

Employee's Performance Development via Fuzzy Logic Technique and Expert System

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Abstract— Human resources work performance quality is one of the strengths to maintain the success and sustainability. The efficient work performance enables enormous opportunities for local and global competitions in the field. Evaluating, monitoring, and motivating employees' efficiency are few factors that improve an organizational performance. However, most of these factors rely on manual and partially computing-based systems and need to upgrade with evolving technologies. Artificial intelligence is vital one in providing intelligent solutions for most of the human problems. This study aims to propose an expert system for evaluating employee performance based on certain predefined factors which are used at King Khalid University. The proposed system is designed using fuzzy logic through Fuzzy-CLIPS performance. "IF-Then" rules are formulated to CRISP inputs following the Ricard triple scale. Fuzzy sets are created and the moment-defuzzy functions are chosen for the Defuzification process and outputs as CRISP output values. The system is expected to simulate the employees' behavior, evaluates performance, and provides valuable recommendations to decision making authorities. The system includes the factors, such as a sense of responsibility, cooperation, communication, achieving results, development, functional connection, and leadership. System test results show that the proposed expert system performs efficiently following ground rules, gives expert opinions, and is deemed capable of simulating a human expert.

Keywords— Employee performance, artificial intelligence, fuzzy logic, expert system. Business school

I. INTRODUCTION

High-quality human resources are employees with balanced interpersonal skills. To achieve this, the company needs to conduct continuous improvement and evaluation of employee performance, Casey (2005).

The system that helps in measuring and evaluating the relationship between the efficiency of the worker's performance and the duties and responsibilities of the job he occupies and each of his behavior and his ability to perform those duties and responsibilities in a way that helps to identify the strengths and weaknesses in past performance and determine how weaknesses can be avoided and the strengths are invested in the present and in the future to reach the highest levels of performance efficiency for the benefit of the individual, the organization and society, Hidayat, D. (2009).

The expert system is based on fuzzy logic evaluates the degree of performance of workers based on the model proposed by Tai and Chen, Kusumadewi, S. (2003), using the

level of performance and the level of importance of each component. In this expert system, the importance and level of performance of each intellectual component is determined indirectly through asking some questions from managers, Casey (2005).

Generally, The University uses paper forms for each of the employees in leadership positions who are the target group of the study and the employees with non-leadership positions. There are 21 variables divided into 6 main categories, each category contains 2-5 variables, and each variable is measured by a degree from 1 to 3, this was relied on the form was downloaded from the university's electronic portal, and these variables were encoded.

II. PROBLEM STATEMENT

The performance evaluation process is one of the continuous processes that require additional effort by the management, as institutions must manage their human resources effectively to maintain their competitive advantage in the local and global market. The performance Assessment process may suffer in most institutions from poor implementation for several reasons, including:

1. The lack of clarity of evaluation criteria for many employees.
2. Management's negligence of the evaluation process and failure of its employees.
3. Lack of transparency in the evaluation result.
4. The employees' lack of self-evaluation.
5. The absence of artificial intelligence systems to carry out the evaluation process.

III. RESEARCH OBJECTIVES

The study aims to use artificial intelligence techniques to improve and develop employees' performance through the following objectives:

1. Identify the standard criteria for evaluating employee performance.
2. Understand and compare fuzzy and binary logic.
3. Building an expert system that helps the college administration in the evaluation process.
4. Promote the concept of employee self-evaluation.
5. Improve and raise the efficiency of employees' performance.

IV. STUDY FRAMEWORK

The proposed system has been implemented in several stages as follows:

- (1) Exploring and gathering the source of knowledge of the system by interviewing specialists and studying the literature.
- (2) Knowledge representation in 'IF-THEN' format.
- (3) Dependence on the inferential mechanism of forward sequencing methods.

- (4) Transfer of acquired experience into machine language using Fuzzy-CLIPS
- (5) User interface design and system testing through verification tests.
- (6) Verification test will be performed to analyze the logical sequence of the system during its operation and to verify this using a sample from the expert decision table.

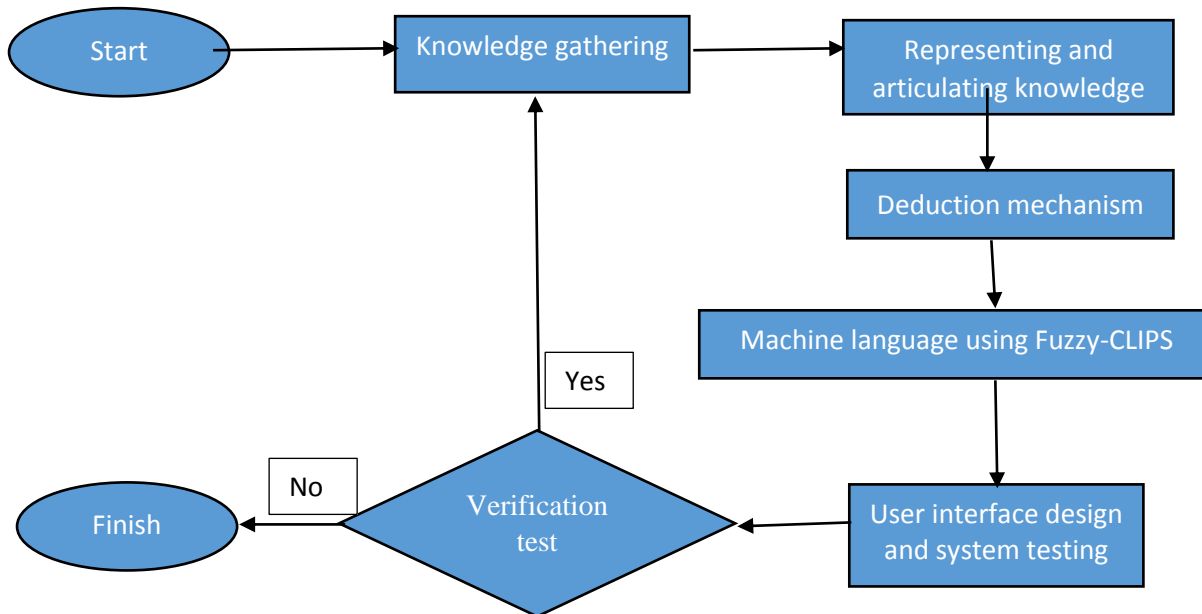


Fig. 1. Framework for designing the proposed system

V. LITERATURE REVIEW

5-1 Fuzzy modeling in human resource management, Mykola Ivanov*, Sergey Ivanov, Nataliia Terentieva, Victoria Maltiz, and Julia Kalyuzhnaya, E3S Web of Conferences 166, 13010 (2020)

This research discusses the theoretical aspects of evaluating the performance of employees in developing the digital economy, by defining eight criteria for conducting the evaluation. A mathematical equation was built to evaluate the standard or average value of the performance of the duties of the job, determine the terms of reference, the educational level, evaluate the level of the institution’s management, describe correspondence and the possibility of job exchange, evaluate the additional characteristics of the employees and describe many additional tasks and their characteristics. The proposed method for analyzing data in personnel management includes four steps. In the first stage, the problem of choosing the analyzed indicators is solved. In the second stage, eight problem-solving procedures are performed. In the third stage, job specialization conformity assessment procedures are implemented. In the fourth stage, the procedure for constructing membership functions based on fuzzy group theory is implemented.

5-2 Adnan Shaout* and Mohamed Khalid Yousif, Employee Performance Appraisal System Using Fuzzy Logic,

International Journal of Computer Science & Information Technology (IJCSIT) Vol 6, No 4, August 2014

This research presents the design and implementation of a performance appraisal system based on fuzzy logic. In addition to the main functions of the performance appraisal units, the system includes systematic "step by step" inference engine operations. These processes clarify many mathematical details in forming relationships and grouping methods such as minimum operator, algebraic product, sup-min product, and sup-product. The system also can analyze and report the result using various measures of similarity. The MS Access database was used for archiving data, building inference logic, and designing end-user interfaces.

5-3 Ashima Aggarwal, Gour Sundar Mitra Thakur, Design and Implementation of Fuzzy Rule Based Expert System for Employees Performance Appraisal in IT Organizations, Intelligent Systems and Applications, 2014, 08, 77-86, DOI: <http://10.5815/ijisa.2014.08.09>

Performance Appraisal system is used to assess the capabilities and productiveness of the employees. In assessing employee performance, performance appraisal commonly includes assigning numerical values or linguistic labels to employees performance. However, the employee performance appraisal may include judgments which are based on imprecise data particularly when one employee tries to interpret another employee’s performance. Thus, the values

assigned by the appraiser are only approximations and there is inherent vagueness in the evaluation. By fuzzy logic perspective, the performance of the appraisee includes the evaluation of his/her work ability, skills and adaptability which are absolutely fuzzy concepts that needs to be define in fuzzy terms. Hence, fuzzy approach can be used to examine these imprecise and uncertainty information. Consequently, the performance appraisal of employees can be accomplished by fuzzy logic approach and different defuzzification techniques are applied to rank the employees according to their performance, which shows inconsequential deviation in the rankings and hence proves the robustness of the system.

5-4 Bryan Irvin Joven Lamarca, Shaneth Cueno Ambat, *The Development of a Performance Appraisal System Using Decision Tree Analysis and Fuzzy Logic*, *International Journal of Intelligent Engineering and Systems*, Vol.11, No.4, 2018, DOI: <http://10.22266/ijies2018.0831.02>

This study shows the development of a performance appraisal system, which aims at studying the human recourses specific to the educational environment and brings out the role of data mining in achieving quality enhanced development in its faculty. The researchers in this research used CRISP-DM and Extreme Programming methodologies, focusing on generating models for the Decision Tree algorithm, combined with Fuzzy Logic Controller in predicting faculty performance. J48-generated IF-THEN rules is utilized in conjunction with FLC to predict individual or institutional faculty performance. Finally, main users found the system to be Very Acceptable through ISO/IEC 20510:2011 software quality tool.

VI. THEORETICAL PART

6.1 The performance assessment process

The performance evaluation process is one of the important processes practiced by human resources management in organizations and at all levels of the organization. Starting with the senior management and ending with workers in the lowest functional positions and in the lowest production lines, and it is one of the effective management control tools based on which the actual performance is compared to what is intended. A means that pushes departments to work with vitality and activity as a result of monitoring the performance of employees continuously by their superiors and pushes subordinates to work actively and efficiently to appear in the appearance of productive workers in front of their superiors, and to achieve higher levels of evaluation in order to receive the incentives and bonuses set for this, and for the process to achieve the desired goals of it must be dealt with systematically Accurate and with the participation of all parties that could benefit from the final results of the evaluation process.

Performance appraisal represents the definition of the individual on how he/she is performing his work and making a plan to improve and develop his performance. When the performance evaluation is applied correctly, it shows to the individual his current level of performance, and it may affect the level of the individual's effort and future task directions and support efforts to improve performance in a correct manner.

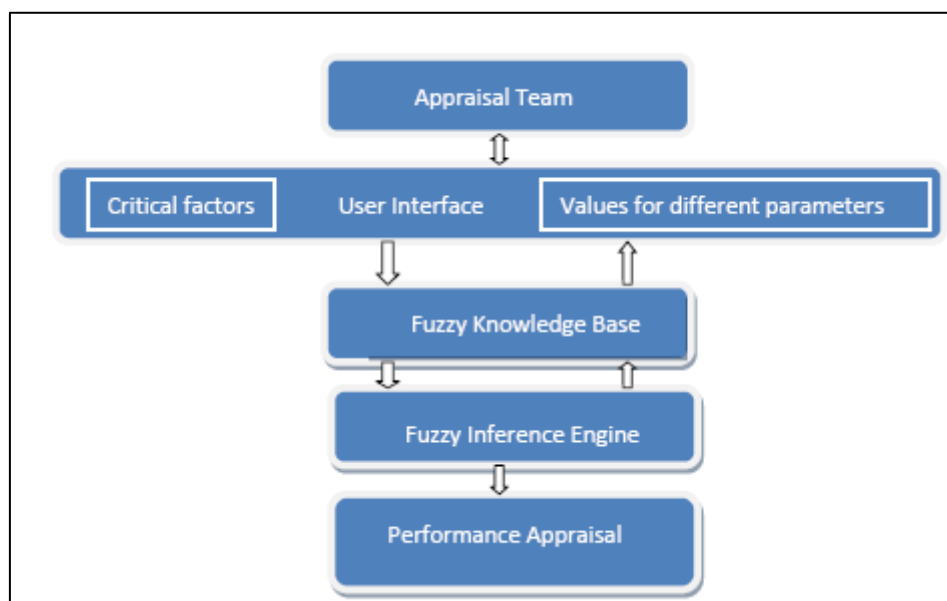


Fig. 2. Architecture of Fuzzy Inference System for Employee Performance Appraisal

6.2 Fuzzy logic

It is one of the modern sciences in mathematics and control, and it is a new logical method to reflect the human way of thinking and add this characteristic to computer

software, and it has made a great development in the field of programming and is considered a shift from the binary logic that expresses the right and wrong or one and zero to become the fuzzy logic multi-value between Zero and one, and Professor Lotfi Zadeh defines fuzzy logic as a science that

aims to infer patterns from approximate values instead of confirmed values, Lotfi A. Zadah(2007).

VII. PRACTICAL PART

7.1 Knowledge gathering:

The knowledge and experience that was included in the system was collected from two types of sources, formal and informal, as official knowledge was gathered from documented sources, i.e. from the university's website, the self-service portal, and the performance document. The other source includes employees and specialists in the field of human resources from the College of Business. The sources were chosen on the basis of experience and length of work, Casey,(2005).

7.2 Representing and articulating knowledge

A- Knowledge gathered from sources is represented by four stages of development

Step 1 – Define linguistic variables and terms. Linguistic variables are input and output variables in the form of simple words or sentences.

Step 2 – Construct membership functions for them.

Step3 – Construct knowledge base rules.

Step 4 – Obtain fuzzy value.

Step 5 – Perform defuzzification, Muchsam (2011).

B- The basic factors items have been coded as follows: Q11 indicating the factor number and the sub-question associated with it.

The ultimate goal of this step is to obtain a decision table that will be used to determine the value of each criterion as well as to propose the recommendation according to the applicable rules. Figure 2 shows the structure of the expert system and a sample of decision tables in Table 1.

7.3 Deduction mechanism of forward sequencing methods.

This expert system was developed by forward sequencing method; inferential machine development was performed by transferring rules in decision table into machine language in IF-THEN format.

This means that every answer in the table will be implemented as a rule in this system, each answer presented in the decision table represents a fact, and the system will track it accordingly to match it with the available rule and then implement it and make a recommendation as part of that. An example of these analysis results is shown in Table 2.

TABLE 1: Sample of expert decisions

Q 11	Q 12	Q 13	Q 21	Q 22	Q 31	Q 32	Q 33	Q 41	Q 42	Q 43	Q 51	Q 52	Q 61	Q 62	Q 63	Q 71	Q 72	Q 73	Q 74	Q 75	output	
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	H
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	M
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	L
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	M
3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	M
2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	L

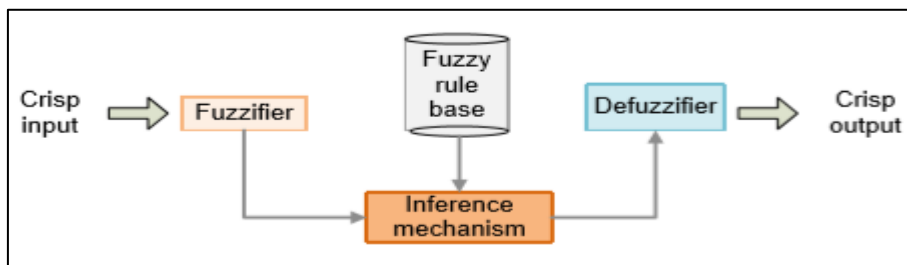


Fig. 3. Architecture of the expert system

TABLE 2: Sample decision table using the forward sequencing method

Q 11	Q 12	Q 13	Q 21	Q 22	Q 31	Q 32	Q 33	Q 41	Q 42	Q 43	Q 51	Q 52	Q 61	Q 62	Q 63	Q 71	Q 72	Q 73	Q 74	Q 75	Output	
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	100
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	69
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	35
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	67
3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	77
2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	57

7.4 Machine language using Fuzzy-CLIPS

This phase is implemented by establishing IFTHEN rules in the knowledge base of the Fuzzy CLIPS Expert System Development Tool shown in Figure 5.

Designing as a prototype system allows further development and improvement according to future changes

and needs. The outputs of this stage is a prototype of an expert system based on fuzzy logic to evaluate employee performance.

7.5 User interface design

The initial user interface was designed by Command line user interface by means of Fuzzy logic tool in a simple and

clear way and needs a short training period in order to be handled properly by all employees, Figure 4 shows the main interface of the proposed system.

Each system should be tested to ensure that it is working properly; the expert system is tested in three aspects, namely validation testing, validation testing and UI evaluation.

The first test is performed by accessing and operating the system with different inputs. This test includes an expert from the Computing and System Analysis Lab. The result shows as in Fig. 6, that the system is behaving correctly according to the given input.

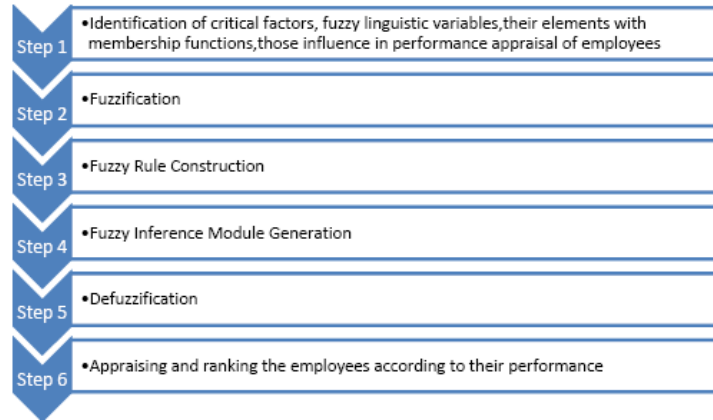


Fig. 4. Fuzzy Inference Process for Employee Performance Appraisal

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Employee Performance Application
The program was designed to help for Assessment of Employee's Performance
=====
-----Q11-----
Enter the level of Q11:( 1-3) 3
-----Q12-----
Enter the level of Q12:(1-3) 3
-----Q13-----
Enter the level of Q13:(1-3) 3
-----Q21-----
Enter the level of Q21:(1-3) 3
-----Q22-----
Enter the level of Q22:(1-3) 3
-----Q31-----
Enter the level of Q31:( 1-3) 3
-----Q32-----
Enter the level of Q32:(1-3) 3
-----Q33-----
Enter the level of Q33:(1-3) 3
-----Q41-----

```

Fig. 5. The main interface of the system

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-----Q71-----
Enter the level of Q71:(1-3) 3
-----Q72-----
Enter the level of Q72:(1-3) 3
-----Q73-----
Enter the level of Q73:(1-3) 3
-----Q74-----
Enter the level of Q74:( 1-3) 3
-----Q75-----
Enter the level of Q75:(1-3) 3
The percentage of employee's performance is :100.0
===== Thanks for using our Product =====

```

Fig. 6. The result interface from the system

7.6 Verification test

The validation test was performed by comparing the results released by the system with those collected from the experts, the test results provided by the system showed similar to the experts' recommendation, the correlation coefficient between the two degrees was 93%. This means that the system is able to represent and replace the true human expert in evaluating employee performance.

The last test was performed to check the usability of this system. This test includes respondents who are asked to use the system and then give their opinion on a designer questionnaire. Five criteria were examined in this test to infer the usability of the system. The criteria as well as their level (on a scale of 1-5) based on user evaluation are as follows: available features, suitability to needs, ease of use, clarity of information and interactivity. Based on these results, it can be believed that the system performs well in terms of usability.

VIII. ACKNOWLEDGEMENTS

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IX. CONCLUSION

The expert system for evaluating employees' performance has been developed to provide quick and easy performance evaluation report. The system relies on five basic skills: *employee productivity*, *work quality*, *ability to solve problems*, *continuous employee training*, and *work as team*. The system give accurate and transparent evaluation and gives improvement suggestions to reach the optimal performance. The system performed effectively in three types of tests. The system will play the role of the human expert in evaluating

employees' performance and making necessary recommendations on human resources issues.

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