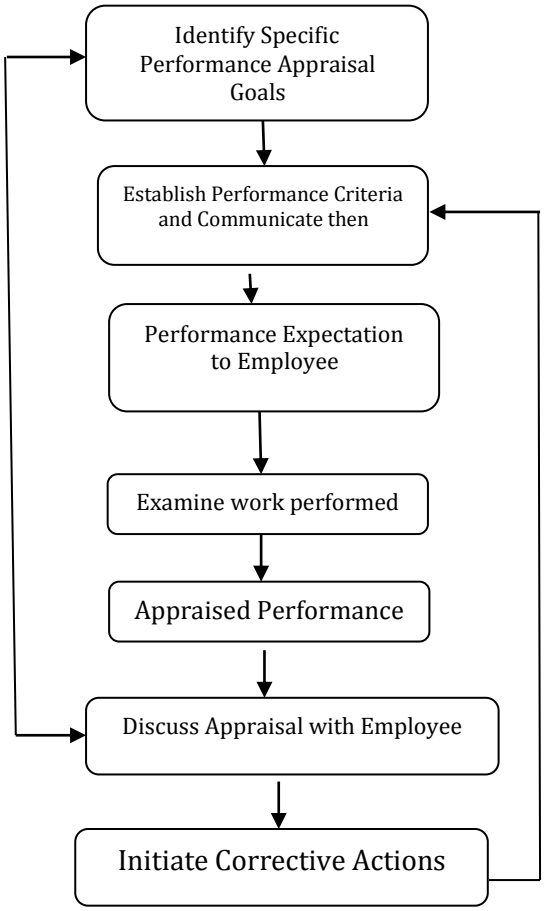

Figure 1: Steps in Process of Performance Appraisal Process [5]

The six steps involved in process of performance appraisal are as follows Establish Performance Standards, Communicate Performance Expectation to Employee, Measure Actual Performance, Compare Actual Performance with Standards, Discuss the Appraisal with the Employee, Initiate Corrective Actions [5]

3.1 ESTABLISH PERFORMANCE STANDARDS

The appraisal process begins with the establishment of performance standards. The managers must determine what outputs, accomplishments and skills will be evaluated. These standards should have evolved out of job analysis and job descriptions. These performance standards should also be clear and objective to be understood and measured. Standards should not be expressed in an articulated or vague manner such as a good job or "a full day's work" as these vague phrases tells nothing

3.2 COMMUNICATE PERFORMANCE EXPECTATIONS TO EMPLOYEES

It is established that once the performance standards are built, there is need to be communicated to respective employees so that they come to know what is expected of them. Past experience indicates that not communicating standards to the employees compounds the appraisal problem. Here, it must be noted that mere transfer of information from the manager to the employees is not communication. It becomes communication only when the transference of information has taken place and has been received and understood by the employees. The feedback from the employees on the standards communicated to them must be obtained. If required, the standards may be modified or revised in the light of feedback obtained from the employees

3.3 MEASURE ACTUAL PERFORMANCE

This is the third step involved in the appraisal process, in this stage the actual performance of the employee is measured on the basis of information available from various sources such as personal observation, statistical reports, oral reports, and written reports. Needless to mention, the evaluator feelings should not influence the performance measurement of the employee. Measurement must be objective based on facts and findings. This is because what is measured is more critical and important to the evaluation process than how it is measured.

3.4 COMPARE ACTUAL PERFORMANCE WITH STANDARDS

In this stage, the actual performance is compared with the predetermined standards. Such a comparison may reveal the deviation between standard performance and actual performance and will enable the evaluator to proceed to the fifth step in the process, i.e., the discussion of the appraisal with the concerned employees.

3.5 DISCUSS THE APPRAISAL WITH THE EMPLOYEE

The fifth step in the appraisal process is to communicate to and discuss with the employees the results of the appraisal. This is one of the most challenging tasks the manager's face to present an accurate appraisal to the employees and then make them accept the appraisal in a constructive manner. A discussion on appraisal enables employees to know their strengths and weaknesses. This in turn creates impact on their future performance. The impact may be positive or negative depending upon how the appraisal is presented and discussed with the employee.

3.6 INITIATE CORRECTIVE ACTION

The final step in the appraisal process is the initiation of corrective action when it is necessary. The areas needing improvement are identified and then measures to correct or improve the performance which are identified and initiated. The corrective action can be of two types. One is immediate and deals predominantly with symptoms. This action is often called putting out fires. The other is basic and delves into causes of deviations and seeks to adjust the difference permanently. This type of action involves time to analyze deviations. Hence, managers often opt for the immediate action, or say put out fires. Training, coaching, counseling, etc is the common examples of corrective actions that managers initiate to improve the employee's performance

3.7 ESTABLISH PERFORMANCE CRITERIA (STANDARDS)

There is an old adage that says what gets watched gets done. Therefore, management must carefully select performance criteria as it pertains to achieving corporate goals. The most common appraisal criteria are traits, behaviors, competencies, goal achievement, and improvement potential.

Traits

Certain employee traits such as attitude, appearance, and initiative are the basis for some evaluations. However, many of these commonly used qualities are subjective and may be either unrelated to job performance or difficult to define. In such cases, inaccurate evaluations may occur and create legal problems for the organization as well. In a performance appraisal system, general characteristics such as leadership, public acceptance, attitude toward people, appearance and grooming, personal conduct, outlook on life, ethical habits, resourcefulness, capacity for growth, mental alertness, and loyalty to organization are susceptible to partiality and to the personal taste, whim, or fancy of the evaluator as well as patently subjective in form and obviously susceptible to completely subjective treatment by those conducting the appraisals. At the same time, certain traits may relate to job performance and, if this connection is established, using them may be appropriate. Traits such as adaptability, judgment, appearance, and attitude may be used when shown to be job-related.

Behaviors

When an individual's task outcome is difficult to determine, organizations may evaluate the person's task-related behavior or competencies. For example, an appropriate behavior to evaluate for a manager might be leadership style. For individuals working in teams, developing others, teamwork and cooperation, or customer service orientation might be appropriate .Desired behaviors may be appropriate as evaluation criteria because if they are recognized and rewarded, employees tend to repeat them. If certain behaviors result in desired outcomes, there is merit in using them in the evaluation process.

Competencies

Competencies include a broad range of knowledge, skills, traits, and behaviors that may be technical in nature, relate to interpersonal skills, or are business-oriented. Some managers recommend that cultural competencies such as ethics and integrity be used for all jobs. There are also competencies that are job-specific. For example, analytical thinking and achievement orientation might be essential in professional jobs. In leadership jobs, relevant competencies might include developing talent, delegating authority, and people management skills. The competencies selected for evaluation purposes should be those that are closely associated with job success.

4. METHOD OF DATA COLLECTION

In this work, primary methods of data collection such as questionnaire, interview, and observation of relevant academic staff records are used to gather staff profiles like names, date of birth, marital status, numbers of awards, qualifications obtained, the number of publication, current rank, number of conferences attended, and communities development. These parameters obtained are uncertain, vague or ambiguous. To achieve better result and to ensure effective utilization of these parameters, there is need to develop input design, output design , database design and program design using unified modeling tools and mysql server, then Interval Type -2 fuzzy logic techniques is deployed and the result obtained will be compared to the existing system. However, we proposed interval type-2 fuzzy logic for academic staff appraisal performance system. Parameters such as qualification obtained, date of the first appointment, present rank , number conferences or workshops attended and number of publications etc will be considered as datasets. The proposed Interval Type-2 fuzzy logic framework system is aimed at addressing the challenges of maual and point of score appraisal methods used in the universities in developing countries to assess the performance of academic staff. In this proposed system, Interval Type -2 Fuzzy Logic will be deployed to design feasible and efficient system that can be used to assess the academic staff performance.

5. SYSTEM ARCHITECTURE

The architectural design of the proposed Interval Type-2 academic staff appraisal performance, the database serves as a store for holding information in the KB. It is a relational database which consists of entities in the domain of faculty appraisal system. The entities in the database are lecturers, courses, departments and faculty. The assessor base their evaluation using the following parameters which are qualification obtained, number of awards, publications in both international and national journals, courses taught, rank of the last appointment , job knowledge, work experience, date of last promotion and number of conferences attended as shown in figure 2

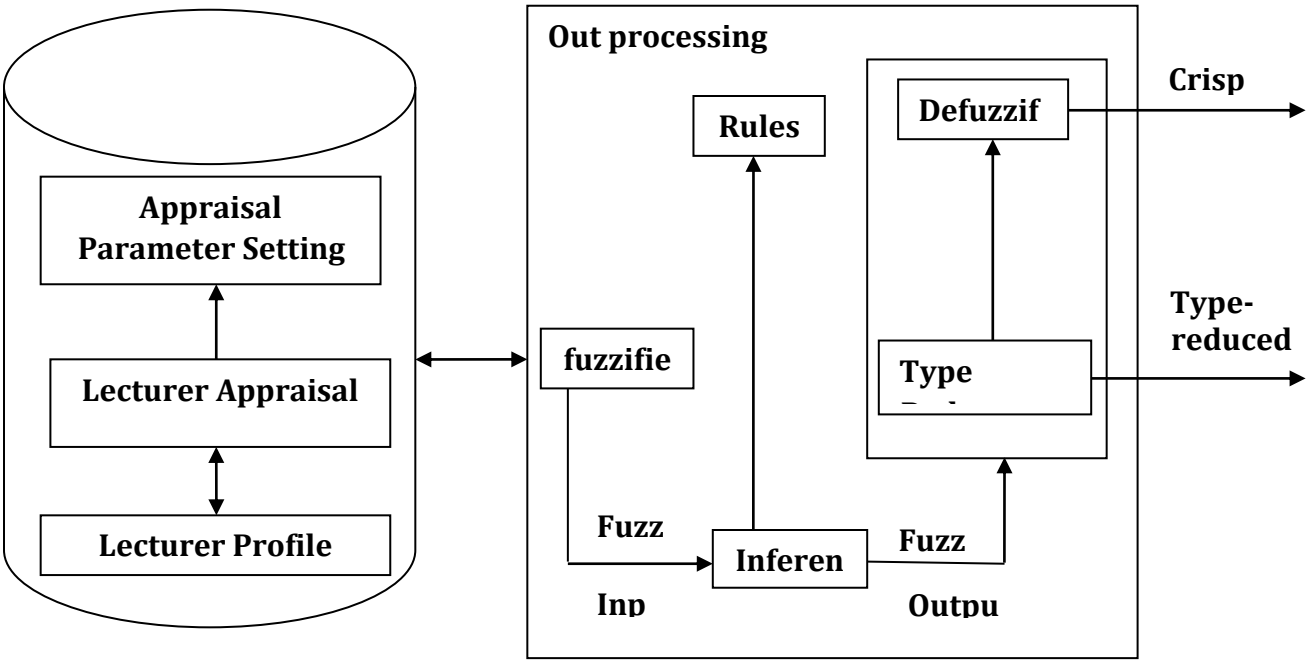

Figure 2: Database for the Interval Type -2 fuzzy logic Framework

The knowledge base stored parameters collected to be used for modeling of the system and these parameters are represented in the table 1

Table 1: Lecturer Table

S/N	Field	Description	Datatype	Length
1	L_Id	Lecturer no	String	4
2	Rank_of _first appointment	Rank of first appointment in the university	String	4
3	Marital_status	Marital status	Varchar	3
4	Date _Appointement	Date of first appointment into university service	datetime	5
5	L_Rank	Lecturer rank	Alphanumeric	10
6	Qualifications Obtained	Qualification obtained	Alphanumeric	10
7	Date_ of_ confirmation	Date of confirmation	Date	5
8	Workshop _attended	Numbers of workshop attended	String	20
	No_of _Publication			
9	L_Dept	Lecturer department	String	20
10	L_Faculty	Lecturer faculty	String	30

5.1 Interval Type-2 Fuzzy Inference System

In this work a fuzzy inference system (FIS) is based on logical rules that can work with numeric values or fuzzy input, when rules are evaluated, the individual results from what is known as the output fuzzy, then, a numerical value must be passed through a process of defuzzification. A type-2 fuzzy set is characterized by a membership function whose membership value for each element of the universe is a membership function in the range [0, 1].

5.2 Membership Functions

We used sigmoid and Gaussian membership functions in this work. Gaussian Membership function is applied to obtain smoothness and concise in system and is suitable for specifying different degree of uncertainties inherent in the parameters. It provides a smooth and nonzero curves at all points. Although the Gaussian membership functions achieve smoothness, it unable to specify asymmetric membership functions, which are important in the proposed system, so to solve this problem sigmoid membership is applied. The sigmoidal membership function is defined, which is either open left or right. Asymmetric and closed (i.e. not open to the left or right) membership functions can be synthesized using sigmoidal functions.

The functions are presented as in equation (1)and (2)

1. Sigmoidal membership function

$$f(x,a,c) = \frac{1}{1+exp(-a(x-c))} \quad (1)$$

Where:
a - sets the direction of the curve of the membership function.
c– sets the inflection point for the lower membership functions
x– is the input vector for the sigmoidal membership function

2. Gaussian membership function

$$f(x) = e^{\frac{-1}{2}\left(\frac{x-c}{\sigma}\right)^2} \quad (2)$$

Where:
c – is the center of the gaussian membership function.
σ – is the variance (or width) of the membership function
e – is the exponential function
x – is the input vector

1. Linguistic Variable/Universe of Discourse. Table 2 shows the linguistic variables and the universe of discourse used in this work.

Table 2: Universe of Discourse

Linguistic Variable	**Universe of Discourse**	**Description**
LRank	[0, 10]	Lecturer's rank
Qualification	[0, 10]	Qualification
Workshop	[0, 30]	Workshop
Publication	[0, 50]	Publication
Awards	[0, 100]	Awards
Appraisal	[0, 1]	Appraisal

The table 3 is generated using Left-Right model of sigmoid membership function and Gaussian membership function.

Table 3: Membership function values

Terms	**Lower MF** **σ c**	**Upper MF** **σ c**
1. LRank [0 10]		
Junior	-2.79, 2.505	-2.49, 2.91
Senior	0.767, 4-.638	1.04, 4.63
Very Senior	1.65, 7.944	1.65, 7.46
2. Qualification [0 10]		
Poor(sig)	-2.73, 2.811	-2.49, 3.28
Good (guass)	0.5474, 4.568	0.7917, 4.68
Exc (sig)	2.9, 7.112	2.554, 6.61
3. Workshop [0 30]		
VS (sig)	-5.528, 1.1	-3.95, 1.70
SM (guass)	1.4, 6.47	1.981, 6.47
M (guass)	1.57, 12.95	2.18, 12.95
H (guass)	1.21, 18.29	1.78, 18.29
VH (sig)	1.93, 23.1	1.718, 22.3
4. Publication [0 50]		
VS (sig)	-4.74, 1.186	-4.27, 1.98
SM (guass)	0.342, 3.958	0.8157, 3.95
M (guass)	0.5344, 6.91	0.898, 6.914
H (guass)	0.788, 11.08	1.26, 11.08
VH (sig)	0.9041, 17.7	0.922, 16.57
5. **Awards [0 100]**	σ c	
VS (sig)	-2.33, 1.985	-1.71, 3.388
S (guass)	1.21, 5.67	2.105, 5.67
M (guass)	1.28, 10.59	2.22, 10.59
H (guass)	1.6, 14.65	2.35, 14.65
VH (sig)	1.02, 23.4	0.8686, 21.6
6. Appraisal [0 1]		
Weakly R	0.1592, 0	0.2123, 0
Fairly R	0.1592, 0.5	0.2123, 0.5
Strongly R	0.1566, 1	0.2123, 1

5.3 Membership Function Plot

This is the diagrammatic representation of a membership function of the table 3 as shown in the figure 3 to 8

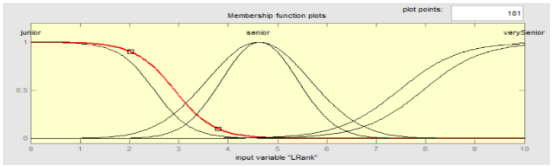

Figure 3: Lecturer's Rank

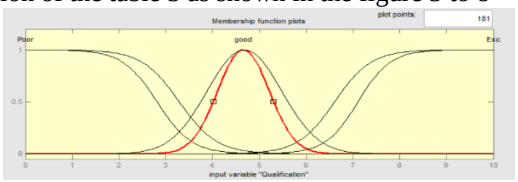

Figure 4: Qualification

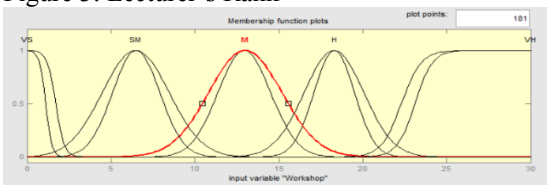

Figure 5: Workshop

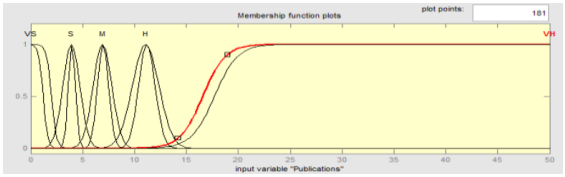

Figure 6: Publication

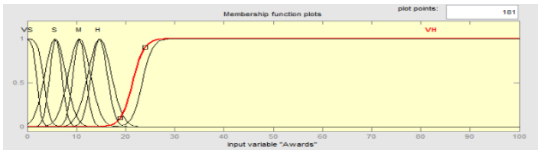

Figure 7: Awards

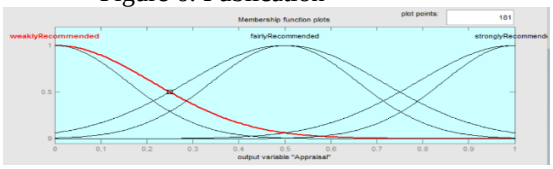

Figure 8: Appraisal

5.4 Rule Base

The rules defined for this system is a conditional statement in the form;

> IF LRank is junior AND Qaulification is poor AND workshop is VerySmall AND publication is VerySmall AND Awards is VerySmall THEN appraisal is WeaklyRecommended

This system uses 1125 rules calculated as the multiplication of the sum of fuzzy terms in each variable. The centroid of the consequent set $[\underline{y}^1, \overline{y}^1]$ is calculated using;

$$\underline{\mu}_{\bar{B}}(y) = \underline{\mu}_F(x) * \underline{\mu}_G(y) \quad \forall y \in Y_d \ldots\ldots (3)$$

$$\overline{\mu}_{\bar{B}}(y) = \overline{\mu}_F(x) * \overline{\mu}_G(y) \quad \forall y \in Y_d \ldots\ldots (4)$$

The fuzzy rules used in this system is presented in table 4

Table 4: The rule base

S/N	LRANK	QUALIFICATION	WORKSHOP	PUBLICATION	AWARDS	APPRAISAL
1	Junior	good	High	High	Small	[Rec]
2	Junior	poor	Small	Vsmall	medium	[NT Rec]
3	Very senior	good	Vhigh	High	vsmall	[Rec]
4	Senior	good	Small	Small	medium	[Nt REC]
5	Senior	poor	Small	High	vhigh	[Rec]
6	Junior	poor	High	High	medium	[NtRec]
7	Senior	good	Vhigh	Vsmall	vsmall	[Rec]
8	Senior	poor	Vsmall	medium	vhigh	[Nt Rec]
9	Senior	exc	Small	Vhigh	high	[Rec]
10	Verysenior	good	Small	medium	high	[Rec]
11	Junior	good	Vhigh	Vsmall	vsmall	[Rec]
12	Senior	poor	High	Vsmall	vhigh	[Nt Rec]

5.5 Fuzzification

This is the conversion of crisp input values to fuzzy set using the membership functions defined in figure 3 to figure 8.Given a sample crisp input vector v = [2, 3, 7, 1, 3], their fuzzy set is presented in the table 5 and is calculated by substituting each input value in its respective membership function as shown in table 5.

Table 5: Fuzzy set

Output Type-2 Fuzzy Sets
$\boldsymbol{LRank}[\underline{\mu}^1, \overline{\mu}^1]$
$\mu_{junior}(2)$ = [0.804 , 0.907] $\mu_{senior}(2)$ = [0.00270 , 0.0401] $\mu_{verySenior}(2)$ = [5.50e-05 , 0.000122]
$\boldsymbol{Qualification}[\underline{\mu}^2, \overline{\mu}^2]$
$\mu_{poor}(3)$ = [0.374 , 0.672] $\mu_{good}(3)$ = [0.00901 , 0.105] $\mu_{exc}(3)$ = [6.62e-06 , 9.90e-05]
$\boldsymbol{Workshop}[\underline{\mu}^3, \overline{\mu}^3]$
$\mu_{verySmall}(7)$ = [6.85e-15 , 8.16e-10] $\mu_{small}(7)$ = [0.931 , 0.965] $\mu_{medium}(7)$ = [0.000761 , 0.0241] $\mu_{high}(7)$ = [1.25e-19 , 1.84e-09] $\mu_{veryHigh}(7)$ = [3.20e-14 , 3.84e-12]
$\boldsymbol{Publication}[\underline{\mu}^4, \overline{\mu}^4]$
$\mu_{verySmall}(1)$ = [0.707 , 0.985] $\mu_{small}(1)$ = [5.70e-17 , 0.00138] $\mu_{medium}(1)$ = [2.55e-27 , 3.82e-10] $\mu_{high}(1)$ = [2.94e-36 , 1.27e-14] $\mu_{veryHigh}(1)$ = [2.77e-07 , 5.83e-07]
$\boldsymbol{Awards}[\underline{\mu}^5, \overline{\mu}^5]$
$\mu_{verySmall}(3)$ = [0.0859 , 0.660] $\mu_{small}(3)$ = [0.0876 , 0.447] $\mu_{medium}(3)$ = [2.32e-08 , 0.00290] $\mu_{high}(3)$ = [3.07e-12 , 4.61e-06] $\mu_{veryHigh}(3)$ = [9.19e-10 , 9.63e-08]

5.6 Inference Engine

The fuzzy rules used in this system are evaluated using the equation

$$F^i(x') = \left[\underline{f}^i(x'),\ \overline{f}^i(x')\right] \equiv \left[\underline{f}^i,\ \overline{f}^i\right] \quad \text{.....(5)}$$

$$\underline{f}^i(x') = \underline{\mu}_{\tilde{F}_1^i(x')} * \ldots * \underline{\mu}_{\tilde{F}_1^i(xp')} \quad \text{.....(6)}$$

$$\overline{f}^i(x') = \overline{\mu}_{\tilde{F}_1^i(x')} * \ldots * \overline{\mu}_{\tilde{F}_1^i(xp')} \quad \text{.....(7)}$$

Using the input vector v = [2, 3, 7, 1, 3], and the fuzzy set in table 6, to table 7 evaluation of rules gives the following firing rules and the firing intervals;

Table 6: The firing rules

S/N	LRank	Qual	Workshop	Publication	Awards	Appraisal
1	Junior	Poor	SM	VS	VS	nt_rec[0.3, 0.5]
2	Junior	Poor	SM	VS	S	nt_rec[0.24, 0.89]
3	Junior	Good	SM	VS	VS	rec[0.45, 0.94]
4	Junior	Good	SM	VS	S	nt_rec[0.5, 0.76]

Table 7: The Firing Interval

Rule No.	Firing Interval $[\underline{f}^i, \overline{f}^i]$	Consequent $[\underline{y}^i, \overline{y}^i]$
1	[(0.804, 0.374, 0.931, 0.707, 0.0859) , (0.907, 0.672, 0.965, 0.985, 0.660)] = [0.804, 0.985]	nt_rec[0.3, 0.5]
2	[(0.804, 0.374, 0.931, 0.707, 0.0876) , (0.907, 0.672, 0.965, 0.985, 0.447)] = [0.931, 0.985]	nt_rec[0.24, 0.89]
3	[(0.804, 0.00901, 0.931, 0.707, 0.0859) , (0.907, 0.105, 0.965, 0.985, 0.660)] = [0.931, 0.985]	rec[0.45, 0.94]
4	[(0.804, 0.00901, 0.931, 0.707, 0.0876) , (0.907, 0.105, 0.965, 0.985, 0.447)] = [0.931, 0.985]	nt_rec[0.5, 0.76]

5.7 Type Reduction

The Karnik Mendek Type reduction algorithm is used in this work. This algorithm seeks to find switch points (L, R) and then leftmost point (y_l) and the rightmost point (y_r) determined by;

$\underline{y}^L \leq y_l \leq \underline{y}^{L+1}$

$\bar{y}^R \leq y_r \leq \bar{y}^{R+1}$

Where $\underline{y}^n$ *and* $\bar{y}^n$ have been sorted in ascending order, respectively.

The algorithm to find the switch points are as follows;

a. KM Algorithm for Computing y_l

Step 1: sort $\underline{y}^n$ (n = 1, 2, … , N) in increasing order and call the sorted $\underline{y}^n$ by the same, but now $\underline{y}^1 \leq \underline{y}^2 \leq \cdots \leq \underline{y}^N$. Match the weights $F^n(X')$ with their respective $\underline{y}^n$and renumber them so that their index corresponds to the renumbered$\underline{y}^n$.

Step 2: Initialize f^n by setting

$f^n = \frac{\underline{f}^n + \bar{f}^n}{2} \quad n = 1,2, \ldots, N$……(8)

And then compute

$y = \frac{\sum_{n=1}^{R} \underline{y}^n f^n}{\sum_{n=1}^{R} f^n}$……..……(9)

Step 3: Find the switch point k $(1 \leq k \leq N-1)$ such that $\underline{y}^k \leq y \leq \underline{y}^{k+1}$

Step 4: Set $f^n = \begin{cases} \bar{f}^n, n \leq k \\ \underline{f}^n, n > k \end{cases}$

And compute

$y' = \frac{\sum_{n=1}^{N} \underline{y}^n f^n}{\sum_{n=1}^{N} f^n}$…….....(10)

Step 5: Check if $y' = y$. If yes, stop and set $y_l = y$ and L = k. if no, go to Step 6.

Step 6: Set $y = y'$ and go to Step 3

b. KM Algorithm for Computing y_r

Step 1: sort $\bar{y}^n$ (n = 1, 2, … , N) in increasing order and call the sorted $\bar{y}^n$ by the same, but now $\bar{y}^1 \leq \bar{y}^2 \leq \cdots \leq \bar{y}^N$. Match the weights $F^n(X')$ with their respective $\bar{y}^n$and renumber them so that their index corresponds to the renumbered $\bar{y}^n$.

Step 2: Initialize f^n by setting

$f^n = \frac{\underline{f}^n + \bar{f}^n}{2} \quad n = 1,2, \ldots, N$……(11)

And then compute

$y = \frac{\sum_{n=1}^{N} \bar{y}^n f^n}{\sum_{n=1}^{N} f^n}$……(12)

Step 3: Find the switch point k $(1 \leq k \leq N-1)$ such that $\bar{y}^k \leq y \leq \bar{y}^{k+1}$

Step 4: Set $f^n = \begin{cases} \underline{f}^n, n \leq k \\ \bar{f}^n, n > k \end{cases}$

And compute

$y' = \frac{\sum_{n=1}^{N} \bar{y}^n f^n}{\sum_{n=1}^{N} f^n}$……(13)

Step 5: Check if $y' = y$. If yes, stop and set $y_r = y$ and R = k. if no, go to Step 6.

Step 6: Set $y = y'$ and go to Step 3

The algorithm to find the leftmost and the rightmost points are given by the equation below;

$$y_l = \min_{L\in[1,N-1]} \frac{\sum_{n=1}^{L} \bar{f}^n \underline{y}^n + \sum_{n=L+1}^{N} \underline{f}^n \underline{y}^n}{\sum_{n=1}^{L} \bar{f}^n + \sum_{n=L+1}^{N} \underline{f}^n} \quad \text{.....(14)}$$

$$y_r = \max_{R\in[1,N-1]} \frac{\sum_{n=1}^{R} \underline{f}^n \bar{y}^n + \sum_{n=R+1}^{N} \bar{f}^n \bar{y}^n}{\sum_{n=1}^{R} \underline{f}^n + \sum_{n=R+1}^{N} \bar{f}^n} \quad \text{.....(15)}$$

From the equations above, for L = 1 and R = 3

$$y_l = \frac{\bar{f}^1 \underline{y}^1 + \underline{f}^2 \underline{y}^2 + \underline{f}^3 \underline{y}^3 + \underline{f}^4 \underline{y}^4}{\bar{f}^1 + \underline{f}^2 + \underline{f}^3 + \underline{f}^4} \quad \text{.....(16)}$$

$$y_l = \frac{0.985 * 0.3 + 0.931 * 0.24 + 0.931 * 0.45 + 0.931 * 0.5}{0.985 + 0.931 + 0.931 + 0.931}$$

$$y_l = \frac{1.40339}{3.778} = 0.37146$$

$$y_r = \frac{\underline{f}^1 \bar{y}^1 + \underline{f}^2 \bar{y}^2 + \underline{f}^3 \bar{y}^3 + \bar{f}^4 \bar{y}^4}{\underline{f}^1 + \underline{f}^2 + \underline{f}^3 + \bar{f}^4} \quad \text{.....(17)}$$

$$y_r = \frac{0.804 * 0.5 + 0.931 * 0.89 + 0.931 * 0.94 + 0.985 * 0.76}{0.804 + 0.931 + 0.931 + 0.985}$$

$$y_r = \frac{2.85433}{3.651} = 0.78179$$

5.8 DEFUZZIFICATION

The fuzzy set is defuzzified using the model below;

$$y_k(x) = \frac{y_l + y_r}{2} \quad \text{.....(18)}$$

$$y_k(x) = \frac{0.37146 + 0.78179}{2} = 0.576625$$

The results obtained from equation 1 to 18 will pass into the interval type 2 fuzzy model for implementation using Matlab software tool which is to be done in the further study.

6. CONCLUSION

The Interval Type 2-fuzzy logic for Academic Staff Appraisal Performance management system is investigated. Framework used is to find solutions to the University appraisal system and is designed based on the lecturer profiles obtained from the various departments in the faculty of Science, University of Uyo. The framework is reliable and efficient and it is capable of solving problems inherent in staff appraisal management system. In this work we primarily include the basic algorithm which firstly gets all the information required like staff bio-data, work information ,staff profiles, awards obtained, conferences attended, publication made etc. The system will filter out the imprecise information such as consideration of lecturer publication in a particular journal (that is some journal will be ranked higher than some others) and the upgrading of some lecturers in some faculties than the others (examples engineering faculty, pharmacy and clinical sciences) a lecturer that is back from masters programme will be promoted to Lecturer II while other faculties will be ranked Assistant Lecturer which create rooms for impartiality in the system.

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