"DEVELOPMENT OF FUZZY LOGIC MODEL FOR PERFORMANCE RATING (PR) OF EMPLOYEE'S"

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Abstract- The most important and complicated task in every organization is the proper evaluation of employee's performance. Most of the organizations use conventional and subjective Performance Appraisal (PA) system to evaluate the effectiveness and efficiency of their employee's. The critical and difficult aspect of PR is that at times it is biased in human judgement and perception. PR is a part of career development of employees and its review is periodic in nature. The judgemental error which may influence the PR and affect the Organization as well as employees has always been a concern for the Peers.

This Paper deals with a scientific approach in evaluation of PR and developed a model based on the fuzzy reasoning for PR. It also demonstrates a comparison between a conventional and fuzzy logic approach in PR. The PR model developed has been systematically tested through simulation and results obtained have considerably shown shift in PR towards realistic and practical.

Keywords: Performance Rating, Fuzzy inference system, Matlab, Simulink.

Introduction

PR involves identification of certain critical elements or attributes which can reflect employee's performance in the best possible way [1]. PR involves judgement when a

superior person tries to interpret the performance of his/her subordinates [2]. PR system not only reveals the level of performance of an employee in the past but also determines his/her expected performance level in the future [3]. The benefits of practicing PR are twofold [4], on one hand employee will know their progress and performance and on the other hand the management can see the system as a whole which helps in overall human resource development of the Organization. Due to increased emphasis on PR there is a need to develop consistent and fair models [5]. The emerging methodology of fuzzy logic provides the necessary tools to identify and address many issues of PR and reasonably eliminates the judgemental/ bias elements in error.

Fuzzy logic is a scientific principle in which the operational performance of any system is determined based on the logical sequence applied in the process. It's more predominant in electronically controlled machines e.g. washing machines, automatic traffic light controllers, robotics etc. In this paper the attributes of human being has been applied to logical sequence of fuzzy reasoning and accordingly the performance of employee has been rated.This paper is described in six parts viz. Part 1 gives an introduction of traditional non fuzzy approach to PR. Part 2 explains fuzzy logic approach to PR system. Part 3 includes the design of fuzzy logic model using Matlab software. Part 4 shows simulation results and comparison. Part 5 and 6 includes conclusion and references respectively.

1. Non fuzzy approach

In traditional non-fuzzy approach the attributes of human nature are considered and rated on a numeric scale. In this study we have rated each attribute on a scale of 0-5.The critical attributes which are considered here as a minimum for employee's PR are shown in table 1.0.

S.No	Critical Attributes	Numerical Rating
1.	Quality of Work	
2.	Quantity of Work	
3.	Reliability	
4.	Relationship	
5.	Knowledge	
6.	Competence	
7.	Communication	
8.	Supervision	
9.	Timeliness	
10.	Rules	
	Total Numerical Rating	

Table 1.0 List of Critical Attributes

Now, the Overall Rating can be evaluated as average principle therefore,

Overall Rating = Total Numerical Rating/No. of attributes

Therefore, Overall Performance Rating (OPR) of an employee is then decided based on the basis of rating as shown in table 1.1

OPR	Symbol	Overall Rating
Extraordinary	EO	4.0-5.0
Excellent	E	3.5-3.99
Superior	S	3.0-3.49
Fully Successful	FS	2.5-2.99
Minimally Successful	MS	2.0-2.49
Unsatisfactory	US	1.5-1.99
Poor	P	<1.5

Table 1.1 Rating Table for OPR evaluation of employee's.

2. Fuzzy Reasoning Approach in PR

In this study we have used Stage-wise fuzzy reasoning approach [1] which reduces fuzzy if-then rules by dividing the whole system into various fuzzy inference stages [6]. This approach effectively evaluates OPR of an employee.

If we look at the critical attributes mentioned in the table 1.0 then we can see that elements like Quality and Quantity reflects employee's ability to perform 'Work'. Reliability and Relationship with others reflects employee's 'Attitude'. Knowledge and Competence reflects employees 'Aptitude'. Communication and Supervision reflects employee 'Skills' and Timeliness and Rules relates to 'Punctuality' requirements of an employee. Therefore, the critical attributes can be grouped as shown in table 1.2

Group	Critical Attributes
Work Related	Quality of work, Quantity of work
Attitude Related	Reliability, Relationship
Aptitude Related	Knowledge, Competence
Skills Related	Communication, Supervision
Punctuality Related	Timeliness, Rules

Table 1.2 Grouping of attributes

Hence performance analysis can be divided into multiple thought process.

'Quality of Work' and 'Quantity of Work' is combined in the first stage to build 'Work Analysis'.

'Reliability' and 'Relationship' are combined in the first stage to build 'Attitude Analysis'.

'Knowledge' and 'Competence' are combined in the first stage to build 'Aptitude Analysis'.

'Communication' and 'Supervision' are combined in first stage to build 'Skills Analysis'.

'Timeliness' and 'Rules' are combined in the first stage to build 'Punctuality Analysis'. All of these analyses have been logically shown in figure 1.0.

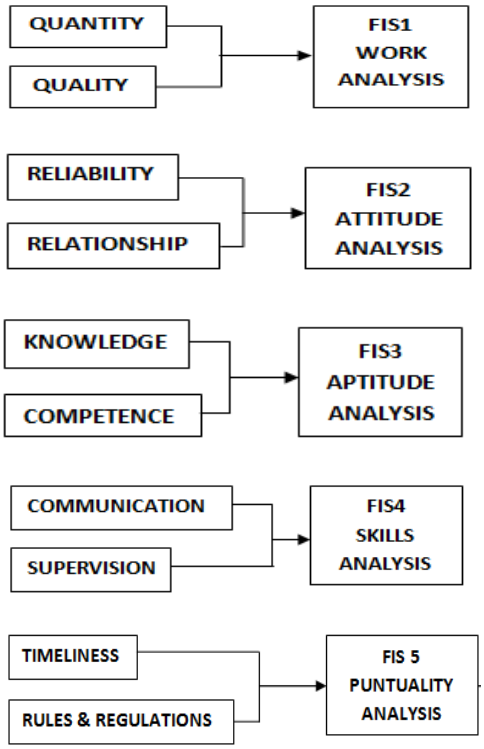

Fig1.0 Stage wise fuzzy approach (stage-1)

Similarly, in second stage 'Work' and 'Attitude' are combined to build 'Work-Attitude Analysis'.

'Aptitude' and 'Skills' are also combined in the second stage to build 'Aptitude-Skills Analysis' as shown in figure 1.2

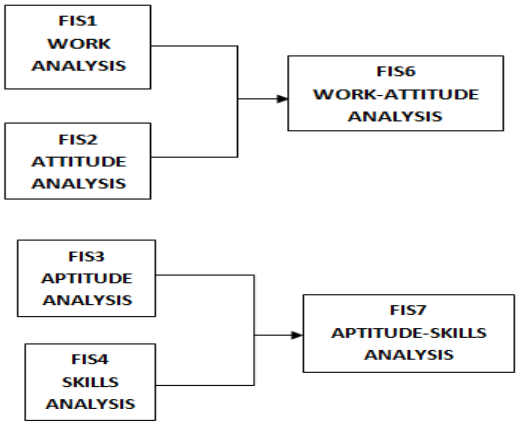

Fig 1.2 Stage wise fuzzy approach (stage-2)

Since 'Work-Attitude' and 'Aptitude-Skills' are dependent on each other therefore combined in the third stage to build 'Attribute Analysis' which is then finally combined with 'Punctuality Analysis' to generate 'OPR Analysis' as shown in figure 1.3.

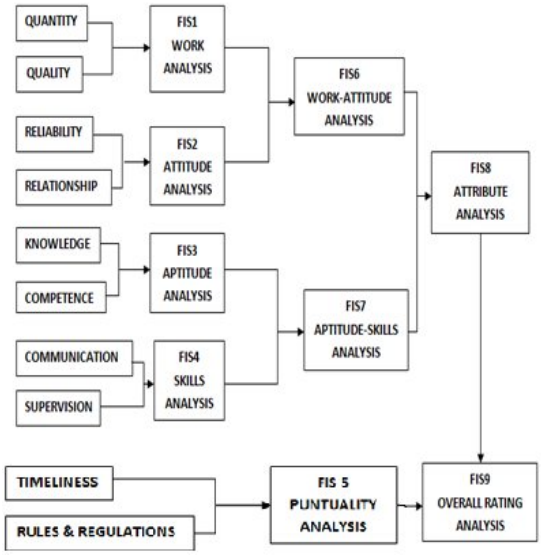

Fig 1.3 Stage wise fuzzy approach: model

3. Design of fuzzy logic model using 'Matlab'.

As shown in figure 1.3 total nine Fuzzy Inference Systems (FIS) namely FIS1, FIS2, FIS3, FIS4, FIS5, FIS6, FIS7, FIS8 and FIS9 are created in Matlab using Fuzzy Logic Toolbox [7].

After defining the input/output variables we have created membership functions (MF's) and fuzzy control rules for each FIS.

Step I: Defining Universe of Discourse (UOD), Fuzzification of critical attributes and MF's:

Each of the ten identified input parameters (critical attributes: Quality, Quantity, Reliability, Relationship, Knowledge, Competence, Communication, Supervision, Timeliness and Rules) have been given a UOD of [0 5] and have been fuzzified with seven linguistic variables (fuzzy subsets: Poor-P, Unsatisfactory-US, Minimally Successful-MS, Fully Successful-FS, Superior-S, Exceptional-E, Extraordinary-EO) using triangular membership functions [1].

Examples of fuzzified input/output for FIS1 are shown in figure 1.4, figure 1.5 and figure1.6

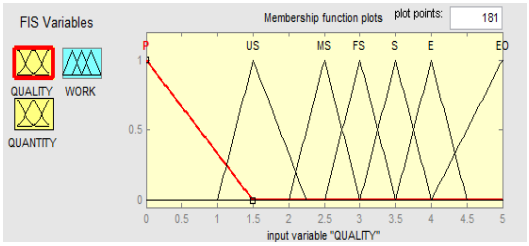

Fig 1.4 Fuzzified input parameter-Quality

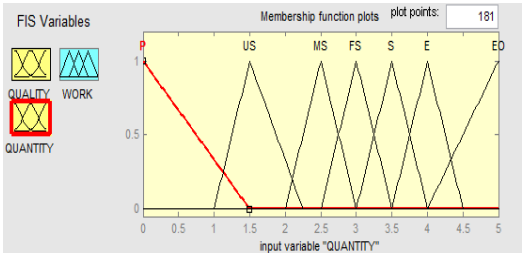

Fig 1.5 Fuzzified input parameter-Quantity

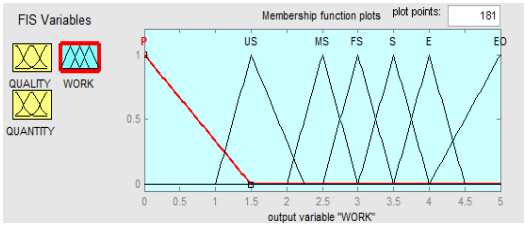

Fig 1.6 Fuzzified output parameter-Work

Similarly, we have defined input's/output parameters for the remaining FIS's.

Step II: Defining fuzzy control rules: Fuzzy control rules [1] for various fuzzy controllers are defined as follows:

Fuzzy controller FIS1 (refer to fig 1.0): Quantity and Quality are fuzzy input variable and Work is fuzzy output variable. The fuzzy control rules can be seen from the table 1.3

	QUANTITY							
QUALITY	WORK	P	US	MS	FS	S	E	EO
	P	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$
	US	$P_{1.0}$	$US_{0.5}$	$US_{0.6}$	$US_{0.7}$	$US_{0.8}$	$US_{0.9}$	$US_{1.0}$
	MS	$P_{1.0}$	$US_{0.6}$	$MS_{0.6}$	$MS_{0.7}$	$MS_{0.8}$	$MS_{0.9}$	$MS_{1.0}$
	FS	$P_{1.0}$	$US_{0.7}$	$MS_{0.7}$	$FS_{0.5}$	$S_{0.2}$	$S_{0.8}$	$S_{1.0}$
	S	$P_{1.0}$	$US_{0.8}$	$MS_{0.8}$	$S_{0.2}$	$S_{1.0}$	$E_{0.4}$	$E_{0.8}$
	E	$P_{1.0}$	$US_{0.9}$	$MS_{0.9}$	$S_{0.8}$	$E_{0.4}$	$E_{1.0}$	$EO_{0.8}$
	EO	$P_{1.0}$	$US_{1.0}$	$MS_{1.0}$	$S_{1.0}$	$E_{0.8}$	$EO_{0.8}$	$EO_{1.0}$

Table 1.3 fuzzy control rules-'FIS 1'

As can be seen from the table above there are total forty nine rules and each rule has its own Degree of Support (DOS between 0 and 1) which clearly shows the importance of each rule in rating analysis e.g. if the rating for 'Quality of work' is 'Poor' then irrespective of rating 'Quantity of work', overall rating for 'Work' is 'Poor' and has the highest priority i.e. its DOS is 1(full membership). The fuzzy rules are defined and based on personal experience of expert and varies from one expert to another.

With the help of surface viewer we can easily determine the value of output critical attribute (i.e. Work) corresponding to input critical attributes (i.e. Quality and Quantity). A surface viewer for FIS 1 is shown in figure 1.7.

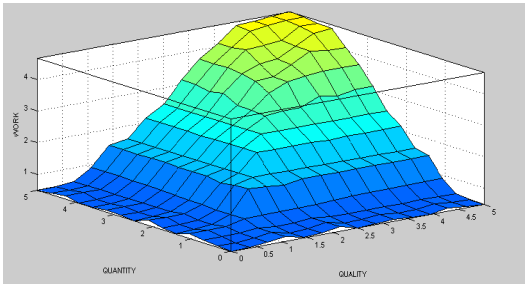

Figure 1.7 Surface viewer for FIS 1

Fuzzy controller FIS2 (refer to fig 1.0)*:* Reliability and Relationship are fuzzy input variable and Attitude is fuzzy output variable. The fuzzy control rules can be seen from the table 1.4

		RELIABILITY						
	ATTITUDE	P	US	MS	FS	S	E	EO
RELATIONSHIP	P	$P_{1.0}$	$US_{0.2}$	$MS_{0.2}$	$MS_{1.0}$	$FS_{0.8}$	$FS_{1.0}$	$S_{0.8}$
	US	$P_{1.0}$	$US_{0.4}$	$MS_{0.3}$	$FS_{0.5}$	$S_{0.4}$	$S_{0.6}$	$E_{0.2}$
	MS	$P_{1.0}$	$US_{0.5}$	$MS_{0.4}$	$FS_{0.8}$	$S_{0.6}$	$S_{0.8}$	$E_{0.4}$
	FS	$P_{1.0}$	$US_{0.6}$	$MS_{0.6}$	$FS_{1.0}$	$S_{0.8}$	$S_{1.0}$	$E_{0.6}$
	S	$P_{1.0}$	$US_{0.7}$	$MS_{0.7}$	$S_{0.5}$	$S_{1.0}$	$E_{0.6}$	$E_{0.8}$
	E	$P_{1.0}$	$US_{0.8}$	$MS_{0.8}$	$S_{0.8}$	$E_{0.6}$	$E_{1.0}$	$EO_{0.8}$
	EO	$P_{1.0}$	$US_{1.0}$	$MS_{1.0}$	$S_{1.0}$	$E_{0.8}$	$EO_{0.8}$	$EO_{1.0}$

Table 1.4 fuzzy control rules-‘FIS 2’

As can be seen from the table 1.4 if ‘Reliability’ is ‘Poor’ then irrespective of Rating for ‘Relationship’ rating for attitude is ‘Poor’. A surface viewer for FIS 2 is shown in figure 1.8

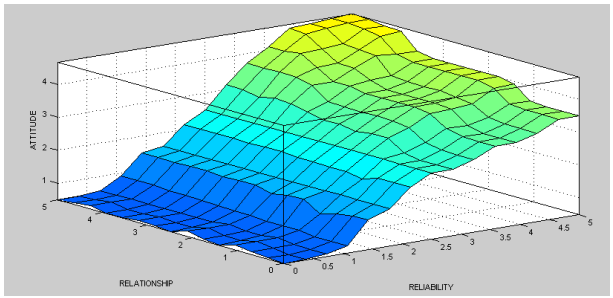

Figure1.8 Surface viewer for FIS 2

Fuzzy controller FIS6 (Ref to fig 1.3):'Work' and 'Attitude' are fuzzy input variable and 'Work-Attitude' is fuzzy output variable. The fuzzy control rules can be seen from table 1.5

	WORK							
ATTITUDE	WORK-ATTITUDE	P	US	MS	FS	S	E	EO
	P	$P_{1.0}$	$P_{1.0}$	$US_{1.0}$	$MS_{1.0}$	$FS_{0.8}$	$FS_{1.0}$	$S_{1.0}$
	US	$P_{1.0}$	$US_{0.4}$	$MS_{0.5}$	$FS_{0.5}$	$FS_{1.0}$	$S_{1.0}$	$E_{1.0}$
	MS	$P_{1.0}$	$US_{0.5}$	$MS_{0.6}$	$FS_{0.6}$	$S_{0.2}$	$E_{0.4}$	$EO_{0.2}$
	FS	$P_{1.0}$	$US_{0.6}$	$MS_{0.7}$	$FS_{0.7}$	$S_{0.4}$	$E_{0.6}$	$EO_{0.4}$
	S	$P_{1.0}$	$US_{0.7}$	$MS_{0.8}$	$FS_{0.8}$	$S_{0.6}$	$E_{0.8}$	$EO_{0.6}$
	E	$P_{1.0}$	$US_{0.8}$	$MS_{0.9}$	$FS_{0.9}$	$S_{0.8}$	$E_{1.0}$	$EO_{0.8}$
	EO	$P_{1.0}$	$US_{1.0}$	$MS_{1.0}$	$FS_{1.0}$	$S_{1.0}$	$EO_{0.8}$	$EO_{1.0}$

Table 1.5 fuzzy control rules-'FIS 6'

A surface viewer for FIS 6 is shown in figure 1.9

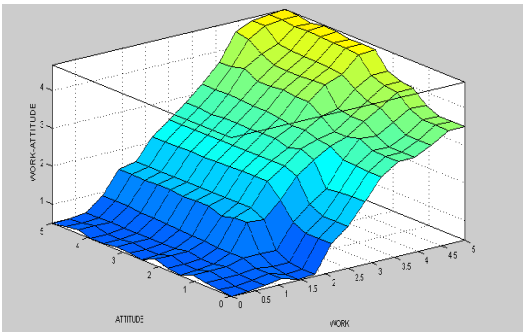

Figure 1.9 Surface viewer for FIS 6

Fuzzy controller FIS 9 (Refer to Fig 1.3):

'Attribute' and 'Punctuality' are fuzzy input variables and 'Overall Rating' is the fuzzy output variable. The fuzzy control rules can be seen from table 1.6

PUNCTUALITY \ ATTRIBUTE	OVERALL RATING	P	US	MS	FS	S	E	EO
	P	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$	$P_{1.0}$
	US	$P_{1.0}$	$US_{0.8}$	$US_{1.0}$	$MS_{0.2}$	$MS_{0.6}$	$MS_{0.8}$	$MS_{1.0}$
	MS	$P_{1.0}$	$US_{1.0}$	$MS_{0.8}$	$MS_{1.0}$	$FS_{0.6}$	$FS_{0.8}$	$FS_{1.0}$
	FS	$P_{1.0}$	$MS_{0.2}$	$MS_{1.0}$	$FS_{1.0}$	$S_{0.6}$	$S_{0.8}$	$S_{1.0}$
	S	$P_{1.0}$	$MS_{0.6}$	$FS_{0.6}$	$S_{0.6}$	$S_{1.0}$	$E_{0.8}$	$E_{1.0}$
	E	$P_{1.0}$	$MS_{0.8}$	$FS_{0.8}$	$S_{0.8}$	$E_{0.8}$	$E_{1.0}$	$EO_{0.8}$
	EO	$P_{1.0}$	$MS_{1.0}$	$FS_{1.0}$	$S_{1.0}$	$E_{1.0}$	$EO_{0.8}$	$EO_{1.0}$

Table 1.6 fuzzy control rules-‘FIS 9’

A surface viewer for FIS 9 is shown in figure 2.0

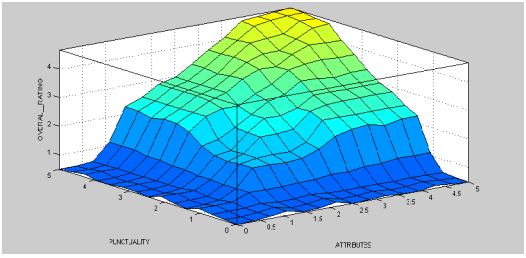

Figure 2.0 Surface viewer for FIS 9

Similarly, we have constructed other remaining fuzzy controllers i.e. FIS’s along with their fuzzy control rules and surface viewers.

4. Simulation of proposed fuzzy model and comparison with traditional non-fuzzy approach.

The proposed fuzzy reasoning model for PR was developed in Matlab Simulink software (Fuzzy Logic Toolbox) as shown in figure 2.1. Fuzzy logic controller was used to link all the FIS’s together.

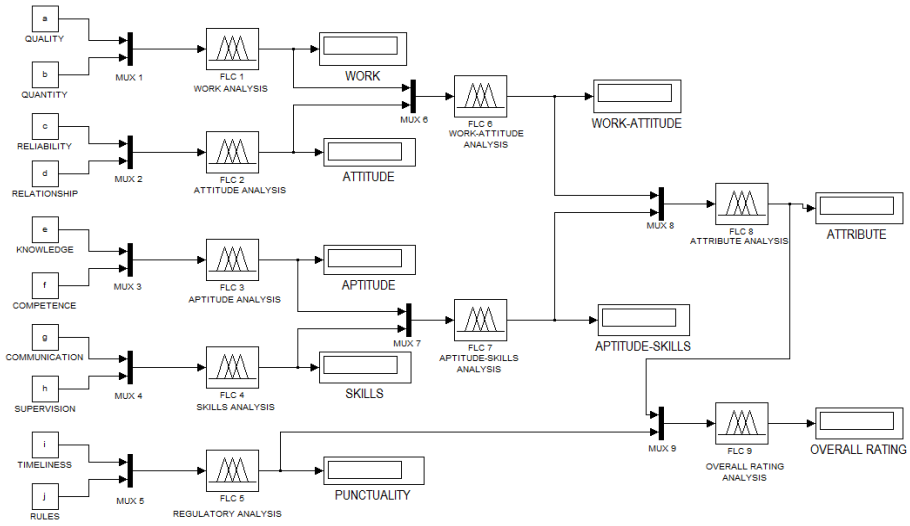

Fig2.1 Fuzzy reasoning- Simulink model

Results and comparison of various simulations for different set of critical attributes are shown below:

Set 1:

(a) Non-fuzzy traditional approach

Table 1.7 shows the ratings for various critical attributes

S.No	Critical Element	Numerical Rating
1	Quality of Work	1
2	Quantity of Work	5
3	Reliability	5
4	Relationship	5
5	Knowledge	5
6	Competence	5
7	Communication	5
8	Supervision	5
9	Timeliness	5
10	Rules & Regulation	5
	Total Numerical Rating	46

Table 1.7 Critical Attribute rating

Now, **Overall Rating = 46/10 = 4.6**

So according to non-fuzzy traditional approach employee's performance is **'extraordinary'** as can be seen from table 1.1

(b) Fuzzy reasoning approach

The simulation (t=10sec) results are shown in figure 2.2

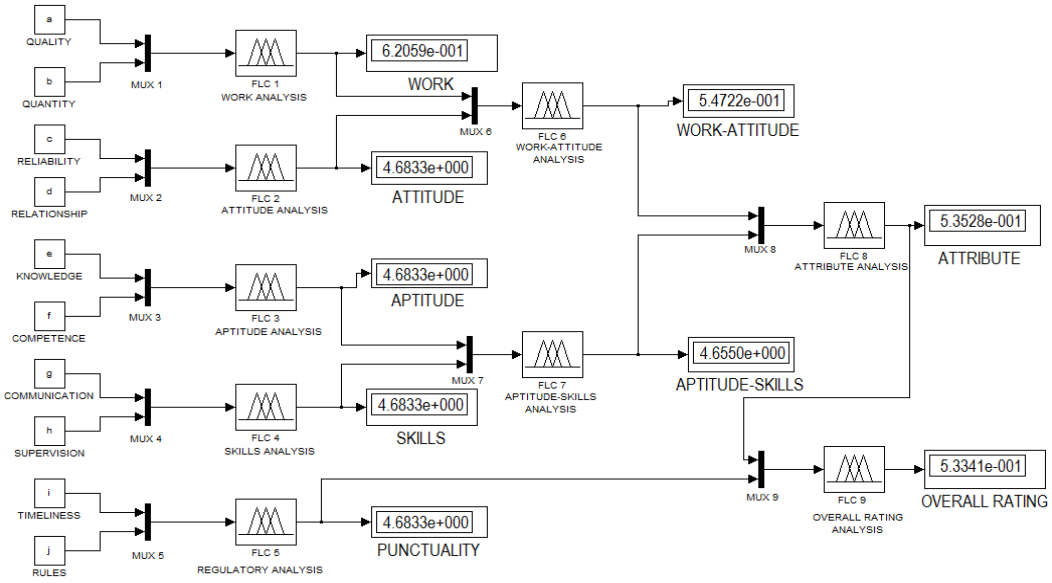

Fig 2.2 Simulation results

As can be seen from figure 2.2 Overall rating is **0.53341** i.e. employee's performance is **'poor'** because of weightage given to 'Quality of work'.

Set 2:

(a) Non-fuzzy traditional approach

Table 1.8 shows the ratings for various critical attributes

S.No	Critical Element	Numerical Rating
1	Quality of Work	5
2	Quantity of Work	5
3	Reliability	5
4	Relationship	5
5	Knowledge	5
6	Competence	5
7	Communication	5
8	Supervision	5
9	Timeliness	2
10	Rules & Regulation	2
	Total Numerical Rating	44

Table 1.8 Critical Attribute rating

Now, **Overall Rating = 44/10 = 4.4**

So according to Non-fuzzy traditional approach employee's performance is **'extraordinary'** as can be seen from table 1.1

(b) Fuzzy reasoning approach

The simulation (t=10sec) results are shown in figure 2.3

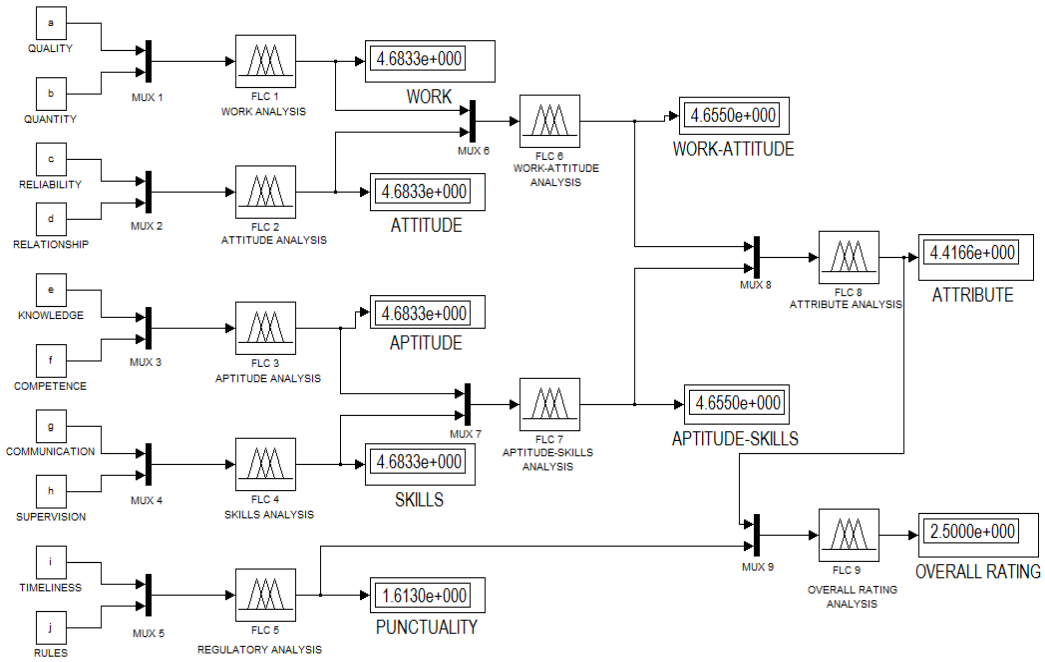

Fig 2.3 Simulation results

As can be seen from figure 2.3 Overall rating is **2.500** i.e. employee's performance is **'fully successful'** because of weightage given to 'Timeliness and Rules'.

5. Conclusion

A Matlab Simulink model has been developed and the results are compared with traditional non-fuzzy approach. The comparison between the two approaches shows the difference in their respective methodologies. The fuzzy reasoning approach proves to be more realistic as compared to traditional non-fuzzy approach. The fuzzy reasoning provides a more logical approach to PR. It also enhances the flexibility of organizations to give different weightage to different critical attributes. Therefore, a new approach for evaluation of PR of an employee using fuzzy logic reasoning has been proposed.

6. References

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