

Artificial Neural Network (ANN) based novel Performance evaluation technique

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Abstract: In this study we have highlighted different performance evaluation techniques in order to carry out adequate performance based appraisal of employees working in different organisations. The paper briefly describes and compares both traditional as well as several modern Performance appraisal techniques which are currently in practice. In this study we have proposed a new soft-computing based appraisal technique which works by combining learning ability of artificial neural networks and reasoning capability of fuzzy logic theory. The results are validated by comparing working of proposed approach to conventional average based rating technique. The results further confirmed appropriateness of above mentioned technique over other traditional appraisal approaches.

Keywords: Artificial neural network, Performance appraisal, soft-computing, ANFIS, fuzzy, Matlab.

1. Introduction to Performance appraisal

Performance appraisal of an employee is a significant factor in success of any individual as well as for the growth of any organisation. An appraisal is considered to be good if it is performed fairly and motivates employees thereby resulting in improved performance of the organisation [1]. Sometimes performance appraisal does not results into a valid and reliable evaluation thus creating conflicts in the workplace [2]. These conflicts will affect the output and performance of both the employees as well as the organisation. Performance appraisal plays a vital role in both human resource management as well as strategic management and therefore widely employed for both theoretical and practical study [3]. In the past few years researchers have been showing keen interest to develop various appraisal tools and techniques [4]. A case study on effects of performance appraisal in the Norwegian municipal health services was carried out by Vasset et al. [5]. In the study authors evaluated the effect of job motivation, learning and self-assessment on performances of health personals. Shaout and Yousif [6] highlighted various methods and techniques for performance evaluation of employees. The study considered both traditional as well as new approaches for effective appraisals. The authors further proposed a fuzzy based appraisal technique for evaluating performances of academic staff in Sudanese Universities.

A new construct for performance evaluation of teachers was proposed by Yonghong and Chongde [7]. The study conducted literature survey, case study, interview and qualitative research for analysing reliability and validity of different empirical approaches. Keaveny and McGann [8] observed the effectiveness of different performance appraisal formats in terms of clarity. The different formats which were adopted for analysis were simple graphic rating scale, complete graphic rating scale and behavioural rating scales. The study highlighted superior performance of behaviour rating scale compared to other two scales. Jawahar [9] demonstrated a correlation between employee satisfaction and their performance feedback. The study considered a survey on 112 employees which proved that satisfaction with appraisal feedback was directly related to job satisfaction and organisational commitment and inversely related to turnover intentions. Banner and Cooke [10] explained some of the main conceptual issues in performance appraisals. The authors highlighted some practical dilemmas and their solutions which may arise during process of appraisals. The results concluded that one can morally justify use of appraisals under certain specific conditions. Osmani and Maliqi [11] carried out a study to examine the process of management and performance evaluation of employees. Authors focused on importance of individual performances, stages through which appraisal is realised, targets, key indicators and challenges faced during the process in both public and private organisations.

Sanyal and Biswas [12] examined the attitude of employees towards performance appraisal in software companies in West Bengal (India). A survey on 506 employees from 19 software companies was carried out followed by binary regression analysis. The authors identified main consequences of performance appraisal and their impact on motivation of employees. Min-peng et al. [13] proposed a fuzzy comprehensive evaluation approach for measuring performance of engineering R&D staff. The study considered different performance indicators based on morality, ability, diligence and performance to determine weight of every index. The proposed model is feasible and practical through empirical research. Wu and Hou [14] proposed an employee performance estimation model for logistics industry. The proposed model includes three modules for performance estimation i.e. direct performance determination, indirect performance determination and performance score analysis. The proposed model helped in accurate estimation of employee performance. Katerina et al. [15] identified different performance appraisal methods in agricultural organisations. The study initially described some formal appraisal techniques and further designed a questionnaire to rate different appraisal techniques in agriculture sector of Czech Republic. The results showed that most widely used techniques for performance appraisal includes goal-based appraisal, predefined standard outcome-based appraisal and appraisal interviews.

2. Performance appraisal techniques

In this we have briefly described some of the most widely used traditional and modern performance appraisal techniques. It can be concluded from the discussion that selection of an

adequate appraisal technique for performance evaluation is an important facet for any organisation.

2.1 Traditional performance appraisal techniques

Some of the commonly used traditional or conventional techniques for performance evaluation of employees are as follows:

i. Annual confidential report (ACR): It is an old evaluation technique developed in 1940s and is still applicable in many public/government sector organisations of many developing countries like India and Srilanka. It is normally carried out yearly for making decisions related to promotions. ACR reports are confidential and employees can't discuss their performance with their seniors [16].

ii. Ranking/rating technique: It is one of the simplest and oldest rating technique in which appraiser rates the employee on a Likert scale of 1 to 5 (say). The performance can vary from best to poor depending on the rating [17]. A simple illustration of ranking technique is given with the help of Table 1.

Employee	A	B	C	D	E
Likert Scale Rating	4	5	2	1	3
Grading	Good	Very good	Poor	Very poor	Satisfactory

Table 1. A simple illustration of ranking technique

iii. Graphic rating scale: This scale was developed by Peterson in 1922 for employees of a Scott company. It is basically an upgradation of simple ranking technique discussed in previous section. In this technique rating is given pertaining to different qualities or traits of an individual as decided by the organisation [18]. The performance parameters or traits may vary from one organisation to another and includes traits like work quality, attitude, discipline, punctuality etc. A simple illustration of graphic rating technique is given with the help of Table 2.

Employee					
Traits	A	B	C	D	E
Work quality	Good	Very good	Poor	Very poor	Satisfactory
Attitude	Very good	Poor	Satisfactory	Poor	Good
Discipline	Poor	Good	Good	Very good	Poor
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Table 2. A simple illustration of graphic rating scale

iv. Paired comparison technique: In this technique performance of each employee and job is compared with other employees and jobs. Employees are compared on the basis of overall performance while jobs are compared on the basis of skill, knowledge, time required etc [19]. It is an ideal tool for deciding relative importance of qualifications, experience, skill, team working ability etc. Consider a case illustrated in Table 3, if employee 'A' is rated better compared to employee 'B' he is rated '1' else '0', Similarly ratings were obtained for jobs. It is clear from

Table 3, that employee ‘B’ performs best compared to other employees. The overall ratings were obtained by considering ratings for both employees as well as jobs.

		Related Employee				
		A	B	C	D	E
Compared to	A	---	1	1	0	0
	B	0	---	0	0	0
	C	0	1	---	1	0
	D	1	1	0	---	1
	E	1	1	1	0	---

Table 3. A simple illustration of paired wise comparison technique

v. Checklist technique: In this technique ‘Yes’ or ‘No’ based questions checklist were prepared for different traits of an individual [20]. The main advantage of this technique is its economical and easy to use approach. The disadvantages may include biasness because of rater and incapability of using relative ratings.

vi. Essay evaluation technique: This method gives an easy and effective approach for assessing an employee. This technique is especially applicable in startups. The essay technique includes writing a detailed essay regarding performance of the employee and includes both shortcomings and achievements of an individual [21].

vii. Trait focused appraisal technique: This technique is helpful in inducing a positive work culture and ethics in the organisation [22]. The organisation undergoing this type of appraisal considers attributes like helpfulness, kindness, punctuality etc for evaluation of employee. Trait focused appraisal should be conducted once in a while in every organisation to reinforce positive culture in it [23].

viii. Critical incident technique: In this appraisal technique employer prepares a list of statements for very effective and ineffective behaviour of an employee. These critical incidents represent the outstanding or poor behaviour of employees [24]. The manager or leader has to maintain a record of critical incidents of all the employees which were further used for evaluating their performance.

ix. Forced distribution method: This method was proposed by Tiffen in order to remove central tendency of rating most of the employees at a higher end of the scale [25]. The technique assumes that employee performance confirms to a normal statistical distribution. This approach is helpful for rating large number of employees and effectively eliminates biases. It is simple to understand and easy to apply in organisations.

x. Forced choice method: This method was developed by J.P. Guilford. It comprises of a group of statements either positive or negative which describes a particular employee effectively. Each statement carries a particular weight being determined by HR section of that particular

organisation [26]. The final rating is obtained by combining scores obtained from all the statements.

2.2 Modern performance evaluation techniques

Some of the widely adopted modern performance appraisal techniques are as follows:

i. 360-degree appraisal technique: This technique includes gathering feedback of an individual from multiple sources like managers, heads, co-workers, customers, vendors etc [27]. The review becomes more accurate and precise as the size of collected data increases. The main disadvantage of the proposed technique is its time consuming and laborious approach.

ii. 720-degree appraisal technique: This technique includes measuring feedback of an individual from management, colleagues, customers etc. It is sometimes referred to as twice 360° appraisal review because review is done initially when goals are set and again when feedback is given [28].

iii. Cost accounting technique: This technique examines the monetary returns yielded by an individual for his/her organisation to evaluate their performance. This technique adopts cost and benefit analysis for rating a particular employee [29].

iv. Management by objective: It is an interactive and fair appraisal technique which consumes less time and resources. The technique aims at setting goals and objectives for an individual by his employer [30]. The setting of goals helps an individual in performing better and yielding better results. The rating of an employee is done by examining the extent to which predetermined work objectives have been met.

v. Fuzzy based appraisal technique: Fuzzy logic theory was initially introduced by L.A Zadeh in early 1965. This theory is mostly applicable to systems having imprecise or incomplete data available. Fuzzy logic theory is widely used in multi-criteria-decision-making processes. Since process of performance appraisal includes fuzziness and uncertainty in judgments of decision maker therefore fuzzy logic reasoning can be effectively applied for performance appraisal of employees [31]. The two most commonly used fuzzy based appraisal techniques for evaluating performance of an employee are as follows:

a. Fuzzy analytic hierarchy process (FAHP): This technique combines concepts of fuzzy sets and hierarchical structure analysis for multi-criteria-decision-making process. FAHP defines each performance attribute in terms of natural language which a common language in fuzzy logic theory [32]. FAHP replaces crisp value with a range of values to incorporate decision maker's uncertainty. It resembles impressively human thoughts and perception. The comparisons made by experts are represented in form of fuzzy numbers to construct pair-wise comparison matrices.

b. Adaptive neuro fuzzy inference system (ANFIS) based performance appraisal technique:

This study introduces a novel ANFIS based learning approach for evaluating performance of employees working in different organisations. ANFIS is an adaptive learning technique based on principle of operation of artificial neural networks. It comprises of a set of input, output and hidden layers connected with the help of nodes whose weights are adjusted and tuned during learning process [33]. A schematic view of ANFIS architecture is shown with the help of Figure 1. During training process input vectors are supplied to the input layer which further propagate through hidden layers and reaches the output layer. In the output layer actual output is compared with the desired output and an error is generated which is further propagated backwards thereby adjusting connection weights of the nodes.

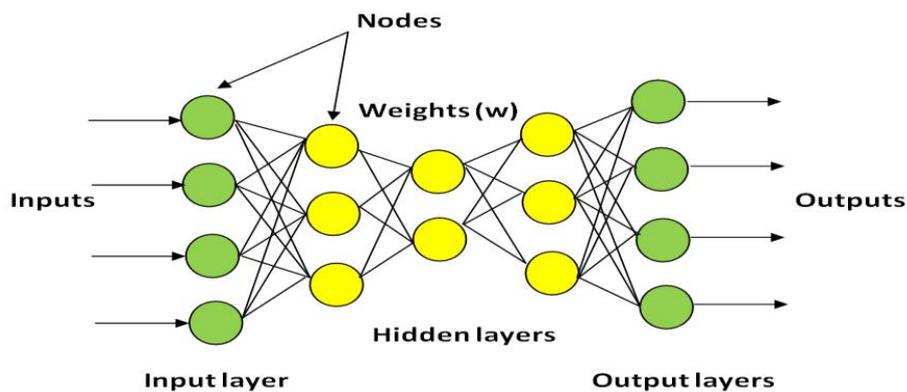


Figure 1. ANFIS architecture

ANFIS technique is a fusion of fuzzy logic reasoning and artificial neural networks approach [34]. These networks can learn and mimic behaviour of supplied data samples in a very effective manner incorporating back-propagation learning algorithm [35]. Therefore, ANFIS architecture is suitable for learning and prediction applications [36]. In Table 4, we have illustrated the working principle and comparison analysis between ANFIS and conventional average based rating technique. We have considered five different employees whose performance are rated based on three different performance parameters namely quality of work, timeliness and behaviour. The ratings given to each employee against each attribute are mentioned in the table. ANFIS based learning approach provides the rater with an advantage of giving different weightages to each attribute depending upon the work culture and scope of work of any particular organisation. An initial data samples based on the decision of experts can be fed into the controller which can be used for performance analysis. For an instance consider ratings given to employee-2, which clearly shows that the rating for attribute ‘Quality of work’ is ‘1’ i.e. very poor while for other two attributes i.e. for timeliness and behaviour ratings are very good. The performance of any organisation can be considered as a function of quality of work obtained by different employees. Therefore, it can be given some extra weightage compared to other attributes. As can be observed from the results that the overall rating obtained for employee-2 using ANFIS is 2 i.e. poor even though he has obtained very good ratings for attributes behaviour and timeliness. It can be also observed from the results that for the similar ratings the

overall rating obtained using average method is 3.67 i.e. satisfactory to good. Therefore, it is clear from the results that ANFIS based rating technique gives an opportunity to assign different weights in an easy and innovative manner.

Employee	Quality of work	Timeliness	Behaviour	ANFIS rating	Average method
1	5	5	5	5	5
2	1	5	5	2	3.67
3	2	2	5	2	3
4	1	1	5	1	2.33
5	3	3	3	3	3
5-Very good; 4-Good; 3-Satisfactory; 2-Poor; 1-Very poor					

Table 4. Comparison between ANFIS and conventional average based technique

A complete data for learning and tuning of ANFIS can be initially fed into the controller. This data can be later used for faster and accurate prediction process. Another advantage of proposed technique is that it can be extended and applied for performance evaluation of n-number of employees with m-performance attributes as can be illustrated from Table 5. The computer based simulation approach makes the complete procedure less cumbersome and time efficient.

Employee	Quality of work	Timeliness	Behaviour	---	(m-1) th	m th	ANFIS Rating
1	a ₁₁	a ₁₂	a ₁₃	---	---	a _{1m}	X ₁
2	a ₂₁	a ₂₂	a ₂₃	---	---	a _{2m}	X ₂
3	a ₃₁	a ₃₂	a ₃₃	---	---	a _{3m}	X ₃
---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	---
(n-1) th	---	---	---	---	---	---	---
n th	a _{n1}	a _{n2}	---	---	---	a _{nm}	X _n

Table 5. ANFIS technique extended for multi-employee performance evaluation

3. Conclusion

This paper highlighted various performance appraisal techniques for effective performance evaluation of employees. Both traditional and modern appraisal techniques have been analysed for study. The paper briefly touches various advantages, disadvantages and suitability of a particular appraisal technique in any organisations. The study also proposed a new performance appraisal approach based on soft-computing based ANFIS technique. The proposed approach has been further compared to traditional average based rating technique. ANFIS based appraisal approach has got an inherent advantage of learning through supplied data samples, removes biasness and exhibits faster computation compared to other conventional techniques. The proposed approach allows the rater to carry out evaluation in Matlab environment thereby giving faster and accurate results. The results showed that proposed approach can be effectively applied to carry out evaluation of multiple employees considering several performance attributes.

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